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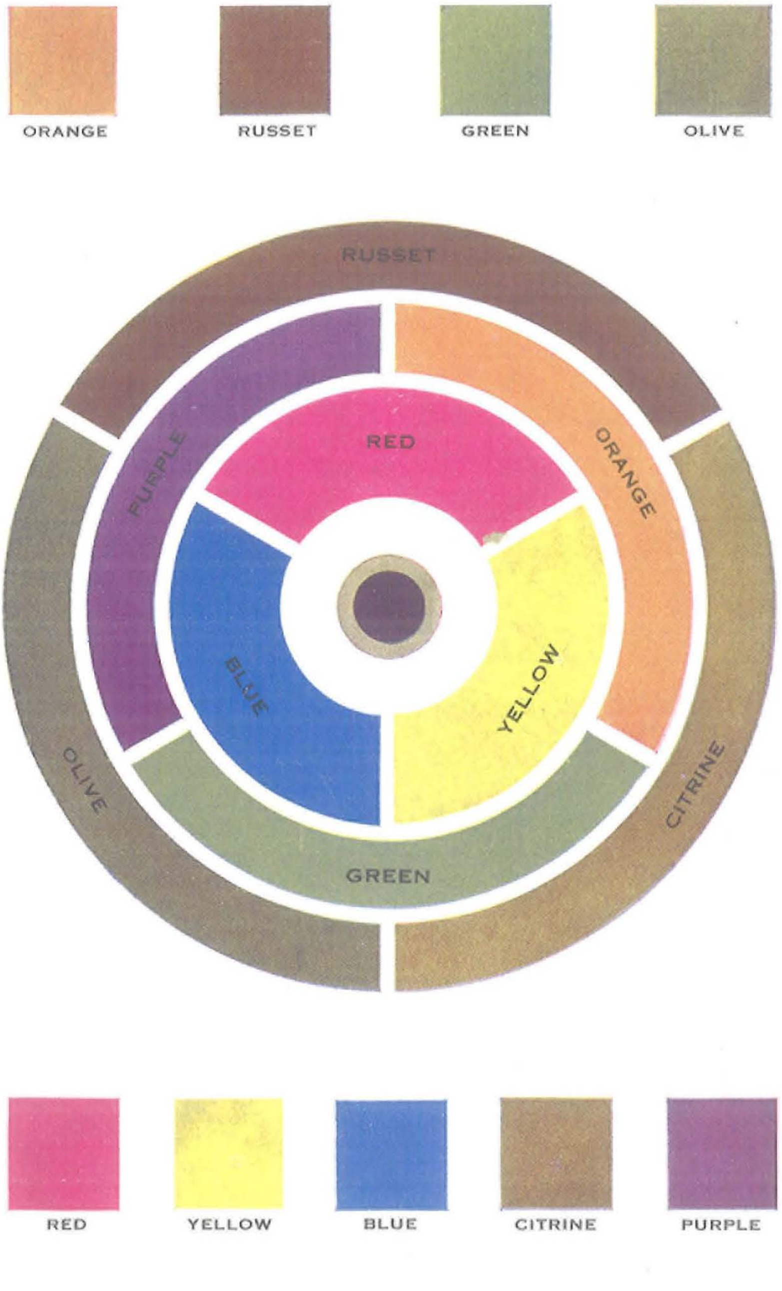

Chart of Primary, Secondary and Tertiary Colors

PROSTHETIC DENTISTRY

BY

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PROFESSOR OF PROSTHETIC TECHNIC, PROSTHETIC DENTISTRY AND METALLURGY
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As a Slight Token of Admiration and Appreciation for
Kindly Help and Advice Rendered the Writer
Through Years of Association,
this Book is Dedicated
to the Memory of

Greene Vardiman Black, M.D., D.D.S., Sc.D., LL.D.

Whose Persistent and Untiring Efforts
in the Fields of Science have Immeasurably Benefited
not only the Profession of which he was a
Most Distinguished Member,
but Humanity as well

PREFACE

The revision of a former edition of this book has resulted in very nearly a fourfold enlargement.

Prevailing dental educational methods, although covering only those subjects considered essential, leave little time to the beginner for collateral reading. In the hour to hour transition of his mind from one recitation to another the student sometimes fails to realize the breadth and scope of some particular subject, or its relation as a part to the whole. This is especially true in the prosthetic field. Innumerable devices and methods of technic have been evolved for the replacement of lost natural teeth. To burden the student's mind with all of these would be impracticable.

The writer has endeavored to introduce the essentials in four main subjects of prosthesis, viz., denture, crown, bridge and inlay construction, with sufficient elaboration to enable the beginner to acquire a practical as well as theoretical knowledge of them. Stress is laid upon the fact that, although involving many problems in physics and mechanics, the calling of a prosthetist is much more than that of a mechanic. The appliances which he constructs are placed in apposition to or rest upon living, sensitive tissue susceptible to pathologic changes when substitutes are not well planned. Frequently, as a result of improper planning, many restorations, although well executed from a mechanical standpoint, result in infinitely more harm than benefit.

A synopsis of color principles has been included because, without a knowledge of crude primary colors and their complements, it is impossible to discern fine distinctions between attentuated tints and their complements, as should be done in the harmonious selection of teeth.

A section on metallurgy has been incorporated, since the prosthetist is constantly dealing with metals and alloys in one form or other; consequently a knowledge of their physical properties is essential. The *outline of recent discoveries* has been added, with the idea of exciting further interest in the wonderful phenomena of the elements and their relation to each other.

A section on the history of prosthesis has been added, so that the student may form some conception of the sequent growth and progress in this field. Brief though it is, the subject-matter presented involved a considerable expenditure of time. It is hoped that it may aid in rounding out the beginner's conception of the breadth and scope of the field he is entering.

The writer desires to express his appreciation to various individuals, organizations and supply houses, as follows:

To the National Dental Association, through its officers, for the use of cuts which appeared in Dr. Guerini's History of Dentistry.

To the S. S. White Dental Manufacturing Company for many cuts throughout the text, and particularly those relating to crown and bridge work, included in the chapter on history.

To the Dentists' Supply Company of New York for Dr. J. Leon Williams' typal forms of teeth and Dr. Gysi's appliances.

To H. D. Justi & Son, through Mr. Bowe; Ash & Sons, through Mr. Sykes; Lee S. Smith & Co., Samuel A. Crocker, Ransom & Randolph, Cleveland Dental Supply Company, J. W. Ivory, Lea & Febiger, Johnson & Lund, Goldsmith Bros., Detroit Dental Manufacturing Company and others for various cuts used through the text.

To Dr. A. J. Bush of Columbus, Ohio, for his essay and charts on the classification of fixed bridgework.

To Dr. L. J. Weinstein of New York for his recent work on alloys of gold, investments and fluxes.

Finally, thanks are due to the untiring efforts of my assistant, Dr. Joseph Ridgway, for help in arranging text and illustrations and in proofreading.

JAMES HARRISON PROTHERO.

Chicago, January 25, 1916.

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CHAPTER I

PROSTHETIC DENTISTRY

GENERAL REMARKS

The science of dentistry pertains to the recognition and treatment of diseases of the teeth and oral tissues, of the general neuritic conditions of the head and neck that may have their direct origin in, or be indirectly connected with, the fifth cranial nerve, and of the repair and replacement by operative or prosthetic procedures, of the partial or complete loss of the teeth through accident or by disease.

Prosthetic dentistry is that branch of dental science which treats of the various methods of replacing the lost organs of the mouth in whole or in part, the artistic and mechanical processes involved in such restoration, together with a description of the physical properties and peculiarities of the various materials employed.

Specifically considered, prosthetic operations may be classed as follows: Construction of crowns, bridges and dentures, obturators and appliances for correcting defects of the palate, appliances for correcting irregularities of the teeth and jaws, appliances for retaining in position fractured bones of the face when reduced, and the construction of metallic and porcelain inlays.

In all prosthetic procedures the attainment of three objects is desirable: First, the *restoration of the function of mastication;* Second, *the esthetic requirements should be given due consideration and wrought out correctly;* Third, *the substitute, of whatever character, should cause the wearer no discomfort.* The late Dr. Pritchett concisely stated this by saying that in prosthetic procedures "we strive to give our patients dentures that are *useful,* will *look* well, and be *comfortable.*"

RESTORATION OF THE FUNCTIONS OF MASTICATION — UTILITY

The first consideration is the most important. When from any cause the function of mastication is interfered with or impaired, the digestive organs are necessarily required to do an extra amount of work for which they are unfitted, and which will eventually result in impaired digestion, systemic disurbances and general ill health of a more or less serious character. Without doubt, many lives are shortened by years because of the partial or total loss of this most important function, and in constructing substitutes for the natural teeth, they should be made to restore, as fully as possible, the function of the natural organs. This point is of such importance as to bear repetition by restatement. Ability to masticate and digest food means good health and generally normal bodily functions, while inability to do so entails discomfort, ill health, disease and a curtailing of the span of life.

ESTHETICS

The second consideration—esthetics—relates to the artistic phase of prosthesis, the ability to produce or create appropriate and natural appearing devices and substitutes to take the place of the lost natural teeth, to reproduce by skilful technic not only a successful masticatory apparatus, but to restore lost facial contour as well.

The principal part of the face to suffer change by the loss of the teeth, and the consequent absorption of the alveolar process, is the mouth, although at times a considerable portion of the lower half of the face is modified in outline. The lips lose their normal pose and assume an unnatural expression, more or less marked in proportion to the loss of the bony substructure. Premature wrinkles form upon and encompass the mouth and cheeks, and an appearance of age, not warranted by years, sets its seal upon the subject.

It is the province of the prosthetist to correct, as far as possible, the ravages occasioned by disease, and time, as well, and restore to the patient his normal appearance.

To do this the prosthetist should be a master of his art — one who can, at will, imitate nature in her ideal, as well as less typical forms and moods. From the nature of his vocation, he should be an anatomist, a sculptor, an artist and an artisan, thorough and proficient in each field mentioned, in order to fulfill, in the highest degree, the requirements imposed upon him by his profession.

Many eulogistic effusions on the beauty, attractiveness and importance of the mouth and teeth are to be found. They have emanated from the artists and poets of every race and clime. They emphasize the high regard and even veneration in which these features of the face have been held by the human race in general from time immemorial. The following are some of the selections referred to.

Lavater, one of the early writers on physiognomy, says, in reference to the mouth: "The mouth is the interpreter of the mind and of the heart. It combines, both in a state of rest and in the infinite variety of its motions, a world of characters. It is eloquent even in its silence." * * * "I conjure our painters and every artist whose mission it is to represent man, I conjure them with all my might to study the most precious of all our organs in all its varieties; in all its proportions; in all its harmonies."

"What shall I say, painters and designers, that may induce you to study this sacred organ in all its beauteous expressions, in all its harmony and proportions?" "Take plaster impressions of characteristic mouths (lips) of the living and the dead; draw after, attentively examine them, learn, observe, continue day after day to study one only; and having perfectly studied that, you will have studied many. * * * Among ten or twenty draughtsmen to whom for three years I have preached, whom I have instructed, have drawn examples for, not one have I found who felt as he ought to feel, saw what was to be seen, or could represent that which was evident." * * * "I expect everything from a collection of characteristic plaster impressions which might so easily be made, were such a collection once formed—but who can say whether such observations might not declare too much. The human machine may be incapable of suffering to be analyzed; man, perhaps, might not endure such a close inspection, and, therefore, having eyes, he sees not." Lavater further lays down rules for the guidance of the artist, as follows:

"Distinguish in each mouth, *a* the upper lip, singly; *b* the under lip, the same; *c* the line formed by the union of both when tranquilly closed, if they can be closed without constraint; *d* the middle of the upper lip in particular, and *e* of the under lip; *f* the bottom of the middle line at each end, and lastly *g* the extending of the middle line on both sides, for unless you distinguish you will not be able to delineate the mouth accurately."

Herder, the eminent German poet and critic, says of this prominent feature of the face: "It is from the mouth that the voice issues, interpreter of the heart and soul, expression of feeling, of friendship, and of the purest enthusiasm. The upper lip translates the inclinations, the appetite, the disquietude of love; pride and passion contract it; cunning attenuates it; goodness of heart reflects it; debauchery enervates and debases it; love and the passions incarnate themselves there in an inexpressible charm."

Concerning the teeth, Paolo Mantegazza, the noted Italian anthropologist, says: "It is a flaw in beauty to have bad teeth; it is like a spot on the sun. Since the hygiene of the teeth is at the same time the hygiene of beauty, good dentists merit a golden statue, or at least a place of honor among the principal benefactors of humanity." * * * "The most beautiful teeth are not enough to make a man beautiful; but ugly teeth would spoil the beauty of the Venus of Milo herself."

Again reverting to Lavater's remarks on the teeth, he says: "Nothing is more certain, striking or continually visible than the characteristics of the teeth, and the manner in which they display themselves." * * * "Whoever leaves his teeth foul and does not attempt to clean them, certainly betrays much of the negligence of his character, which does him no honor. As are the teeth of man, that is to say, their form, position and cleanliness (so far as the latter depends upon himself), so is his taste."

The loss of the teeth and consequent absorption, to a greater or less extent, of the bony substructure supporting the lips and cheeks, results in marked disfigurement. The exterior of the dental arch, as well as the face, is convex. The lips form a movable curtain or *pallium*, to close the oral opening. They are supported by the dental arches and alveolar borders. The loss of the teeth allows the lips to sink in, and the profile, as well as contour of the face, suffers.

It requires a keen artistic sense to determine the correct lines of contour to develop in order to restore harmony in each individual type or cast of countenance. Too much or too slight convexity of the substitute will mar the symmetry and pose of the patient's face, through improper support of the lips. The color of the teeth in artificial cases must harmonize with the color of the eyes, hair and general tone of the patient's complexion. The form, size and arrangement of the teeth and their general treatment by grinding to simulate wear appropriate to the age of the patient, must also be determined. No two cases will be exactly the same. Each factor must be studied by itself, and all of the factors considered as a whole in every case that presents.

The prosthetist's highest attainment in the esthetic field consists in imitating nature so closely that his work can not be detected by casual or even close observation, and so well done that his patient does not seriously feel the loss of the natural teeth, or will not be disturbed by the presence of the substitute.

COMFORT

The third desirable object sought in denture construction is a most important one. It is possible to construct substitutes that fulfill requirements from the standpoint of utility and esthetics as well, and yet cannot be worn by the patient with ease or comfort. Imperfect adaptation of denture to tissues, causing undue or uneven pressure at certain points; extension of baseplate on palatal muscles so far as to cause irritation, retching, or by the contraction of the muscles, dislodgment of the substitute; impingement of the periphery of the denture on the labial or buccal muscles or the frena; rough, unpolished surfaces, particularly in the palatine portion of the denture, are some of the sources of discomfort that impair, and at times seriously inhibit the usefulness of otherwise well-constructed dentures.

The ability to recognize such annoying conditions as mentioned, and be able to anticipate and overcome them during constructive processes, is a most important attainment, and should be developed by every prosthetist.

In entering upon the study of dentistry, the student should understand and thoroughly appreciate the fact that the vocation of a dentist embraces a much broader field than is usually accorded it by the public or the uninformed in general. Dentistry is a specialty of the healing art — medicine — and has been so recognized from ancient times.

Herodotus (500 to 425 B. C.), in writing of the practice of medicine in Egypt, says: "The exercise of medicine is regulated and divided amongst the Egyptians in such a manner that special doctors are deputed to the curing of every kind of infirmity; and no doctor would ever lend himself to the treatment of different maladies. Thus Egypt is quite full of doctors; those for the eyes; those for the head; some for the teeth; others for the belly, or for occult maladies." (Guerini.)

In this day the dentist is a scientific specialist who is constantly called upon to treat living, sensitive, vital tissue; to recognize and treat obscure, as well as plainly apparent disorders and diseases having their origin in, and adjacent to, the oral cavity. In addition to such treatment, it is the province of the prosthetist, through highly developed mechanical skill, to replace teeth and parts of teeth that have been lost through accident or by disease.

The knowledge, skill and handcraft necessary to carry out the requirements mentioned come only with close, long-continued and patient application. The artistic and esthetic, as well as the mechanical faculties, should be encouraged and developed in the course of study laid down in the dental curriculum, for the student's success depends upon the thorough, harmonious and balanced development of all of these faculties. He gets out of his course only what he puts into it. The half-hearted acquirement of a few smattering facts is not sufficient in these days of strenuous competition to fit one for the practice of dentistry in general, or any one of its special branches.

Patience, persistence, energy and enthusiasm are essential to success in the acquirement of a dental education, as well as in other departments of science. Equipped with these qualities, no one can place a limit to the heights attainable by a student or practitioner in his chosen work. The field is broad. Many scientific problems are still unsolved. Investigators are few and in demand. Preventive measures are being devised and introduced for the benefit of the patient. The public is being gradually educated in the principles of personal care of, and attention to, the teeth. Dental inspection in public schools is being realized, and the children are being taught that good teeth, good health and good minds go hand in hand, in the order named, for without good teeth the health suffers and the mind and mental processes are disturbed.

CHAPTER II

BODILY FUNCTIONS

The human body is an organism, which exhibits the phenomena of life and in and through which the vital forces act. The history of a living entity, its daily routine of life from inception to final dissolution, is one of perpetual change.

The general epochs in the life of an individual are conception, birth, a varying period of growth, a vaguely determinate period of existence unmarked by radical change, and finally, gradual or sudden diminution and cessation of the vital functions, terminating in death, with ultimate resolution of the organism into primal chemical elements or compounds.

METABOLISM

In the human body during life, constant changes are continually going on. Every mental effort, every movement of the body or any portion of it, the normal or abnormal, voluntary or involuntary, action of the functional organs themselves, call for the expenditure of energy and result in loss of substance. These changes are known as metabolism.

Every normal living organism contains within itself a varying amount of reserve force or stored up energy ready for use on demand. To maintain equilibrium and consequently a normal condition of health, the stock of energy when depleted, and the loss of substance as it occurs, must be replenished.

In the human organism this repair of loss is accomplished by taking into the body substances known as food, capable of being masticated, digested, absorbed, circulated and assimilated. Food is composed, more or less, of extraneous matter. That is, the intrinsic or nutritive elements contained therein, capable of being assimilated, or replacing waste tissue and developing heat, energy, etc., represent in bulk only a portion of the material taken into the body as food.

Bulky, and in fact all varieties of food, when broken up and finely divided, are more readily acted upon by the saliva, the gastric juice and intestinal digestive fluids, and the nutritive elements more quickly appropriated than when taken into the system unprepared by mastication.

IMPAIRMENT OF BODILY FUNCTIONS

The bodily functions are carried on by various organs, each of which performs its part in the maintenance of life. Some of the organs are of minor importance. Their functions may cease or the organs themselves may atrophy or be obliterated by disease or traumatism, and yet the general health of the individual may not be seriously impaired.

The organs of the special senses are examples of this type, as the loss of hearing, the sense of smell, taste or eyesight are of common occurrence, and although the loss of any one of these senses may be keenly felt, yet existence may be prolonged for many years, with a greater or less degree of comfort.

Other organs are of vital importance. Should they from any cause be destroyed or cease to carry out their functions, the result usually involves serious and permanent impairment of health, or even the cessation of life itself. The respiratory, circulatory, masticatory and digestive organs are examples of the type under consideration.

The Mouth

ITS IMPORTANCE IN THE HUMAN ECONOMY

The cavity of the mouth contains those tissues and organs which are of special interest to the oral surgeon and dentist. Through it all food substances and liquids are taken into the body. By the organs contained therein the food is triturated, insalivated, and prepared for deglutition. From it articulate sounds proceed.

In the oral cavity many forms of bacteria find lodgment, and, on account of the heat and moisture present, it furnishes a favorable soil for their propagation and growth. The average mouth usually contains from twenty to fifty varieties of micro-organisms, some harmless, while others are pathogenic in character. The latter, while not always, are frequently present, ready to exhibit destructive energy when favorable conditions develop. For this reason the mouth, under normal conditions, although a neutral focus of infection, is a constant menace to the health of the individual, unless given proper care and attention.

The mouth consists of two parts, viz., the vestibule and the oral cavity proper.

THE LIPS

One of the most prominent features of the face is the external orifice of the mouth. This is a transverse fissure bounded above and below by the upper and lower lips, respectively. At their extremities they unite to form the commissures. Internally they are covered with mucous tissue, and externally with integument. The orbicularis muscle, which largely develops mobility and closes the lips, is situated between the internal and external surfaces. Composed as they are of two thick, fleshy folds, and containing within themselves no bony support, they settle inward and backward when loss of the teeth, and the resultant absorption of the alveolar process, occurs. It is the province of the prosthetist to restore such deformity of the face by means of suitably constructed and contoured substitutes as conditions require.

THE VESTIBULE

The vestibule is that portion of the oral cavity which lies external to the teeth and alveolar arches, and internal to the cheeks and lips. It extends from the space just back of the third molar on one side, through which it communicates with the oral cavity proper, around the labial and buccal surfaces of the teeth and arches, to the corresponding space on the opposite side. Its upper and lower boundaries are terminated by the attachment or blending of the mucous membrane of the cheeks and lips with that covering the upper and lower alveolar arches.

When the jaw and lips are closed, and the teeth are in normal occlusion the mucous membrane of the cheeks and lips rests against the outer surfaces of the teeth and arches, and no appreciable space between these surfaces is noticeable. By inflation from within, or by parting the lips and distending the cheek walls, the cavity of the vestibule becomes apparent.

The upper and lower peripheral circumferences of the vestibule are known as the *superior* and *inferior cul de sacs.*

The salivary secretions from the parotid glands are discharged into the vestibule opposite the second upper molar through the ducts of Stenson.

THE ORAL CAVITY PROPER

The oral cavity is bounded anteriorly and on each side by the lingual surfaces of all the teeth and the alveolar arches;

above by the palatal vault, including both the hard and soft palate; below by the tongue and its mucous membrane reflected against the lingual surfaces of the lower alveolar arch; posteriorly it merges into the pharyngeal space through the isthmus of the fauces. The tongue and palatal muscles acting conjointly form a temporary distal boundary, or wall, to the oral cavity as occasion requires, in the act of mastication, deglutition or phonation.

MUCOUS MEMBRANE

The entire interior of the oral space is lined with mucous membrane, being "composed of a layer of stratified squamous epithelium, supported upon a tunica propria, which is usually described as composed of two parts — the papillary layer and the reticular layer. The epithelium and the tunica propria make up the mucous membrane proper, which is supported upon a submucous layer composed of a coarse network of white and elastic fibres, containing the larger blood vessels"
* * *

EPITHELIUM

"The stratified squamous epithelium is provided with a horny, or cornous layer only in the portions covering the alveolar process and the hard palate, or in other words, where the submucosa is firmly attached to the periosteum. In these positions the horny layer consists of dead cells which have lost their nuclei, and whose cytoplasm has been converted into keratin or horny material." (Noyes' Histology, p. 323.)

The mucous membrane is continuous over cheeks and gum tissue and extends from the lips to, and merges with, that in the naso-pharyngeal space.

THE PALATINE VAULT

The vault of the mouth is formed anteriorly by the hard, and posteriorly by the soft palate. The lingual surfaces of the alveolar arch form the lateral and anterior boundaries of the vault, while the free margin of the soft palate forms the posterior boundary.

THE BONY STRUCTURE OF THE HARD PALATE

The hard palate is formed by the junction of the palatine processes of the superior maxillæ and the horizontal plates of the palate bones. These processes unite in the median line to form a suture or linear ridge called the raphe. Sometimes this ridge is quite prominent and irregular, and renders the fitting of dentures a difficult task.

PALATINE FORAMINA

Just back of the central incisors in the median line is situated the anterior palatine fossa, in which are seen the orifices of four small canals. Two of these, the foramina of Stenson, are located one on either side of the median suture, and transmit the anterior palatine vessels and nerves. Situated just inside the alveolar arch and about opposite the location of the third molars on either side, two, and sometimes three, open-

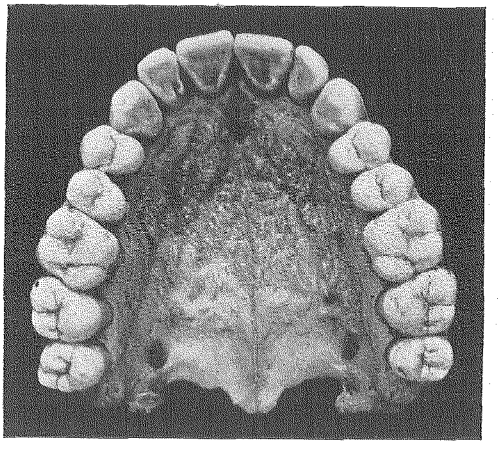


Fig. 1.— The Maxilla, with Full Complement of Teeth Showing Anterior and Posterior Palatine Foraminæ

ings are seen. The larger, or anterior of these canals transmits the posterior palatine vessels and nerves, which pass forward in grooves parallel with the inner alveolar plates. These bony grooves are nearly always plainly marked at their beginning, but usually become indistinct and finally obliterated about opposite the bicuspid teeth. The vessels and nerves coming forward from these canals supply the mucous tissues of the hard palate. Some filaments of the nerves and branches from the arteries pass forward and anastomose with the vessels and nerves transmitted through the anterior palatine canal.

When denuded of the soft tissues covering it, the bony surface of the palate presents a more or less irregular appearance. Frequently sharp, well-defined points of bone, and occasionally nodules of varying sizes, are present, sometimes along the margins of the grooves which transmit the palatine vessels, but more commonly at various places on the alveolar border. The sore spots and areas which so often develop on introducing a denture are often traceable to the presence of such irregular points and nodules, which, under pressure of the base plate, naturally become sources of irritation to the overlying soft tissues. It is advisable in such cases to relieve the pressure of the denture over these areas, as well as opposite the openings of the posterior and anterior palatine canals, especially when the mucous and submucous tissues are thin, hard and unyielding. Excessive continued pressure on the vessels and nerves, transmitted through these canals, will undoubtedly lower the nutrition of the parts supplied, temporarily at least, and cause unnecessary discomfort and pain to the wearer of the denture.

THICKNESS OF THE PALATINE PROCESS OF THE MAXILLÆ

The palatine processes of the superior maxillæ by their upper surfaces form the floor of the nasal fossa. The thickness of the bony partition between the oral and nasal cavities varies in different individuals. In some specimens of young adults the thickness of these plates scarcely exceeds 1-100 of an inch at a point about midway between the raphe and the outer wall of the nasal fossa.

The extreme thinness of the palatine processes in this location converts them into sounding boards, so to speak, and gives a finer, clearer quality to both nasal and oral sounds than would be possible if the bony floor were thick. Base plates, whether of metal or vulcanite, frequently tend to impair tone quality, and therefore care should be taken in denture construction to avoid unnecessary bulk in the vault portion.

Strength is given to the thin, bony vault on the nasal side in its central portion, by the junction of the nasal septum with the palatine processes at the median suture opposite and above the raphe.

THE MUCOUS MEMBRANE OF THE PALATE

The mucous membrane covering the hard palate and alveolar arches is provided with a horny or cornuous layer, as before stated. This layer is less sensitive than the ordinary mucous membrane, as well as firmer, denser and more fibrous. These characteristics render it less liable to injury during the mastication of hard varieties of food, and less irritable to friction or stress than are membranes devoid of the cornuous layer.

THE RUGÆ

Situated just back of the central incisors and slightly in front of the position of the anterior palatine canal, is a small pear-shaped eminence called the *papilla of the palate.* Ex-

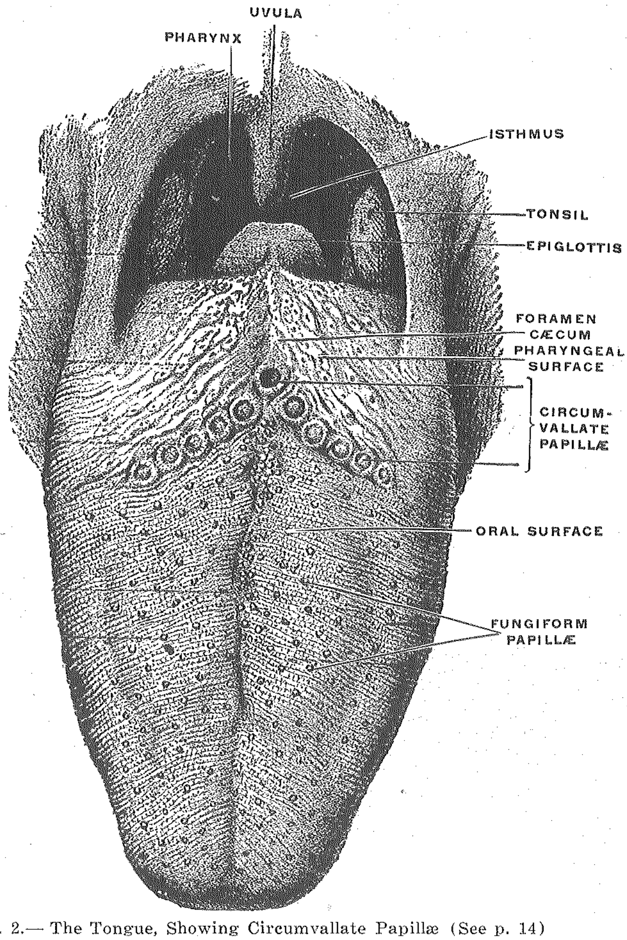


Fig. 2.— The Tongue, Showing Circumvallate Papillæ (See p. 14)

tending posteriorly from this, and following the raphe, is also a ridge of mucous tissue.

A number of smaller irregular ridges pass out laterally, usually running obliquely, but not necessarily paralleling each other, sometimes extending back as far as the second bicuspid. These are called *plicæ palatinæ,* or folds of the palate. The papilla, with its distal extension, together with the laterals which are arranged on either side, are known as the *rugæ,* from *ruga* — a fold or wrinkle. Oftentimes when well defined, the central ridge and laterals present the appearance of a symmetrical tree trunk with spreading branches.

THE TONGUE

The tongue is the organ of the special sense of taste; it is one of the principal organs of speech, and is an indispensable factor in mastication and deglutition. When at rest it occupies the space between the internal walls of the body of the mandible, the lingual surface of the lower alveolar arch and practically all of the teeth (see cut, page 13).

THE SENSE OF TASTE

The special sense of taste is located principally in the circumvallate papillæ which are situated on the dorsum of the tongue. They are in two rows, arranged in V form, the apex

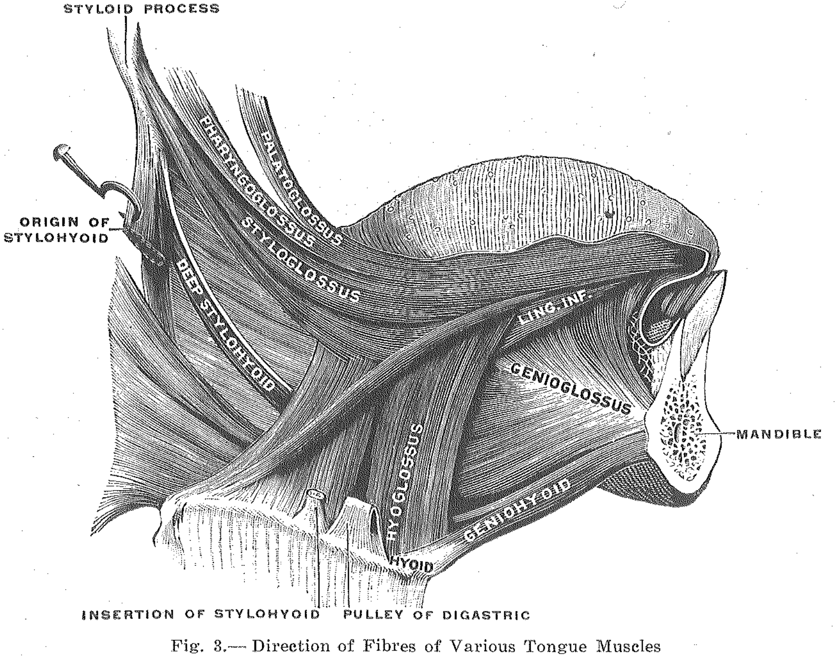


Fig. 3.— Direction of Fibres of Various Tongue Muscles

being on the median line and pointing distally, the rows running forward and outward. They are of large size and vary in number from eight to ten, or even more. In addition to these, there are numerous other papillæ, called filiform papillæ, distributed over the sides and dorsum of the tongue, which give it a roughened, or furred, appearance. Still another variety, called fungiform, are found interspersed with the filiform papillæ, but are less numerous than the latter.

THE SALIVARY GLANDS

The parotid, submaxillary and sublingual glands, to a limited extent, empty the salivary secretions in the mouth at

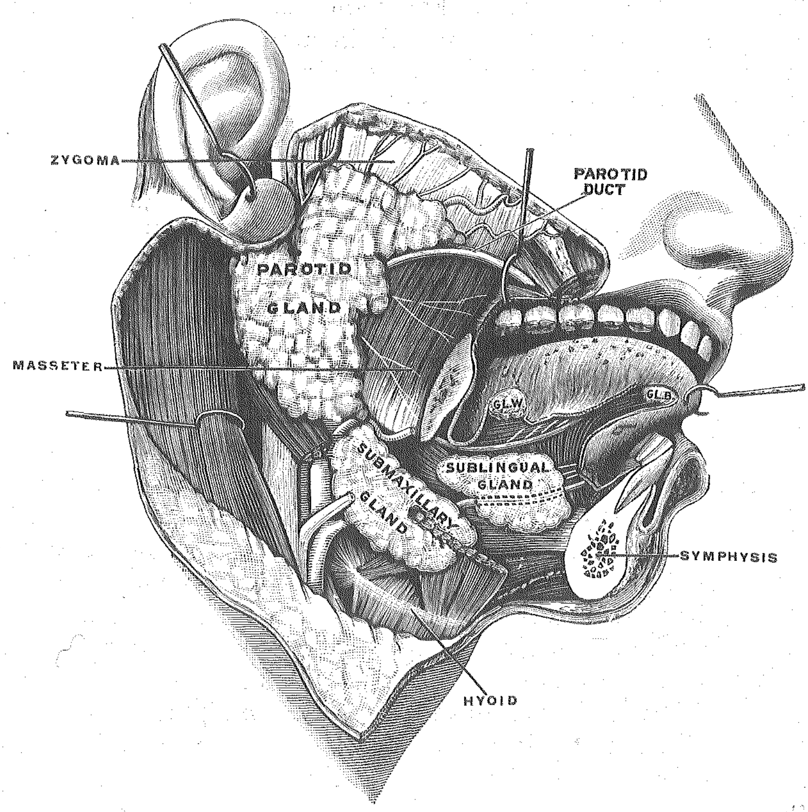


Fig. 4.— The Salivary Glands

all times, but more or less profusely during the mastication of food. The saliva is the first digestive fluid to act on the food, partially converting the starches into sugars, and in conjunction with the mucous secretions, lubricates the bolus of food and prepares it for deglutition.

CHAPTER III

EXAMINATION OF THE MOUTH

GENERAL REMARKS

To render the most skillful service to a patient it is necessary for the dentist to know the exact conditions of the tissues and organs of the mouth in detail. Such knowledge can only be acquired by a close examination of the parts. Intelligent questioning of the patient will assist, to a certain extent, but the burden of the diagnosis rests upon the operator.

He must be a histologist and pathologist as well, to recognize conditions of health and disease. No detail, that has a direct or even a remote bearing on the dental aspect of the case in hand, should escape his notice. The general method of procedure for an examination, as here outlined, may be followed with good results.

POSITION OF PATIENT

Seat the patient and adjust the chair, first, so that he may feel comfortable; second, so as to bring the mouth within convenient range for examination. Adjust a towel over the patient's clothing, attaching it around the neck. A mouth mirror, probe, explorer, tongue depressor, pliers, cotton, water syringe, and a small electric mouth lamp, are the instruments most useful for examination, and should be placed conveniently at hand, although not necessarily in sight.

Everything being in readiness, the operator should cleanse his hands in the presence of the patient, or so the latter may know it is being done. This is necessary for two reasons — first, to prevent possible danger of carrying infection to the patient's mouth, and second, to engender within the mind of the latter a feeling of confidence in the operator's knowledge and ability to cope with disease. The free application of tepid water, or normal salt solution, with the syringe to the teeth and oral tissues is nearly always advisable before beginning an examination.

The lips guard the entrance to the alimentary tract, and as they are first encountered, the examination should begin with them. Note whether they are of good color and normal in appearance, or if lesions are present such as fissures, cold sores, etc. If so, avoid giving any unnecessary pain by distension, or pressure on the parts. If in a healthy condition, the index finger should be passed around between the alveolar process and cheeks, a general idea being thus gained of the distendability of the lips and cheek walls. The first glance in the mouth, in most cases, discloses to the examiner something of the charactèr of the patient and the class of operations required.

EXAMINATION OF MOUTH WHEN NATURAL TEETH ARE PRESENT

Note specifically the general appearance of the mouth as to health and cleanliness. If any natural teeth are present, look for calculus, pyorrhea pockets, alveolar and gingival abscesses, dead pulps, peridental inflammation and gingivitis.

Note any and all peculiarities of the mucous membrane, redness, discoloration and swelling usually being signs of some irritated or diseased condition. Stomatitis, leugoplakia, mucous patches, cancrum oris, etc., are liable to be present, and if so should be recognized immediately. If any condition found is infectious in character, the operator should take due precautions for his own safety during the examination, and thoroughly sterilize all instruments as soon as the patient is out of the chair. If teeth are carious, observe the extent to which the disease has progressed, the teeth affected, and the probable method of treatment. Note also the relation of the teeth in the same arch to each other, and to those in the opposite arch, as well. Observe the forms of the teeth themselves, whether constricted at the neck; elongated or normal; whether tissues have receded, leaving them standing more or less unsupported; whether they diverge or converge to an unusual degree; whether loss of proximate contact has occurred; the form of the spaces where the teeth and spaces alternate. By noticing the extent of abrasion on the occlusal surfaces of the teeth, some idea can be formed of the stress exerted in masticatory effort.

If the patient is past middle age and no signs of occlusal abrasion appear, as it normally should at such an age, try to discover the cause, whether due to mal-occlusion or to a diseased condition of the peridental membrane of one or more of the natural teeth. Tenderness of the peridental membrane, and slight elongation of a single tooth, will often —

sometimes for years — inhibit or seriously impair proper masticatory effort.

EXAMINING EDENTULOUS MOUTHS

In edentulous cases, note particularly the form of the alveolar processes, or as Dr. G. V. Black has appropriately termed them the *residual ridges,* the amount of absorption that has occurred, the extent and position of muscular attachments to the labial, buccal and lingual surfaces. In the upper jaw, determine the location and extent of the hard and soft areas, and the thickness of the mucous and sub-mucous tissues in the vault portion. Notice particularly the form of the raphe (the bony ridge formed by the union of the palatine processes of the upper maxillae) and compare the thickness of the mucous membrane which covers it with that covering the crest of the borders. Determine whether there are any sensitive or tender areas on which the prospective denture will rest. These areas usually will be found on either side of the vault just internal to, and a little in front of the tuberosities, and in the median line, just back of the central incisors, where the four canals are situated which transmit the posterior and anterior palatine vessels and nerves.

When the mucous and submucous tissues are sparse and thin on these areas, the pressure of the denture is at times very disagreeable, sometimes producing pain. It can be obviated by properly relieving the impression. Examine particularly the buccal aspect of the tuberosities as well as other locations, to determine whether undercuts are present. If so, what effect, if any, they will have on the removal of the impression. When the vault is deep, rising abruptly back of the incisor region, there will frequently be an undercut area in the anterior portion of the mouth, the distance from the labial to the palatine alveolar plates through the region of the incisive fossa being less than through the border portion near the crest.

In examining the arch and tissues of the lower jaw, observe the amount of absorption and the position and extent of muscular attachment to the outer and inner sides of the alveolar arch, whether the tongue and cheek muscles, and the tissues above the submaxillary glands are liable to interfere in impression taking; how far distally and downward the lingual wings of a full denture case can extend without impeding tongue movements. Notice the relative size of the arches, and the probable ease or difficulty of introducing the impression tray through the oral opening.

A pad of charts having diagrams of the upper and lower arches should be on the bracket, and any points of interest should be marked thereon as soon as found. While the chart can, or may not, be used after the examination is completed, the marking of the important points will fix them firmly in the mind. Every peculiarity of the teeth or tissues that may have a direct or even a remote bearing on prosthetic procedures, should be recognized and kept in mind in order that the most efficient service may be rendered.

PREPARATION OF THE MOUTH FOR DENTURES

All operative procedures, as a rule, such as the placing of fillings and inlays, removal of calcareous deposits, and treatment of the soft tissues, should be completed before taking impressions. Useless teeth and roots should be extracted, and in some cases the tissues should be allowed to heal before introducing a denture. Further surgical procedures are at times very necessary, such as freeing muscle fibers and tissues of the cheek wall that may at some previous time have been lacerated, and in healing, have been drawn over and become attached to the tissues on the process, in such manner as to interfere with the correct seating of the denture. The late Dr. Burchard's suggestion is a good one, of taking an impression of the mouth, including the cicatrized tissue, and from this securing a cast. This is then trimmed to represent the normal form of the ridge, that portion representing the cicatrized soft tissues being dissected away on the cast, and leaving the trimmed portion rather more prominent than the natural hard tissues. A denture of vulcanite is constructed, the margins rounded and polished smoothly, which when in position holds the severed tissues apart until healed, and thus the normal alveolar surfaces are regained.

SPONGY BORDERS

Often, when the teeth have been lost from phagedenic troubles, the bony process is practically all absorbed, or destroyed. The border in such cases, although presenting a fairly good form, is soft and flabby, consisting of thickened, sometimes fibrous, mucous membrane, devoid of bony support. Such a ridge affords an unsatisfactory foundation for a denture, without some preliminary treatment of the mouth itself, or of the cast to be used in construction.

REDUCING SPONGY BORDERS

Three methods are in vogue for minimizing this very annoying condition:

First. A method whereby the treatment of the cast used in denture construction will, in certain cases, correct the difficulty mentioned. This will be described later in proper order.

Second. A very satisfactory method suggested by Dr. C. P. Pruyn of absorbing excess tissues — construct a temporary baseplate for the case, or if the patient is wearing an old, even though ill-fitting, denture, it will serve the purpose. Line the interior with oxychloride or oxyphosphate of zinc, mixed to medium consistency. Place it labially and lingually of the border position, thus leaving sort of a groove for the crest of the ridge to enter. Under pressure the cement is compressed between the baseplate and the unyielding tissues, and is forced from both sides against the flabby ridge, reducing its bulk without materially distorting or changing its position or depth. Two or three weeks' constant wear, of this *cement corrected* denture, will improve the density of the border very noticeably. If further absorption is deemed advisable, the denture is thoroughly cleansed, an additional layer of cement is spread over that already adapted, and the ridge subjected to pressure as before. When the density of the border is satisfactory, a permanent denture is constructed.

Third. The most severe method of treatment consists in surgically removing such portion of the spongy border as may be deemed necessary, and stitching the margins of the membrane together to accelerate the healing process.

When, in preparing a mouth, extractions are performed, care should be taken to see that the sharp or prominent pieces of alveolar process that frequently project from the border, are removed. This can easily be done with a cutting forcep or bur while the trauma is fresh, The border, if left smooth and rounded, and free from sharp projections, will afford a better foundation for a denture, and the soft tissues will heal more rapidly than when this smoothing up process is neglected.

When sharp, bony points are present as the result of previous operations, it is advisable, in most cases, to dissect away the gum and periosteum, remove the prominences, and if the wound gaps open, stitch the gum tissues together. If, for any reason, it is not advisable to remove the points by cutting, then those areas in the impression impressed by the points should be scraped to obviate pressure and consequent irritation, when the denture is introduced.

TEMPORARY DENTURES

When, by recent extraction, the mouth has been cleared of all remaining teeth, the problem confronting the patient and prosthetist is — *How soon shall dentures be fitted to the edentulous borders?* Without question, in most cases, the patient will be best served by constructing dentures immediately, that is to say, within a few days after the loss of the teeth. It is a noticeable fact that patients who have never worn dentures become accustomed to the presence of substitutes with less effort, when introduced soon after the loss of the natural teeth than do patients for whom the introduction of dentures has been deferred for a varying period of from six months to a year. Just why this is so, is not clear. Perhaps the inconvenience felt from the introduction of the temporary dentures is so slight as to be nearly lost sight of, while the cataclysmic effect, both physical and mental, resulting from the loss of the natural teeth and the consequent inability to masticate food, is engrossing the attention of the patient.

Another factor of importance is the marked aversion most persons have of presenting themselves, toothless, in public, or to their friends. Almost without exception they will submit to much inconvenience, and pain as well, rather than suffer the humiliation occasioned by the absence of the teeth. This is the psychological moment and should not be neglected by the operator. The ability to tolerate the presence of temporary dentures in the mouth is positive assurance that the permanent substitutes will prove both useful and comfortable. Another point in favor of temporary substitutes is that the alveolar processes absorb more uniformly, as to density of tissue, and the ridges will maintain their form for a longer period with less change, than where the introduction of the dentures is deferred.

PERMANENT DENTURES

Usually the temporary should be replaced with permanent dentures in from six to twelve months. The inequalities of the borders will usually in this period have become smooth and rounded, the alveoli filled in, and the soreness will have disappeared from the soft tissues. Since as a result of the absorption that has occurred the adaptation of the denture to the tissues is imperfect, deferring the construction of the permanent sets beyond the time mentioned usually results in unnecessary and deleterious absorption of the alveolar process. Stress, therefore, should be laid upon this fact, and the patient advised accordingly.

In the examination of any mouth with a view of carrying out prosthetic procedures, certain things should be kept in mind by the operator.

First, he should carefully consider what class of substitute will give the patient the best service, as indicated by the conditions in the mouth.

Second, when the class of work indicated is not to be considered on account of expense, what other method can be followed to the best advantage.

Third, the operator and not the patient should determine what class of work is indicated, and how it should be done. This he can do if by his ability and sincerity he can inspire within the mind of his patient, confidence in his knowledge, judgment, and honesty of purpose, all of which are essential in order to bring together and hold a desirable clientele.

CHAPTER IV

ARTIFICIAL DENTURES

Physical and Mechanical Problems Involved in Their Construction

THE THREE ESSENTIAL REQUIREMENTS

The production of artificial dentures, either full or partial, is accomplished by the carrying out of a series of technical details that follow each other in sequence.

The *degree* of *success* attained in denture construction is directly dependent on the skill with which the details are wrought out. The test of success lies first, in the patient's ability to use the dentures successfully in masticatory effort; second, in the greater or less complete fulfillment of esthetic requirements; and third in the ability of the wearer to use them without inconvenience, or to briefly summarize —*usefulness — good looks — comfort.*

FULL DENTURES

Perhaps the most difficult problem confronting the prosthetist is that of retention or securing stability of the finished dentures when introduced and subjected to use. In full cases, the natural teeth having been lost, no mechanical aids to retention can be resorted to, such as are used in partial substitutes. In extreme instances spiral springs can be applied but they are objectionable, on account of the constant pressure exerted to force the mandible and maxilla apart, also on account of unhygienic conditions caused by their presence. Retention of *full* dentures is largely a question of physics and not of mechanics, although good mechanical judgment and skill must be exercised in developing the physical aids to retention.

Full upper and lower dentures are retained in position on the alveolar borders by *adhesion* and *atmospheric pressure.* In lower cases *gravity* also assists. Partial dentures are usually retained with some form of clasps, or mechanical devices, which attach to some of the remaining natural teeth or roots. In favorable cases both means first mentioned, viz., adhesion and atmospheric pressure, are utilized. The same general conditions which are requisite for developing good atmospheric pressure, are also essential for developing good adhesive qualities.

ADHESION

(a) Adhesion is defined as "the molecular attraction exerted between the *surfaces* of bodies in contact."

(b) This peculiar property is attributed to some reciprocal action between the contact surfaces. The particles must be brought within the limit or distance of molecular attraction.

(c) *"The attraction increases as the contact is prolonged and is greater in proportion as the contact is closer."*

Adhesion takes place between dissimilar substances. It is more powerful between a solid and a liquid than between solids, or between the molecules of a liquid itself.

If a thin layer of oil is interposed between two perfect planes of metal, they will adhere firmly, but when pulled asunder each plate is moistened by the oil, showing that in separating the plates, the cohesion of the liquid is overcome, but not the adhesion of the oil to the metal. (Ganot's Physics.)

That adhesion plays a part in the retention of dentures is beyond question, but the conditions surrounding a denture when in position and in use in the mouth, tend to reduce the effectiveness of adhesion, viz., the slight yet unavoidable movement which occurs when the denture is subjected to stress, due to the natural resiliency of the tissues. This movement is opposed to *prolonged* as well as close contact. (See paragraph c.)

ATMOSPHERIC PRESSURE

The *atmosphere* is the aeriform fluid which envelopes the earth and extends outward from its surface a distance of almost 50 miles. It is composed mostly of free oxygen (21) and nitrogen (79), with about 4 parts of carbonic acid to 10,000. Ammonia, sulphuretted hydrogen and other gases are also present in varying quantities in different places, due to local causes.

The air has weight. One hundred cubic inches of dry air, under ordinary atmospheric pressure of 30 inches, and at a temperature of 62 F., weigh 31 grains. Twelve cubic feet of air under the same conditions, weigh 1 pound. The air in a room 16x16x10 feet weighs 210 pounds.

Since the air has weight, and the earth's surface is at the bottom of the aerial sea, the outer layers of the atmosphere are constantly pressing down upon the deeper layers with a very considerable force, the earth's surface being the site of greatest pressure.

This pressure is not noticeable under ordinary conditions, as the air presses equally in all directions, and upon all objects. If, however, it is excluded from between two surfaces, the pressure is immediately apparent. In case of perfect exclusion of the air, the pressure at sea level amounts to 14.7 pounds per square inch. When two perfectly ground plane plates of glass or metal are placed together, and the air between the contact surfaces is excluded, it will require a force equal to the area of the plates in square inches multiplied by 14.7, to separate them. If the plates are 4 inches square, the formula would be stated thus: $4 \times 4 \times 14.7 = 235.2$.

To summarize, it would require a pull of 235.2 pounds to overcome atmospheric pressure and separate the plates, without considering the *adhesive* force which is also present, and which would have to be overcome before separation could take place.

RETENTION BY MEANS OF ATMOSPHERIC PRESSURE

In applying the principle of atmospheric pressure to the retention of an artificial denture, it is necessary to develop certain conditions between the denture and the tissues on which it rests, similar to those present in the plane plates mentioned, viz., close or uniform adaptation of the contact surfaces particularly *peripheral contact.*

The denture is seated upon the mucous membrane of the mouth, which in turn is supported by and rests on a bony structure or foundation. The thickness of the mucous tissue varies in different mouths, and often varies greatly in different areas of the same mouth.

For example, as often happens, the central vault portion of the mouth is covered with a thin, unyielding, and the maxillary area with a thick and yielding, layer of mucous tissue. Unless precautionary measures are taken to prevent, a denture fitted to such a mouth will be readily dislodged under stress, the hard central area acting as a fulcrum on which the base plate will tip, the side on which stress is exerted being forced upward, the opposite side being carried downward correspondingly, just as the arms of a lever rotate about the fulcrum. This movement disturbs the equilibrium of the denture, breaks the contact surfaces, and the air, if at first excluded, rushes in between the denture and tissues.

The same condition would prevail were the margins of the plane plates previously alluded to soft and yielding and the central area hard and unyielding. Pressure produced on the margins of the plates on one side, to force them together, brings the hard central area into action as a fulcrum, separates the opposite sides and destroys atmospheric pressure. By proper precautionary measures the difficulty mentioned in denture construction may, to a great extent, be obviated.

NECESSARY CONDITIONS FOR RETENTION

First, there must be uniform contact, or bearing, of the denture against the tissues on which it rests.

Second, the peripheral margins of the denture at all points should be so formed that the tissues when at rest, or under muscular tension, will remain in close contact with these margins, thus preventing the ingress of air between the denture and tissues.

With the first requirement realized, it is comparatively easy to develop the second one. In both cases the necessary conditions are developed, principally during the taking of the impression, the details of which will be given in the chapter on this subject.

Briefly stated, the principle involved in carrying out the first requirement, viz., uniform bearing on hard and soft areas, consists in exerting pressure on the soft areas by means of suitable impression material, of proper plasticity, to compress them so that the finished denture will bear firmly on the soft, and lightly and in some cases not at all on the hard areas. This condition can be still further carried out and accentuated by scraping the impression in certain areas, the details of which will shortly be given.

The second requirement, viz., close peripheral adaptation, is accomplished first by careful manipulation of the impression materials against the peripheral areas, and second, by having the patient exercise the muscles actively while the impression material is still soft and plastic, and thus mark their form, direction and limit of attachment to the alveolar process.

The object sought in carrying out this step is to secure a peripheral outline to the denture that will not impinge on, or cause irritation of, the muscular or soft tissues, and yet will have such close adaptation as to seal against the ingress of air — to afford "relief without leak," as Dr. J. W. Greene expresses it.

RELIEF FROM PRESSURE BY SCRAPING THE IMPRESSION

When the impression is secured, those parts impressed by the exceedingly hard and unyielding areas of the mouth should be scraped slightly to insure relief from bearing of the finished denture on these areas. It is especially necessary to afford such relief in the central palatine portion of the mouth when the raphe is distinctly marked and prominent and is covered with only a thin layer of tissues.

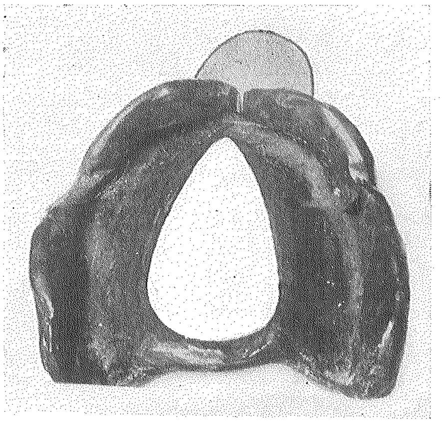


Fig. 5.— An Impression Showing Medium Amount of Relief

In relieving this area the scraping should extend *slightly* beyond the margins of the hard outline in every direction. Usually the relief should not exceed 1/25 of an inch in depth in the deepest part, and should gradually taper out to a thin, invisible periphery, losing itself in the general contour of the vault impression.

The idea in thus treating the impression is not to produce a vacuum chamber in the denture, but to afford relief from pressure on the raphe and adjacent tissue, and thus prevent the hard areas from serving as a fulcrum to tip the denture when stress is applied.

A little experience will enable one to readily determine the outline and extent of the hard areas by merely scanning the impression. It is a good plan, however, to make a digital examination of the mouth, either immediately before or after the impression is taken, to be absolutely certain of the extent of relief necessary to provide for.

VACUUM CHAMBERS

Vacuum chambers, often incorrectly called *air chambers*, are shallow, depressed areas with a definite outline, usually formed in the central palatine surfaces of dentures during the constructive steps, and which are supposed to assist in retention. As ordinarily constructed, they are not intended to, nor do they seldom afford, relief from pressure. The efficiency of a vacuum chamber is dependent upon its area, depth,

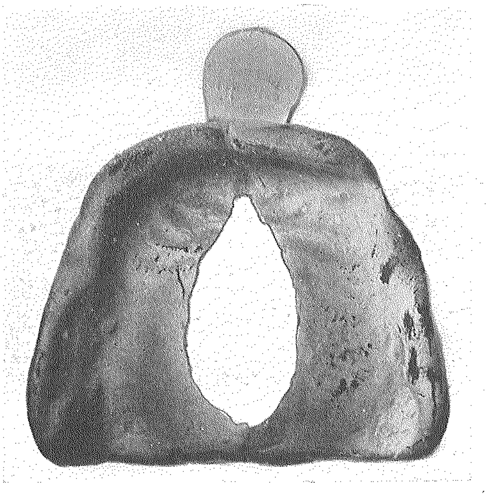


Fig. 6.— An Impression Showing Slight Amount of Palatine Relief

adaptation of its peripheral margins to the opposing tissues, and the ability of the patient to exhaust the air from the interior.

Under the most favorable conditions, the usefulness of the vacuum chamber is questionable. The tissues are soon drawn into, and usually after a time permanently fill, the cavity, thereby defeating the object for which it was designed. When the chamber is very deep, the tissues, while they may not fill it entirely, are kept in an irritated condition, more or less annoying and frequently painful to the patient. On the other hand, when the chamber is shallow and the tissues are not drawn into it, it is not, as its name would indicate — a *vacuum chamber* — but merely a useless and unsightly depression which increases the thickness of the denture in a region where bulk is objectionable on account of its tendency to modify the resonance of the voice.

For more than fifteen years past the use of this very questionable method of retention has been discontinued by the writer, both in clinical work and in private practice. The results during this time furnish convincing proof of the greater advantages over vacuum chamber for retention purposes of well defined uniform bearing developed in taking the impression and by scraping the cast to secure peripheral adaptation of the denture.

COMPENSATING FOR EXPANSION OF THE CAST — FULL UPPER DENTURES

Since all plasters expand in setting, to a greater or less extent, some means of compensating for the enlargement of the cast should be adopted.

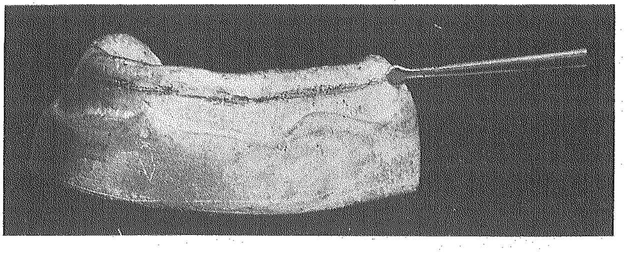


Fig. 7.— Scraping the Periphery of a Cast

The plan followed, and which has proven very satisfactory, is to scrape a slight groove, extending from one tuberosity to the other, on the buccal and labial surfaces of the cast. This groove should be made with a discoid 20 or small Kingsley scraper, to avoid the formation of any angles, and be very shallow,— so slight as to scarcely be noticeable except on close inspection. It should occupy a position about midway between the crest of the border and the peripheral line of termination of the denture, and as before stated extend from one tuberosity to the other on the labial and buccal surfaces. This groove on the cast produces a slight, rounded bead on the inner aspect of the labial and buccal surfaces of the denture, reducing the diameter of the latter by an amount equal to the elevation of the bead, thus insuring close peripheral adaptation, and overcoming any slight enlargement of the cast due to expansion.

POSITION AND OUTLINE FORM OF THE DISTAL MARGIN OF UPPER DENTURES

The distal terminal margin of an upper denture should follow the line of junction of the soft with the hard palate, or be laid on the soft *immovable* area, being careful to avoid encroaching on the soft *movable* tissues or palate muscles. The latter become an active cause of displacement when the denture overrides them to any appreciable extent.

Usually the distal margin of the denture should assume a double compound curve, extending either way from the median line, to correspond in general with the distal margin of the hard palate.

In those cases where the tissue between the hard central area and the tuberosities is soft, the terminal line on either side of the center may be carried forward somewhat, without

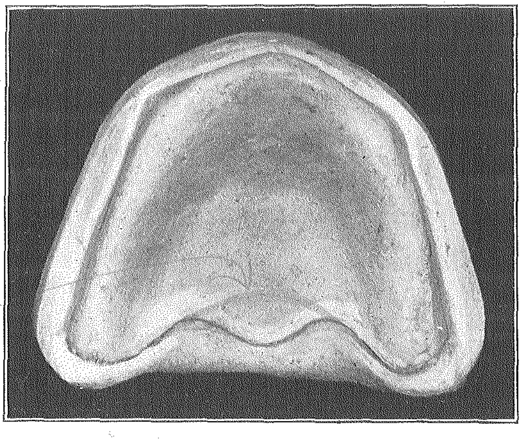


Fig. 8.—Distal Form of Upper Baseplate

impairing the adaptation. Such trimming will also relieve pressure to a certain extent on the posterior palatine vessels and nerves which find their exit from the canals situated just inside of the tuberosities. Pressure of the denture directly on the overlaying tissues and indirectly on the nerves in this region is a frequent cause of nausea.

The distal terminal line when properly laid will form a pleasing symmetrical curve which will harmonize well with the buccal and labial outlines of the denture. See Fig. 8.

PREPARATION OF LOWER IMPRESSIONS

In full lower cases it frequently happens that the alveolar border is thin and the crest of the process is very hard.

In such cases the *impression* should be trimmed or scraped in the deepest part with a discoid instrument similar to the one used in the peripheral scraping of the upper cast. The scraping of the impression of the crest should not be carried

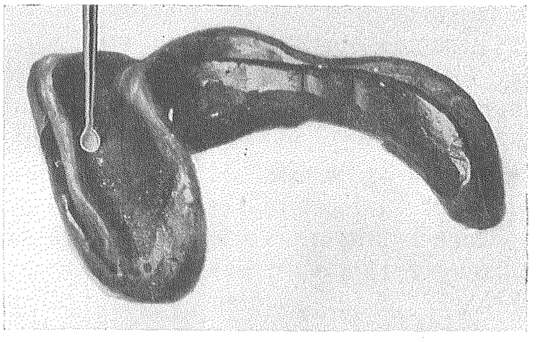


Fig. 9.—Scraping the Deeper Portion of Lower Impression to Relieve Stress on Border Crest

too close to the distal terminals, for when extended entirely back, a vent is formed, through which the air finds its way, affecting adversely the stability of the denture.

The effect of scraping an impression as described, is to

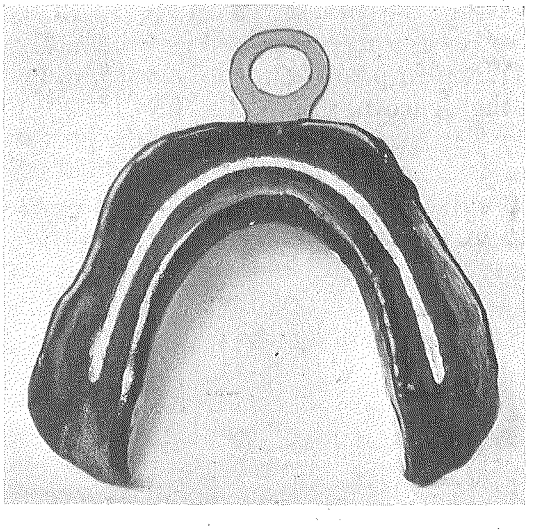


Fig. 10.—Linear Distance Usually Relieved on Lower Impression

increase the height of the crest of the border on the cast so that a denture when moulded on the cast will not rest on the extreme crest, while the labial, buccal and lingual flanges will be brought in closer contact with their respective surfaces, the air forced out and atmospheric pressure utilized for retention purposes. In many cases, a considerable amount of adhesion that could not otherwise be realized, will be developed in this manner.

SOFT ALVEOLAR BORDERS

When the alveolar border in either upper or lower cases is of average form, but devoid of bony support due to excessive absorption of the process, it is frequently advantageous to pare the labial or buccal and lingual surfaces of the cast, slightly, being careful not to reduce the height of the crest, so that these surfaces of the border will be compressed when the denture is introduced. In many cases in practice the carrying out of this plan has added greatly to the stability of dentures, the effect in most instances being to condense and render the tissues permanently harder without any ill effects. A method of correcting extreme cases of soft and yielding borders — spongy or flabby gums, as they are sometimes called — is detailed on pages 19-20.

Partial dentures are usually retained in position by means of clasps, or some of the forms of frictional appliances in common use. In the case of a clasp, the pressure of the appliance, which is slightly smaller than the tooth it embraces, is due to the resiliency or springiness in the metal of which it is composed. When in position in the mouth, the clasp which is attached to the denture, grasps the tooth more or less firmly and prevents displacement. So also with the various specialized appliances, except that usually they are made in two parts, one of which is permanently attached to a natural tooth, or crown set on a root, the other to the denture. They are so adjusted that when in position the friction between the two parts holds the substitute in place. The various appliances used for this purpose will be described later.

CHAPTER V

DEFINITIONS OF SOME COMMONLY USED TERMS

Impression Trays

DEFINITIONS

An *impression* is a *negative* copy or counterpart of some object impressed. In prosthetic procedures, to which the following definitions will refer, an impression is obtained by pressing a plastic material, such as plaster or modeling compound, against some portion of the oral tissues or teeth.

A *cast* is a *positive* copy or likeness of the object impressed and is obtained by casting plaster, or some similar plastic material, into the impression or mold. Casts are used for giving the negative form of the mouth to plastic base dentures.

A *model* is a positive or duplicate copy of the mouth or some portion of it, and is used for producing a similar *positive* of itself, and consequently of the mouth, in metal. A model is produced in the same general manner as a cast, but differs from it in its use, and slightly in its form, being so shaped as to be readily withdrawn from the sand in which it is imbedded, in the sequent steps of die construction.

A *die* is a metal duplicate of the mouth or some portion of it, also of the model from which it is derived. In constructing dentures with swaged metal bases, a die fulfills a similar purpose to that of a cast in the production of plastic base dentures, viz., giving the reverse form of the mouth to the metal base denture. A die is formed by pouring molten metal or alloy into a sand matrix derived from the model, or, in some cases, by pouring directly into the impression.

A *counterdie* is a negative or reverse of the die, and is obtained by pouring a similar or a lower fusing metal or alloy directly against the face of the die.

USE OF THE TERMS "CAST" AND "MODEL"

The term *model* has been and is still very generally used instead of *cast* to designate the product obtained by filling the impression with plaster or plaster compound. All such products so obtained are in reality casts. The term *cast,* is gradually coming into use to designate the product of the impression when it is used to give the reverse form of the mouth to a plastic base, and the term *model,* when it is used as a means to reproduce a die which is a duplicate of itself.

The following definitions of the two terms are given in the Standard Dictionary:

"Cast.—An object founded or run in, or as in a mold, as of metal, plaster, wax, etc."

"A reverse copy of plaster of Paris, or similar material, of a mold, usually distinguished from a casting which is of iron or other metal or alloy."

"Model.—An object usually in miniature, representing something to be made or already existing; a material pattern of natural size; more rarely a plan or drawing as a model of an invention; a model of a building; to draw a model."

"Specifically: In sculpture the plaster or clay original of a work to be executed in stone or metal. A person who does duty as a copy or pattern for sculptors and painters."

"A pattern is always, in modern use, that which is to be copied; a model may be either the thing to be copied or the copy that has been made from it, as the models in the Patent Office. A pattern is commonly superficial; a model is usually in relief. A pattern must be closely followed in its minutest particulars by a faithful copyist. A model may allow a great degree of freedom; a sculptor may idealize his living model; his workmen must exactly copy, in marble or metal, the model he has made in clay."

Before the introduction of vulcanite, the plaster cast derived from an impression was used almost exclusively for the making of metal dies on which to swage gold, silver and platinum bases. For this purpose it is a true *model,* since it serves as a copy from which something like it (the die) is produced.

On the introduction of vulcanite, which came into use rather gradually, the same general form of cast as was used in die construction, served as a shape over which to mold the vulcanite. The similarity in method of production and form of a cast accounts for the retention of the term *model,* even though it does not fulfill the purpose of a model.

IMPRESSION TRAYS

An impression tray is an appliance used for conveying impression material to, and holding it in position against, the tissues of the mouth or teeth while hardening. It is also of material assistance in removing the impression from the mouth, and in holding the parts of the impression, when fractured and removed, in correct relation to each other while securing the cast.

A large assortment of trays, in varying sizes and forms, and constructed of metal, rubber, celluloid, porcelain and papier-mache, are procurable at the supply houses. The trays most commonly used are made of Britannia metal, brass, German silver or aluminum, all of which may be bent without much effort. This latter feature is an important one, since the stock tray will require more or less modification in each case, to meet some peculiar unbalanced or abnormal condition of the alveolar ridge or oral tissue.

The other classes of trays, being rigid, are incapable of much change, and are therefore limited in their application. In difficult cases, special trays are frequently constructed of block tin by casting, or from sheet metal by swaging, the details of which will be given on pages 38, 39, 40.

TRAY NOMENCLATURE

The various surfaces of the oral cavity are definitely named, and those areas of the impression tray that come in close proximity to these oral surfaces are named accordingly. For instance, the outer surfaces (right and left) of the upper and lower alveolar arches, from the distal of the cuspids backward, are termed the *buccal surfaces* because of the close proximity of the buccal muscles to these surfaces. From cuspid to cuspid, anteriorly, the outer surfaces of the arches are called the *labial surfaces* because the labial muscles are in close proximity. Those areas on the inner side of the border that are touched by, and are in close proximity to, the tongue are termed *lingual surfaces*.

In order to describe clearly the adjustment of the tray and the taking of impressions, the tray nomenclature as given by Dr. G. H. Wilson in "Dental Prosthetics" will be made use of.

"A tray has a *body* and a *handle*. The body consists of a *floor* and *flanges*. Upper trays have a *vault portion*. There are two types of floors, *oval* for edentulous jaws and *flat* for accommodating the remaining teeth. The flanges are called *outer* and *inner*. The outer flange has two portions, the anterior, or labial, and the posterior, or buccal. The dividing line is the proximity of the distal surface of the cuspid tooth.

The inner flange is called the lingual flange. The surfaces of the tray are named for the surfaces they approximate, as maxillary, labial, buccal and lingual."

"The vault portion spans the space described by the curve of the lingual flange of the upper tray. The handle is an extension from the union of the floor and the anterior flange."

A tray when fitted should conform closely in general outline and contour to the mouth. Since it *receives* or partially *encloses* the oral tissues, it should be slightly larger to accommodate the impression material, a uniform space of about one-eighth of an inch or less between the tray and tissues being sufficient for this purpose.

Conforming the tray to meet the conditions mentioned, viz., close adaptation and uniform space for impression material, is accomplished by bending, cutting, or making addition to the tray at points where deficient. Occasionally all three methods are resorted to in adjusting a tray to a given case.

CONFORMING THE TRAY BY BENDING

Trays are narrowed or widened by bending the flanges inward or outward, or by compressing or expanding the body of the tray across its buccal diameter. Compression of the body of upper trays increases and expanding reduces the height of the vault portion.

In lower trays, decreasing the buccal diameter by bending the body of the tray usually narrows the space between the labial and lingual flanges anteriorly. To correct this fault the lingual flange can be slit in the median line and the adjacent portions bent and allowed to overlap so as to gain the necessary space. The flanges are bent inward or outward, as the position and form of the border indicates, always keeping in mind two points — the maintenance of the proper space for the reception of impression material, and freedom from muscle impingement by the flanges.

CONFORMING BY CUTTING

Frequently it becomes necessary to reduce the height of the flanges of a tray, particularly in edentulous cases. While trays with deep or wide flanges may be used in such cases and fairly good impressions of the mouth secured, it will, in most cases, be found that the labial or buccal muscles, or both, have been distorted and forced out of normal position. In fact, the compression may be so severe as to obliterate the surface indications of their presence or position on the cast when secured.

These muscles and the frenum frequently have their origin near the crest or maxillary portion of the alveolar process, while the border itself may be deep or high, and if not considered in outlining the peripheral margin of the base plate, may become active causes of displacement by lifting the denture off the crest of the border, thus breaking the adhesion.

It is found that by selecting trays with narrow flanges which do not impede the muscular action, and having the patient exercise these muscles at the proper time, while the impression material is still soft, that their position, under tension, can be determined and indicated on the impression

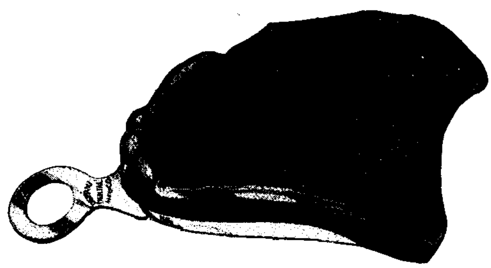


Fig. 11.— Impression Showing Grooves Formed by Muscular Contraction

and the peripheral outline of the denture properly laid on the cast.

Therefore, in selecting trays for edentulous cases, the width of the flanges should be noted; when too wide, the excess should be cut away with the shears, and the margins smoothed with a file to prevent tissue injury, should the trimmed margin be forced through the impression material. In very flat upper arches it is at times necessary to cut away almost the entire labio-buccal flange, while in lower cases both outer and inner flanges are frequently to a great extent removed. The governing factor, in all cases of flange cutting, is the form of the bony tissue or border enclosed by the tray and the muscular attachments to the border with which the flanges may interfere.

A common location calling for the use of the shears is in the median line of both upper and lower trays, in notching the labial flanges to relieve impingement at this point and on the lingual of the lower to obviate contact with the lingual frenum.

MAKING ADDITIONS TO THE TRAY

When the tray selected is of correct outline form and generally suitable for the case, but slightly deficient in some locations, additions may be made where required by building up the deficient portion with wax or modeling compound, or by splicing a piece of metal to the tray. The most common location for building up a tray is on the vault portion, increasing its height and frequently extending it posteriorly. This applies almost exclusively to trays designed for plaster impressions, both full and partial.

In most cases of plaster impressions, better results can be secured by taking a preliminary impression in beeswax or modeling compound, cutting off the excessive surplus and using this preliminary impression as a tray for holding the plaster. In partial cases the wax or compound is removed from around the impressions of the teeth, thus enlarging the openings to make room for a fair thickness of plaster to surround the teeth, so that when fractured the parts may be readily replaced.

Where marked irregularity of the border is noticeable, or in some cases where a few of the natural teeth are present, it is sometimes advisable to construct a tray for the case. This may be done by casting it of block tin or some fusible metal, or by running a die and counterdie and swaging a tray of brass, German silver or aluminum, or by swaging a tray of Ash's metal over plaster casts in a screw press with rubber pads.

SPECIAL CAST TRAYS

Secure as good an impression as possible with the trays at hand. From this impression a plaster cast is formed, and over the cast a sheet of wax is molded to represent the form of the desired tray, including a handle. The wax pattern is then removed from the cast and invested in some suitable investment compound, placing the handle portion upward. Heat is then applied and the wax burned out, after which the fusible metal is poured in through the gate left by melting out the wax handle.

Dr. Walter M. Bartlett of St. Louis has followed a similar method for many years, but has very materially improved the efficiency of the tray by beading it. He applies a narrow wax rim entirely around the inner periphery of the wax model, which bead is, of course, reproduced in the casting. This rim or bead serves to confine the impression material within the compass of the tray, and minimizes the amount required. A tray constructed in this manner, when introduced in the mouth without any impression material present, will frequently exhibit a marked amount of adhesive-

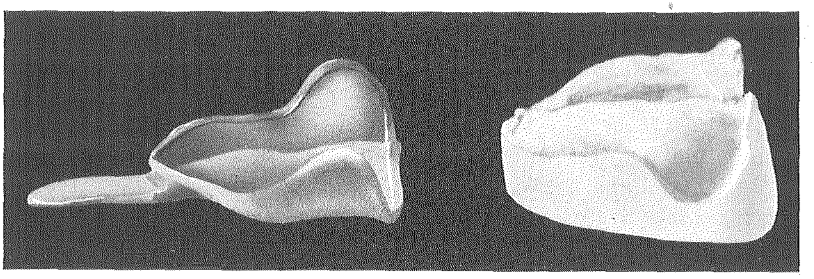


Fig. 12.— Wax Model for Special Impression Tray

ness due to close peripheral adaptation. In constructing the tray, plaster may be used as the matrix and the latter may be of the three or four piece separable type, but the pieces

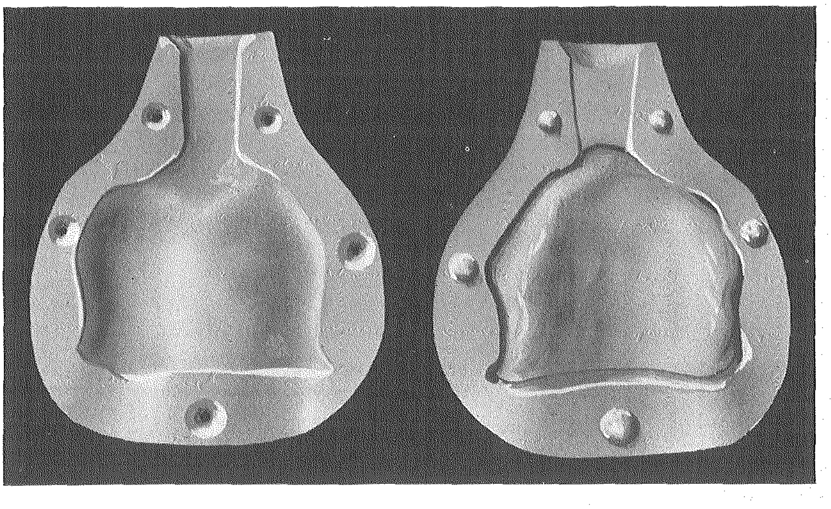


Fig. 13.— Matrix of Plaster in Which Tray Is to Be Cast

should be reasonably thin, and before casting should be warm and dry. The several pieces are held together with binding wire.

SWAGED TRAYS

A swaged tray may be made by securing a die and counterdie from the cast of the mouth. Brass, German silver or aluminum, usually 24 or 22 gauge, is cut to appropriate size, and conformed by swaging. The surplus is trimmed away to give the tray its correct peripheral outline, and a handle attached in the usual location by soldering or riveting.

SPECIAL TRAYS OF IDEAL BASE PLATE

A quickly formed and convenient tray for plaster impression work can be made by adapting a sheet of *special Ideal base plate* to the cast, secured, as in the cases just mentioned. The surplus is trimmed off and correct peripheral outline given the base plate; a piece of 12-gauge German silver or steel wire is bent to the form of the border and extended forward to serve as a handle and laid on the base plate. With a hot spatula the scraps can be melted over the wire and at various points to strengthen the tray and give it necessary rigidity. Sometimes a second sheet of base plate is added to the first, the wire being between the two layers.

METALLIC EXTENSIONS OR ADDITIONS TO STOCK TRAYS

The distal vault portion of a tray is frequently too short to support the plaster against this area of the mouth. An extension may quickly be made by cutting a piece of sheet metal of suitable form so as to overlap the vault portion. Punch two or three holes to correspond, through the addition and the tray, with the plate punch, and attach together with binding wire. Usually, however, additions to the vault portion are made quite as well and more quickly with wax or compound.

In taking impressions where modeling compound is the sole medium used, tray extension or contouring is not so essential, since the compound which escapes distally can be conformed and adapted to the tissues with the fingers, as well in this location as peripherally.

The modeling compound *tracing sticks* are very convenient for making slight additions to trays, particularly along the rim portion. All additions, whether of wax, compound or metal, should be tested by trial in the mouth before introducing the impression material.

As a rule, trays that are too large and with labio-buccal flanges much too broad, are selected for edentulous cases. When it is understood that with close-fitting trays and a minimum quantity of impression material, more accurate impressions can be secured than when an excessive amount is used, much of the difficulty arising from lack of adaptation of dentures will be eliminated.

CHAPTER VI

IMPRESSIONS AND IMPRESSION MATERIALS

GENERAL REMARKS

An impression, in its dental sense, is an imprint, a reverse copy or counterpart of some portion of the oral cavity. It is secured by applying to the parts involved, some plastic medium that conforms readily to the surfaces impressed, and which, when adapted, will harden and retain its form.

The surfaces embraced by an impression may vary from an area involving only a small portion of the mouth, or even of a tooth, to one containing the full complement of teeth, together with the alveolar border in which they are imbedded, and in edentulous cases (mouths devoid of teeth) to the border and adjacent areas.

The character and size of the substitute or replacement under construction determines the area to be included in an impression. It is a safe plan generally, and in partial cases especially, to extend the impression beyond the areas actually involved in an operation, since when the cast is secured, a better conception may be formed of the relationship and proportions of the contemplated substitute to the remaining natural teeth than when the impression is restricted in size.

Absolute accuracy of the impression in representing the parts impressed is positively essential, except in cases to be noted later, and no effort should be spared to secure such an end, since the cast, derived from an impression, becomes the basis and forms the ground work on which most technical procedures are carried out. If the foundation is faulty and imperfect, the structure built thereon will be proportionately inaccurate, and a probable failure.

It does not follow, however, that all impressions for any purpose should be taken in the same manner and under the same conditions, nor do impressions always represent a true reverse copy of the parts impressed. For instance, it is found that in certain cases pressure sufficient to distort or compress the soft and yielding tissues of the mouth is desirable, while in other cases, such compression is not only uncalled for, but detrimental to final results. In any procedure, the prosthetist must first *plan* his substitute, and then thoughtfully and skillfully work out the details of the impression to meet the requirements of the case in hand. Without doubt, most of the mishaps and misfits in prosthetic procedures are due, in part, to faulty manipulation in impression taking. The slighting of this operation in the carrying out of details in a perfunctory and careless manner, is a widespread evil, and cannot be too strongly condemned.

It should be the ambition of the student, and of every practitioner as well, to perfect himself in the technical details, the *art* of impression taking, so that he may overcome any obstacle and meet every emergency that may arise. A thorough understanding of the conditions governing each case, togther with painstaking effort in the handling of the material employed, both in and out of the oral cavity, will accomplish the desired results.

IMPRESSION MATERIALS

Since accuracy in impression taking is an absolute necessity, the choice of the medium used for this purpose requires careful consideration. The following statement of the requirements of an impression material represents the *ideal*, rather than the *attainable*, because no substance has yet been found which is absolutely free from imperfections. Several, however, approach closely to the *ideal* requirements, and with a knowledge of the desirable and detrimental qualities of each, fairly satisfactory and accurate results may be secured in most instances.

REQUIREMENTS

An impression material should possess, as nearly as possible, the following qualities:

First — It should be composed of some material that will not be unduly disagreeable to the patient.

Second — It should become plastic at a temperature the oral tissues can tolerate.

Third — It should copy accurately the fine lines and irregular surfaces to which it is applied, and retain the form so copied, without becoming distorted in removal from the mouth.

Fourth — It should harden in a reasonably short time — from one to three minutes.

Fifth — It should neither expand, contract nor warp at ordinary temperatures to any appreciable degree.

CLASSIFICATION

Several varieties of impression materials are in common use. These may be divided into two groups. First, those which are rendered plastic with a liquid and harden by crystallization. This class includes plaster, impression compounds, and the various dental cements, as oxy-chloride and oxy-phosphate of zinc, magnesia, and the silicates.

The second class embraces those materials that are rendered plastic by heat and harden on cooling. The principal materials in this group are modeling compound, beeswax (both pure and combined with other substances), paraffin and gutta percha. The most commonly used, as well as practical, of these materials are modeling compound and gutta percha.

Group I

Impression Materials That Harden by Crystallization

PLASTER OF PARIS

Plaster of Paris is so called because in former times large quantities were produced at the gypsum quarries at Montmarte, near Paris.

Plaster is made from gypsum, a hydrated calcium sulphate, the chemical formula of which is $CaSO_4 + 2H_2O$. It occurs in a number of different forms, the transparent and crystalline variety being called *selenite,* from the Greek word *selene,* meaning the moon, due to its peculiar soft lustre. This variety sometimes occurs in large plates, and formerly was used instead of glass for window lights. In this form it somewhat resembles mica, but is much softer, and the plates, although slightly flexible, are brittle and inelastic. When it occurs in needle-shaped crystals or in fibrous form, it is known as *fibrous gypsum* or *satin spar.* The ordinary massive, opaque crystals are called *gypsum.* This form presents many varying colors — red, brown, black and yellow — from the enclosed coloring matter, usually the oxides of iron. It also occurs amorphous, in compact, translucent and snowy white masses, and is then termed *alabaster.* This variety is very beautiful, and as it is easily carved, it is much used for small ornaments and statuary.

Gypsum frequently contains more or less foreign matter, such as sand, clay, oxide of iron, or calcium or magnesium carbonate. These impurities are not usually present in excessive quantities, and when not exceeding three per cent, do not seriously impair the commercial grades of plaster. Dental plaster, however, should be produced from the purest quality of gypsum obtainable, and special care should be used in its manufacture to insure uniform results.

MANUFACTURE OF PLASTER

Dental plaster is a half hydrated calcium sulphate, formula $CaSO_4 + 1/2H_2O$. It is formed by heating gypsum, $CaSo_4 + 2H_2O$, at a temperature ranging from 130 deg. to 190 deg. C. If heated above 190 deg. C., the product is unsuitable for dental purposes, but a plaster is produced which has a wide range of usefulness in the manufacturing and building fields.

Two general methods are employed in the conversion of gypsum into plaster. First, by pulverizing and then dehydrating. Second, by dehydrating and then pulverizing the rock. The first method and the oldest is known as the *kettle process,* in which the gypsum is crushed, ground, then placed in large kettles and subjected to heat. This process drives off some of the water of crystallization, and if conducted at the right temperature and for the proper length of time, will produce a fairly uniform half hydrate. Glasenapp, however, says that on account of the difficulty of maintaining a perfectly uniform temperature, a small per cent of the mass may be reduced below a half hydrate or become a partially dehydrated half hydrate, which renders the product slower setting than the half hydrate.

The second method is a more recent one, made possible by improved machinery. The gypsum is broken up into moderate sized pieces, and *burned* to drive off a portion of the water of crystallization, reducing it to a half hydrate. It is then led into a rotary drum and pulverized. In some cases, by means of a partial vacuum, the finest particles of the pulverized product are drawn out into a suitable receptacle, and this constitutes the better grade of dental plaster. The quality of the plaster, however, as before stated, is also dependent upon the purity of the gypsum used in its manufacture, the purer varieties producing the best grades.

PHYSICAL PROPERTIES

Regardless of the fact that plaster of Paris has been employed for many years in dentistry, but little knowledge of its physical properties is current among those who use it, further than that it becomes plastic by mixture with water, that it sets or hardens quickly, and that it is more or less resistant to stress. Why or how it sets, or how much pressure it will withstand without becoming distorted, are points of vital importance, practically unknown to, or at least disregarded by, prosthetists.

The entire bulk of plaster used by the dental profession represents but a very small per cent of the vast output of this material. The greater portion is used in the arts, building trades, and in glass-making industries. A number of investigators, thoroughly competent, by training and with suitable apparatus, have made extended researches in the chemical and physical aspect of this material, and some of the results of their findings, together with some experimental work carried out by the writer, will here be presented.

Professor M. Glasenapp, chief of the technical department of the University of Riga, Russia, an authority on building materials, has gone into this subject exhaustively. Although not relevant in all respects to the use of plaster in the prosthetic field, the following extracts from his writings will shed much light on the chemical as well as the physical aspects of this material. The translation of Glasenapp's work is by Dr. W. Michaels of Chicago.

SETTING

"If ordinary plaster of Paris, representing mainly the half hydrate $CaSO_4 + 1/2H_2O$ is mixed with water and examined under a microscope, a lively process of crystallization can be observed to set in after five or six minutes. In the beginning, very thin needle-crystals form on the cover glass and shortly afterwards also in the liquid and on the particles of gypsum. After 15 or 20 minutes, single needle-crystals and groups of them can be seen in great numbers, and especially the larger fragments of the half hydrate are covered with needle-crystals radiating from them, also the characteristic twin crystals appear abundantly. As fast as the crystals form, the original particles of the half hydrate disappear. After an hour they are completely used up and transformed into crystals, whereby the larger fragments of them become centers of accumulation of crystals, while the smaller have been converted into isolated star-shaped groups. After the same gypsum was heated for several hours to a temperature of 170 deg. C. (whereby the amount of water still remained 6.2 per cent, corresponding with the half hydrate) crystallization began after 3 to 4 minutes, and was practically completed after half an hour; only the largest particles required almost an hour to dissolve and re-crystallize."

"The present state of our knowledge of the hardening of gypsum is that, after having been mixed with water, the half hydrate, plaster of Paris, and the first anhydrous modification of gypsum, which is supposed to be formed between 130 and 200 deg. C., form over-saturated solutions, from which the di-hydrate precipitates in the shape of small crystals, a process which is finished only after all half hydrate or anhydrite is dissolved and transformed into crystals of di-hydrate. Apparently the half hydrate goes into solution more rapidly and crystallizes in a shorter time than the first modification of anhydrite; at least I conclude this from the fact that this first anhydrite, which is considered to be 'easily soluble,' dissolves the more slowly at a higher temperature than it was produced." * * *

"To judge from even the most recent statements to be found in books on chemical technology, only a few chemists seem to be aware of the fact that a complete transformation of every particle of plaster is an essential point in its hardening. Owing to the greater solubility in water of burnt gypsum over crystallized gypsum, the hardening of plaster of Paris has been attributed to a process of crystallization for some time; yet, this crystallizing has mostly been regarded as of secondary importance. The prevailing explanation was that the partly or completely dehydrated gypsum hydrated, combined with water, and hardened without changing its form or place; that is to say, without previous going into solution. The process, therefore, was considered to be similar to the hydration of calcined magnesia, and in many persons' opinion seemed to resemble the hardening of Portland cement and of hydraulic limes. This erroneous conception likewise led to the belief that the strength of the casting depended upon the hardness of the native gypsum from which the plaster was burned. In fact, the difference in hardness between two kinds of raw gypsum is a matter of no consequence.

THE STRENGTH OF HARDENED GYPSUM

The strength of the hardened gypsum depends solely upon the shape of the crystals, upon their size, and upon their more or less close contact. The more slowly the plaster hardens, the larger and stronger the crystals of di-hydrate grow, and the less water is mixed with the plaster, the denser and less porous the casting becomes. Molds which absorb water readily, therefore require a plaster containing as little anhydrite as possible; furthermore, such molds call for a liberal amount of water. Admixtures to the plaster, which retard the setting, so-called negative catalyzers, create large crystals and consequently are the cause of more resisting and stronger castings." * * *

"The microscopical examination of samples of powdered gypsum, burnt at temperatures higher than 200 deg. C., teaches nothing essentially different from the behavior of the half hydrate or plaster of Paris toward water. Only the ability of this anhydrite to form over-saturated solutions is impaired; it is limited the more the higher the burning temperature has been, and the longer the material was heated. Transformation into crystals of di-hydrate takes place in the same manner, but more slowly. The following table gives the various temperatures to which the gypsum was exposed, as well as the time of heating in many instances, and the beginning and termination of the process of crystallization corresponding with them:

TABLE OF "TIME OF CRYSTALLIZATION" OF PLASTER

Temperature	Burning Time	Beginning of Crystallization	Crystallization Completed After
107 Centigrade		6- 7 minutes	½ hour
130 "		6- 7 "	½ to 1 hour
170 "		3- 4 "	½ hour
200 "	7 hours	30-45 "	½ day
200-250 "	14 "	60 "	7 days
250-300 "	7 "	40 "	3 "
400 "	½ hour	1¾ hours	17 "
450 "	½ "	10 days	30 "

"As the hardening of the castings of plaster is caused mainly by the transformation into the di-hydrate, and as this process of crystallization is the same also for 'overburnt' gypsum, the lack of hardening in the case of the latter must doubtlessly be ascribed, wherever it has been observed, to the drying out of the uncovered castings; the process of crystallization, therefore, was interrupted and the casting could not obtain its full strength, which it otherwise would have done. This must happen, especially in cases in which the process of crystallization takes a number of days. With gypsum burnt at 200 deg. centigrade the transformation into crystallized di-hydrate is almost completed within 24 hours; only the larger particles take more time, and as, especially in the case of large castings, still a sufficient amount of water remains for crystallization after 24 or even 48 hours, this explains the fact that gypsum, burnt at 200 deg. centigrade and even above this temperature, unless heated for too long a time, or mixtures of this with standard plaster of Paris, show normal hardening and high strength. Rohland, who assumes that only a small portion of the gypsum, its active part, takes a share in the hardening, is therefore mistaken; the entire mass is active, if given time and opportunity to exhibit its activity, which is greatly diminished, indeed. 'Complete hydration and transformation into di-hydrate without hardening,' as Rohland describes it, is consequently out of the question. The term 'overburnt or dead burnt' gypsum is therefore misleading; the proper name for gypsum burnt at temperatures between 200 deg. and 300 deg. centigrade would be 'slow setting.'

"The process of hardening of such slow setting plaster shows two distinct phases. In the first place, the plastic dough assumes a dull surface and becomes stiff owing to the transformation of the anhydrite into the half hydrate. This point is reached after 1 or 2 minutes in the case of gypsum heated to 200 deg. centigrade and after 30 minutes or more with gypsum burnt at temperatures between 250 deg. and 300 deg. centigrade. If further absorption of water is interrupted at this point by a rapid drying process, the stiff plaster is found to contain from 6 to 6.5 per cent of water of combination, corresponding about with the half hydrate. During the second phase, which requires more time, the half hydrate previously formed goes into solution and crystallizes as dihydrate. Setting and hardening are, therefore, two well pronounced processes in this case. Castings that have only time to set yield insufficient strength; they must be given time to harden. * * * *

SIZE OF CRYSTALS OF ORDINARY PLASTER

"The reason why castings made from ordinary quick setting plaster are low in strength and possess little resistance toward atmospheric influences, is evidently to be found in the minute size of the interlacing needle-crystals of dihydrate, which, owing to the rapid process of crystallization, have not time to develop and grow larger. The following table illustrates this point by giving the dimensions of the crystals in millimeters and the corresponding temperatures at which the various kinds of quick-setting and slow-setting plasters have been burned:

Burning Temperature.	Largest Dimensions of Crystals. Diameter.	Length.
107-130 centigrade	0.0025 mm.	0.04 mm.
140 "	0.012 "	0.14 "
250-300 "	0.075 "	0.50 "
400 "	0.050 "	0.35 "
450 "	0.035 "	0.60 "

"The plaster burnt at 400 centigrade was heated only for half an hour; that burnt at 250-300 centigrade, however, for several hours. This explains the difference in the dimensions of the crystals. The first two of the plasters given in the preceding table are quick-setting, the last three slow-setting.

"The diameters of the needle-crystals of the plaster burnt at 107-130 centigrade are 30 times smaller than those originating from the plaster burnt at 250-300 centigrade; their sectional areas, are, consequently, 900 times smaller. It is, therefore, evident that, other things being equal, a casting made from slow-setting plaster must show greater strength. Hence, whenever time has not to be considered, and increased strength of the casting is desired, as, for instance, in the case of statues for art galleries and so forth, experiments with slow-setting plaster seem to be very advisable.

"In conclusion, the various calcined products obtainable from raw gypsum may be classified in accordance with the results derived from the foregoing research. The limits of temperatures stated must only be considered as approximate figures, of course, as the change from one kind to the other takes place very gradually, and because, as repeatedly stated, not only the height of temperature, but also its duration, determine the properties of the calcined gypsum product.

A. Native gypsum........Di-hydrate containing two molecules of water.

B. 107 centigrade........Half hydrate containing ½ molecule of water.

C. 107-170 centigrade...Consists mainly of half hydrate.

D. 170-200 centigrade...More or less dehydrated half hydrate. Combines with water readily until half hydrate is obtained.

C. and D. represent the commercial plaster of Paris.

E.	200-250	centigrade...	Contains a very small amount of water. Sets more slowly than the former.
F.	250-400	centigrade...	Contains only a trace of water. Slow-setting. B., C., D., E. and F. form crystals of di-hydrate, if mixed with water. Hardening due to crystallization.
G.	400-750	centigrade...	Completely dehydrated, anhydrite, overburnt from a practical point of view.
H.	750-800	centigrade...	Gradual transformation into the granular modification of anhydrite; beginning of the formation of hydraulic gypsum. G. and H. show in contact with water. No hardening, or only very imperfect hardening.
I.	800	centigrade...	Hydraulic gypsum containing minute grains of anhydrite.
K.	900-1000	centigrade...	Genuine hydraulic gypsum, grains fully developed.
L.	1000-1400	centigrade...	Hydraulic gypsum, showing grains increasing in size and hardness with rising temperature. The percentage of "basic calcium sulphate" likewise increases in the same ratio. I., K. and L. harden slowly with water without crystallizing. G., H., I., K. and L. crystallize with alum solution.

"A temperature of from 1300 deg. to 1400 deg. centigrade, in my opinion, can be employed in the manufacture of hydraulic gypsum only in cases in which gypsum does not come in immediate contact with the fuel, as, for instance, in laboratory experiments, in which the burning is done with gas.

"Where coal is used, the ashes of it, as well as the reducing carbon, are bound to contaminate and spoil the calcined product. Moreover, temperatures as high as these are almost out of the question in practical operations."

The foregoing extracts refer especially to the chemistry of setting, and the effects of varying temperatures and time in burning on the time of setting and hardness of plaster. The method of manipulation is not considered. This to the prosthetist is a matter of importance that cannot be overlooked.

INFLUENCE OF MIXING ON QUALITY

Plaster mixed at a medium to thick consistency will set more rapidly and be of better density when set than if an excess of water is present. Too thick a mix, however, should be avoided, particularly where accelerators are used, as under such circumstances the setting frequently begins before the mass is of uniform consistency, and further stirring breaks up the already forming crystals. This interference results in a mass of uncertain density, oftentimes with many spaces present.

The other extreme, too much water, should be avoided, as it retards the setting, and the plaster, when set, is less resistant to stress. Various substances are added to accelerate the setting, particularly in impression work. Common table salt (NaCl) is frequently used, but should never be incorporated in plaster used for casts for vulcanite work, since its affinity for moisture causes rapid softening and deterioration in the presence of steam or water. Sulphate of potassium (K_2SO_4) is by far the best accelerator, because it not only hastens the setting, but has a controlling influence on expansion. This medium, however, should not be used in cast construction for the same reasons that apply to NaCl. Potassium alum has been highly recommended as an accelerator and hardening medium for plaster in dental laboratory procedures, but tests made with this substance fail to verify the claims made for it.

EXPANSION OF PLASTER

The tendency of plaster to expand during and after setting and the deleterious effects of this movement in denture adaptation has long been recognized by some, but its importance is not fully understood.

When freshly mixed plaster begins to set, it contracts slightly, then remains stationary for a short time, then expands, and after assuming a thoroughly dry condition it again contracts to a very slight degree. From 6 deg. to 10 deg. rise in temperature is noticeable during the setting process, due to the chemical action that occurs.

In an ordinary mix of impression plaster that hardens in, say, 3 minutes, the first contractile period occurs between the time of mixing and that of the beginning of setting. Since the consistency of plaster, when freshly mixed, is soft and the mass yielding, no accurate records can be made of any change that may occur within the first minute after mixing. From the beginning of the second minute, usually, the mass being hard enough to resist the tension spring of the micrometer, the contraction is perceptible and usually continues for about 2 minutes, or until the evolution of heat is noticeable. This would establish the contractile period in the last two of the three minutes that elapse between the time of mixing and that of setting. Any variation in the time required for setting would undoubtedly produce a corresponding change in the contractile period.

The contractile stage is followed by a short period of inertia of usually about one-half minute, after which expansion sets in, slowly at first, then increases rapidly for two or three minutes, then decreases gradually, and finally ceases altogether. Usually the greatest expansion is over in ten minutes, although the movement continues in a gradually decreasing ratio for twenty-four hours or more.

The rate and amount of expansion is very greatly influenced by the manner in which the plaster is mixed with the water, and the method and length of time the mass is stirred. Long and rapid stirring increases the rapidity of setting, and the rate and amount of expansion as well, while on the other hand slight stirring for a short time induces only moderate movement.

MEASUREMENT OF EXPANSION AND CONTRACTION OF PLASTER

For the purpose of studying the behavior of plaster under different conditions, the writer constructed a micrometer which registers both the expansive and contractile movements of this and other materials as well. See Fig. 14.

This instrument is graduated to read to the 1/10,000 of an inch and the 1/500 of a mm. In reality readings can be made to the 1/40,000 of an inch. The spring actuating the contact rod is very delicate and offers but slight resistance to expansion, so that practically all of this movement can be noted.

The following records, taken from many hundreds, show the results of stirring the several mixes varying lengths of time. French's impression plaster was the material used, the mixes being practically identical as to weight, amount of water, temperature of room and material. Nothing was added to accelerate setting or control expansion. The plaster was sifted into the water in the rubber bowl. The only appreciable difference was in the length of time each mix was stirred.

No. of Mix.	Time Stirred. Minutes.	Expansion After 10 Minutes. Points.	24 Hours. Points.
1	3/4	2	61
2	1	32	101.5
3	1 1/4	61	93.5
4	1 1/2	93	118.5
5	1 3/4	118	134
6	2	137	157.5
7	2 1/4	140	160
8	2 1/2	142	159
9	2 3/4	147	165
10	3	145	162

The point is 1/10,000 of an inch.

The mixes were of a consistency suitable for impression work.

Further experiments indicate that thinly mixed plaster exhibits less expansion than when more thickly mixed, but the density is proportionately less, as the mixes are made thinner.

CONTROL OF EXPANSION

Many experiments have been made with different substances, singly, in combination, and in varying proportions, in an effort to control this expansive movement, but with the exception now to be mentioned, only negative results were observed.

Potassium sulphate in definite proportions acts as an accelerator, and also decreases expansive movement. The slightest amount of stirring consistent with the production of a uniformly plastic mass is also important in keeping down the expansive movement.

WARPAGE

In prosthetic procedures the principal difficulty resulting from expansion is in the warpage of impressions and models when allowed to remain in the tray for any length of time after the plaster has set.

Dr. Buckingham, in 1860, first noticed the expansive movement in plaster, but he failed to realize the deleterious effect of it. Dr. W. Bowman McLeod, of Edinburgh, Scotland, in 1880, first called attention to the warpage of plaster when confined in an impression tray. His experiment consisted in clamping metal bars to the edges of a rigid metal plate and filling the enclosed space with properly mixed plaster.

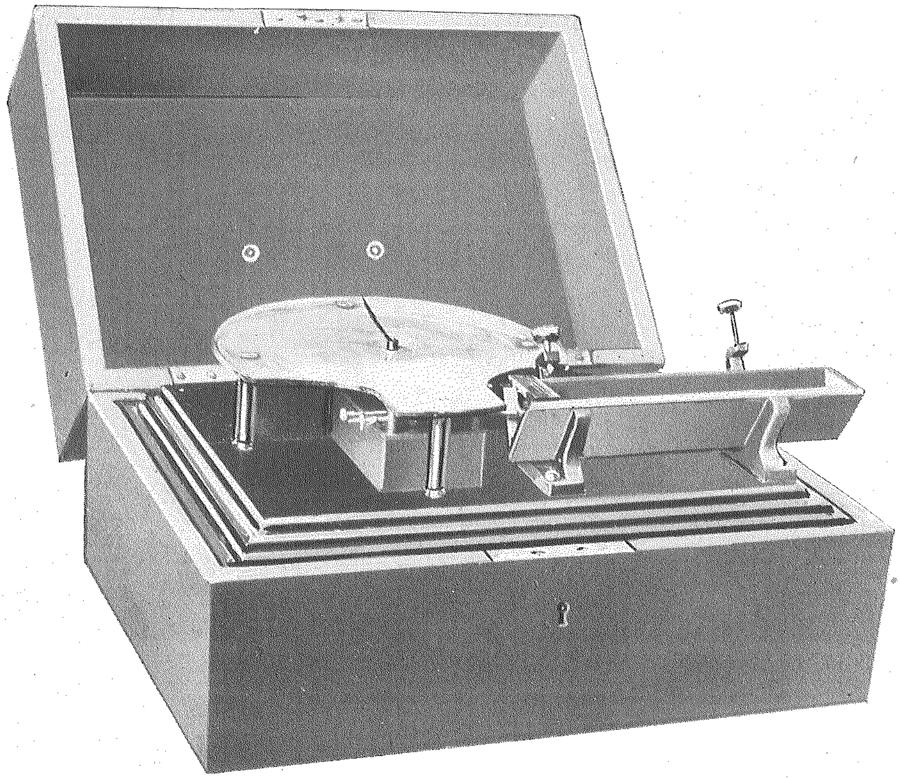


Fig. 14.— Expansion Machine

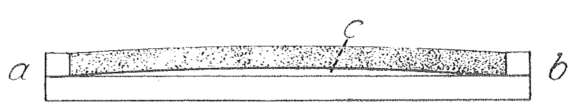


Fig. 15.— Warpage of Plaster on Slab with Fixed Sides (Dr. W. Bowman McLeod's Experiment)

After twenty-four hours the bars were removed, and the slab of plaster sawed diagonally through the center, when it was found that in the central portion it had arched up to a considerable extent, while the edges remained in contact with the plate. This was due to the fact that lateral expansion was prevented by the fixed marginal bars, which, however, did not confine the material on its upper surface, and movement occurred in that direction.

An impression tray with its fixed sides corresponds to the slab with clamped bars. The sides of the tray prevent lateral

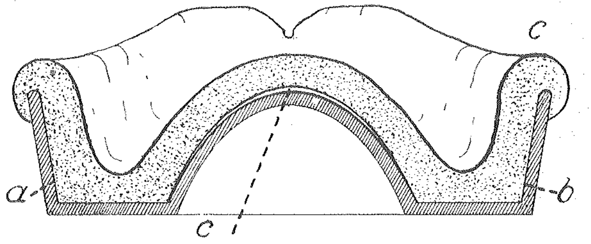


Fig. 16.— Warped Impression Due to Fixed Tray Flanges

expansion, so that the movement is noticeable by the arching up or warping of the palatine portion of the impression, while the sides inclosed by the buccal and labial flanges of the tray remain in close contact with them. The result is that the palatine portion of the impression raises, while no corresponding

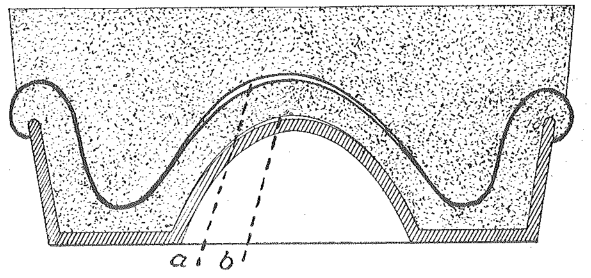


Fig. 17.— Warped Cast Due to Restricted Lateral Movement

movement occurs in the alveolar portion. Now if the plaster for the cast is introduced in the impression and allowed to remain for some time, a similar error due to a corresponding cause will result, and thus establish an additional increase in the height of the palatine arch of the cast.

ERRORS DUE TO WARPAGE

Two errors, due to warpage, have therefore occurred, either one of which might, and certainly both together will, result in the cast being an imperfect reproduction of the mouth it is intended to represent. A denture molded over such a cast will touch the palatine portion of the mouth before it is firmly seated on the alveolar borders, and under stress of mastication will readily tip. In some instances there will be no adhesion whatever. The method for reducing or partially controlling and overcoming expansion of plaster impressions and casts will be taken up when considering the technic of this work.

COMPRESSIBILITY OF PLASTER OF PARIS

An object composed of plaster of Paris appears like a solid substance and is resistant to ordinary stress without change of form. When we examine this material under a microscope, however, it is found, as before stated, to be composed of numerous crystals grouped irregularly in masses with many spaces between the masses and between the crystals themselves. Within and below the *modulus* of *resistance* of these crystals, they retain their form and resist a very considerable amount of stress without crushing.

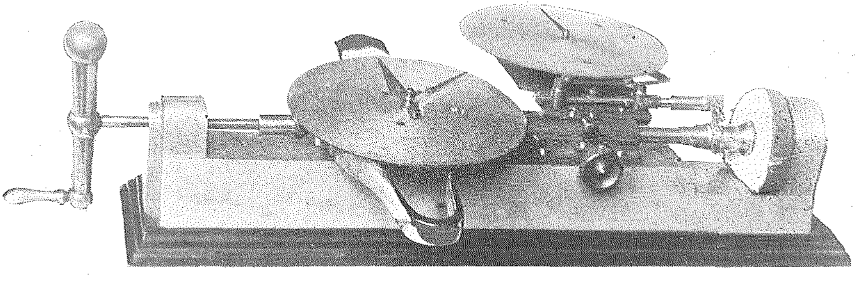


Fig. 18.— Compression Machine

In certain technical procedures, particularly in vulcanite work, plaster is usually subjected to heavy pressure. By experiment it has been found that, in many cases, an amount of force far in excess of the modulus of resistance of this material is ordinarily used in laboratory procedures. While perhaps in some instances the physical change is not apparent to the eye, it can be readily discerned in others. In many instances where no visual change is noticeable, the adaptation of dentures is seriously interfered with, which can be laid to no other cause than that of *compressibility*. Further discussion of this important problem will be continued under the subject of the flasking of vulcanite cases.

ADVANTAGEOUS PROPERTIES OF PLASTER OF PARIS

Plaster has, however, a number of good qualities which commend it for impression work, and notwithstanding the serious disadvantages which have already been cited, it is an indispensable material in prosthetic procedures. Its plasticity when freshly mixed, its tastelessness and freedom from odor, the facility with which the most irregular surfaces can be copied, its rapid setting property, and the fact that it can be introduced in the mouth at ordinary temperatures, commend it for general use. Being inelastic and brittle, it breaks with a clean fracture, and the broken pieces can easily be placed together again in exact relation to each other, so that by its use the impression of any surface, however irregular, may be secured with accuracy.

Only the finest grades of dental plaster should be used for impression-taking, and it should be kept dry and in air-tight receptacles to retain its setting quality. When used with skill and in properly selected cases, it is an excellent medium for impression work, and indispensable for many other purposes.

In mixing plaster, the best results are secured by placing the required amount of water in the bowl and sifting the plaster into it until a sufficient amount has been added to take up the water. No excess of water should be present, while an excess of plaster results in an insufficient amount of water to bring the half hydrate into solution. It should be subjected to the slightest amount of stirring—just enough to make the plastic mass homogeneous and of uniform consistency throughout.

IMPRESSION COMPOUNDS

These are manufacturers' products intended for impression work, and into which, on drying, metal dies can be run without resorting to the usual steps in such cases. The basis of all such compounds, however, is plaster of Paris, which acts as a cementing medium between the particles of refractory material, usually pulverized or granular calcium carbonate, silex, pumice-stone or coarsely ground asbestos. But little, if any, advantage is derived from their use.

CEMENTS

The various dental cements are at times employed in taking impressions of limited areas, as, for instance, of prepared teeth for inlay work, or in certain procedures in crown and bridge work. They are used to such a limited extent as not to be considered as general impression materials.

Group II

IMPRESSION MATERIALS RENDERED PLASTIC BY HEAT MODELING COMPOUND

Modeling compound, as its name implies, is made up of several ingredients combined in such proportions as to produce a material that is plastic and workable at low temperatures, which will copy accurately the surfaces against which it is pressed, and cool or harden quickly. Since the formulæ of the manufacturers are not published, it is not possible to give exact data on this subject. The base of this material, in practically all cases, consists of one or more of the natural resinous gums used in varnish making, such as dammar, copal or kauri. These gums are more or less hard when dry and cold, but become sticky and plastic on heating. Stearin is added to reduce the stickiness, while pulverized soapstone is incorporated to give body to the mass. Carmine is usually used to tint the material, and sometimes a little aromatic flavoring substance is added to render it pleasant in taste and odor.

FORMULA FOR MODELING COMPOUND

A formula which will serve to illustrate the compounding of this material was given to the writer a number of years ago by Dr. E. Lloyd Williams of London:

Kauri	1 part
French chalk	$1\frac{3}{4}$ parts
Stearin	$1\frac{1}{2}$ parts

The stearin is first melted, the kauri added, and the two thoroughly incorporated, then the chalk is gradually sifted in and the mass kneaded until well mixed. The coloring and flavoring ingredients should be incorporated in the stearin and gum before adding the soapstone.

Some varieties of compound show a decided tendency to contract, or warp, on cooling, which properties make them unreliable in impression work, while some, to render them efficiently plastic, require a degree of temperature unbearable to the oral tissues. While the tissues of the mouth can tolerate temperatures ranging from 140 to 170 deg. F. without much discomfort, a compound should be selected that will copy fine lines and irregular surfaces at even lower temperatures than those mentioned, in order to be efficiently workable.

As a rule, modeling compound is heated in water to soften for impression work, but should never be subjected to boiling temperature, as its quality is soon impaired and the material is too sticky to handle conveniently when overheated. The bottom of the vessel used for heating should be covered with a piece of rubber dam, or clean paper, to prevent the compound adhering to it. Softening in water is preferable to dry heat, although some use the latter method. Modeling compound is inelastic and therefore when impressed against a surface it should be thoroughly hardened before removal from the mouth, since in the act of loosening the impression or in its withdrawal, pressure upon the prominent portions is liable to distort it. This precaution also applies to most of the substances made plastic with heat.

BEESWAX

This material is elaborated by bees out of substances collected from flowers and from it the honeycomb is formed. The wax is prepared for use by melting the comb in water after removal of the honey. Impurities lighter than the wax are skimmed off, or if heavier are removed by trimming the under surface of the hardened cake. The natural color of beeswax is yellow. It may be bleached by forming it into thin sheets and exposing it to bright sunlight, or by the use of dilute acids in the melting pan. It may be given almost any tint desired by the addition of suitable pigments.

It was formerly much used as an impression material, but has been to a great extent supplanted by modeling compound. There are two serious objections to the use of beeswax as a material for general impression work: First, when disposed around the labial and buccal portions of the alveolar border unsupported by the tray, in a thin layer, it is very apt to be distorted in removal because of lack of inherent rigidity, even when chilled; second, there is a tendency for it to warp and contract in changing from a heated, plastic condition to a cold state. When manipulated with care it may be used to advantage in some cases, although it is difficult to say in what instances it would be preferable to modeling compound, since in recent years the quality of the latter has been so materially improved.

Wax is furnished by the manufacturers in the form of sheets and cakes, both in a pure state and combined with other substances, such as paraffin or some of the resins, to render it harder or more adhesive, as desired.

BEESWAX AND PARAFFIN

The addition of paraffin to beeswax lowers its melting point and renders it harder when cold, but reduces the adhesiveness of the wax if used in excess. Tallow is frequently used as an adulterant of wax. The combination, however, is worthless for dental purposes. The sticky wax, so useful for many purposes in the laboratory, comes in the form of small sticks or cylinders, and is made by combining some of the resins with beeswax. It is adhesive and hard when cold, and is much used in the assembling of parts in crown and bridge work.

HARD BITE WAX

A material known as *hard bite wax* is procurable, which is very convenient in the making of wax contour models for use in warm weather. When formed of this wax, the rims withstand the stress of trial in the mouth, as well as the effect of oral temperature, without becoming distorted. Wax of this class usually contains rosin.

Beeswax is manipulated much the same as modeling compound, being softened in warm water. It should be broken up in small pieces, if in bulk, or in sheets of moderate thickness, so that the heat may penetrate readily at rather low temperatures, say 130 deg. to 140 deg. F. When thoroughly warmed, it is kneaded with the fingers into a uniform plastic mass and pressed with a towel to take up any moisture that may be present.

None of the plastic, non-elastic impression materials, with one exception, are suitable for taking impressions in undercut spaces, or in partial cases where the teeth have constricted services or the embrasures and interproximate spaces are devoid of gum tissue. Under certain conditions and by following methods to be outlined later, modeling compound may be used.

The difficulty encountered in such cases is due to the drawing or distorting of the impression material in withdrawal from the teeth and spaces designated.

Beeswax is frequently employed as a preliminary impression material in partial as well as full cases, the impression thus obtained being relieved of excessive surplus and used as a matrix or improvised tray for holding the plaster for the final impression. By this means, the wax having been conformed to the tissues, a minimum quantity of plaster is carried to every surface involved, with less discomfort to the patient, while the ratio of expansion in the plaster is correspondingly less. In partial cases, however, the wax should be trimmed well away from around the remaining teeth, so that the plaster enclosing them may be of sufficient thickness when fractured in removal, to be readily placed together again in the wax matrix.

GUTTA PERCHA

This material is obtained from the juice of a tree, the Isonandra or Dichopsis Gutta, found in the Malay Archipelago, on either side of the equator, for a distance of two or three degrees.

The word "gutta" in the Malay language means "gum" and "percha" is the name of the tree, so the term means the "gum of the percha tree." The juice is collected by a method similar to that followed in tapping the rubber tree (Siphonica Elastica) by making a long diagonal cut entirely through the bark and adjusting a trough under the incision, through which the escaping juice is carried into vessels to receive it. As more or less dirt and impurity is mixed with the juice, the crude material is unfit for use. It is refined by first tearing it into shreds in a special machine, washing and agitating in water, and afterward boiling, to bring it into a coherent mass, in which form it is known as commercial gutta percha. It is nearly similar in composition to rubber, being a hydrocarbon, but, unlike that substance, it deteriorates slowly if exposed to the air, the oxygen of the air uniting with it and causing the gum to become brittle and lose its elasticity and strength. It can be mixed with sulphur and vulcanized, but the product, while more durable than the crude material, is not so permanent or lasting as vulcanite, and consequently is not used in this form to any great extent.

The fresh commercial product is sometimes used for taking impressions of the mouth. It becomes plastic enough for this purpose at a temperature of 130 deg. to 150 deg. F. and is prepared by softening in water. It will contract, however, unless dried and heated sufficiently to adhere to the sides of the tray. In general, it is manipulated the same as modeling compound, except that special care must be observed to cement it to the tray before introduction into the mouth and to chill it thoroughly before removal. Being elastic, it will readily draw away from undercuts and teeth with constricted cervices, and immediately resume its proper form when pressure is relieved.

CONSTITUENTS OF GUTTA PERCHA

As it is difficult, or almost impossible, to secure the fresh, unadulterated product, its use as an impression material is very limited. The base plate gutta percha furnished by the supply houses is not composed of the pure gum, but contains chalk, magnesia or oxide of zinc, and frequently coloring matter. The addition of these substances prevents, to a certain extent, rapid deterioration, and also renders the product more rigid. While sometimes used for the base of trial plates, gutta percha is not sufficiently rigid to insure accuracy in such procedures. The sheet base plate is frequently used for taking impression of faced roots in crown and bridge work where it is desirable to force the gingivæ apically to obtain an outline of the root periphery.

Gutta percha consists of a combination of hydrocarbons similar to caoutchouc.

Payen's analysis shows the following:

Gutta	78 to 82 per cent
Albane	16 to 14 per cent
Fluavile	6 to 4 per cent

Chemical composition:

Carbon	86.36
Hydrogen	12.15
Oxygen	1.49

Since the juice is collected from several varieties of trees and comes from different localities, it is a natural consequence that the physical as well as chemical proportions of constituents must vary more or less, so the above may be considered as representing the general composition of this material and not an absolute unchangeable chemical formula.

CHAPTER VII

TECHNIC OF TAKING IMPRESSIONS

GENERAL REMARKS

In general, the taking of impressions in plaster for full and partial, upper and lower cases, is similar in many technical details. A comparatively full description of the manipulative details carried out in taking an impression of an upper edentulous cast, will serve as a basis for all classes of plaster impressions. The *difference* in details will be presented as each class is described.

INDICATIONS FOR THE USE OF PLASTER

The value of plaster as an impression material lies in the fact that it can be readily adapted to the most irregular surfaces and carried into deep undercuts and embrasures, from which it can be removed by fracturing, and the broken parts readjusted with ease.

An outline of those cases where plaster is most strongly indicated, is here in order:

First — In all cases where any of the natural teeth are present.

Second — In case undercuts exist, either on the opposite surfaces of the borders, or in spaces formed as the result of the loss of the natural teeth.

Third — Where flabby ridges are present, such as have previously been described.

Fourth — In edentulous cases where the mucous and submucous tissues are thick and elastic, particularly in the palatine portion of the mouth. When such a condition prevails, the tissues, if compressed uniformly, as when modeling compound is used, assert their resiliency, on pressure being relieved, which breaks the peripheral adaptation of the impression, and later, of the denture that may be constructed when such an impression is used as a basis.

In practically all of the cases just cited, the use of beeswax or modeling compound, as an impression material, is contra-indicated, but the use of either of these substances as a preliminary impression material, in which to hold the plaster for the final impression, is strongly indicated.

Upper Edentulous Cases

PRELIMINARY STEPS IN IMPRESSION TAKING

Taking it for granted that the mouth has been previously examined and is in condition to receive prosthetic substitutes, the patient is seated in the operating chair.

POSITION AND COMFORT OF THE PATIENT

As a general rule in all plaster impression work the patient should sit in an upright position. The chair may be slightly inclined backward, but not to any marked degree. The chair should be raised high enough to bring the patient's mouth within convenient range for manipulation. Further adjustment of the chair should be made for the comfort of the patient, so far as may be consistent with the work in hand.

A covering should be adjusted to protect the patient's clothing from becoming soiled with particles of plaster, or the dripping or overflow of saliva from the mouth. When possible to do so, the saliva ejector should be used to overcome this difficulty. Before taking the impression, the mouth should be rinsed with tepid water, or, preferably, normal salt solution, to remove the viscid, stringy mucous. A glass of water should be placed on the bracket so that the patient may rinse the mouth after the removal of the impression.

POSITION OF THE OPERATOR

For upper impressions the operator should stand on the right side of the chair, and slightly back of the patient. He should stand erect and work with the upper arms perpendicular, and the forearm horizontal. In introducing an upper impression, his left arm should pass to the left of the patient's face, so that the left hand may manipulate that angle of the mouth, and later, support the tray.

In taking lower impressions, the operator will find it more convenient to stand slightly in front, to the right of, and facing the patient. In this position, both hands have more freedom of action, and the line of vision is less obstructed than when the operator stands back of the chair.

SELECTING AND FITTING TRAY TO MOUTH

By a glance in the mouth, the operator can determine the approximate form and size of tray to use, and select one accordingly. This is introduced in the mouth, and its general adaptability to the case ascertained. If approximately of the right form, but not exactly adapted to the case, the points needing modification are noted. By placing the tray in position and subjecting it to a side-to-side movement, the excess of buccal space can be estimated. By holding the distal margin of the tray against the palatine vault in approximately the correct mesio-distal position that it should occupy, and letting the anterior portion of the tray drop down below the border level, so that a view above the tray of the vault and tray curvature may be obtained, the adaptation of the vault portion of tray to tissue can be determined.

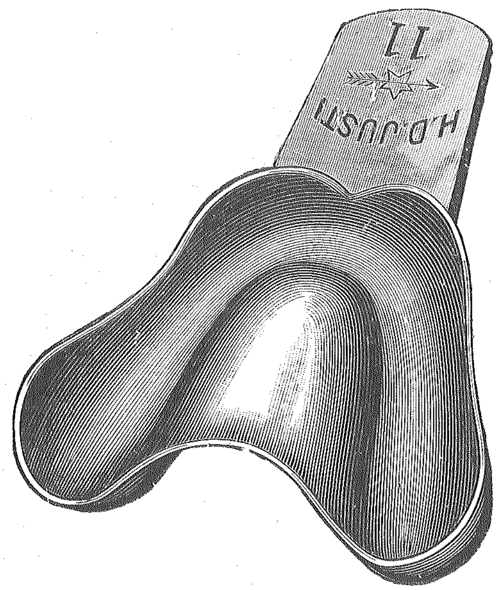


Fig. 19.—Full Upper Impression Tray Suitable for Edentulous Cases

The relative width of the labio-buccal flange to the alveolar border, and the several points of muscular attachment can be determined by holding the tray in position, rather loosely, of course, since the impression material is not present, and subjecting the lips and cheeks to outward and downward traction. If too broad, the amount of excess width can be determined by alternately pressing upward on the central portion of the tray and pulling downward on the lips and cheeks, the amount of movement in the tray indicating the excess present.

Hold the tray in normal position with one hand and pass the index finger of the other hand backward along the central vault portion, past the tray margin, onto the oral tissue, and determine whether this portion of the tray extends to the line of junction of hard with soft palate. If not, make an extension, as described elsewhere. The usual space outline of an eighth of an inch, or less, between tray and tissue, should be closely adhered to, since a small amount of impression material, properly applied, will yield more accurate results and be less objectionable to the patient than an excessive bulk.

MIXING THE PLASTER

A clean rubber bowl is filled about one-fourth full of slightly warm water, into which should be sifted some *impression plaster* (plaster which contains an accelerator). Or, if French's regular dental plaster is used, dissolve about one-half gram of sulphate of potassium in the water before sifting in the plaster. This will hasten the setting and also have a slight control on expansion.

Add enough plaster to take up the excessive moisture, and produce a plastic mass, which, when stirred slightly, will stand when piled upon itself, or in other words, will not drop from the inverted tray. Distribute the mixture in the tray selected, spreading it uniformly over the various surfaces and building it slightly higher on the vault portion than elsewhere, to insure a sufficient amount of material being present. The general contour of the plaster in the tray should be similar to the general contour of the mouth, but reversed, of course.

INTRODUCING THE FILLED TRAY IN THE MOUTH

The tray handle is held in the right hand, thumb on top of handle, index and middle fingers underneath, to support the body on the right side. The right angle of the tray is inserted well back in the right angle of the mouth, while the opposite side is rotated through the left angle of the mouth, the latter being distended with the index or middle finger of the left hand.

After the greatest diameter of the tray has passed the oral opening, its adjustment, although requiring care, is easily accomplished.

See that the tray is centered. The direction of the handle indicates this to a certain extent, although it cannot be depended on in those cases where the buccal alveolar process has been absorbed more on one side than on the other, or where the alveolar processes are not symmetrically related to the medium line of the cranium.

Pass the tray back until the labial surface of the border is within about one-fourth of an inch of the flange and press the tray upward until the border is fairly well imbedded in the plaster, not, however, to the full extent, as at this time muscular impingement is not yet relieved. The index and middle fingers of both hands are placed under the floor of the tray to carry the impression to place. This is the first, or pressure position of the hands. Apply the index and middle fingers of the left hand to the vault portion to support the tray, and quickly pass the index finger of the right hand along the buccal border of the right side of the tray, at the same time producing tension on the buccal muscles, drawing them outward to prevent them from becoming caught by and folded interiorly over the tray margin. Then reverse the position of the hands and carry out a similar procedure on the opposite side, being careful not to disturb the relation of the impression to the border during this step. Now return to first, or pressure position, and apply sufficient force to carry the impression firmly to place.

SECURING PERIPHERAL ADAPTATION

Return to the second, or tray supporting position, and with the free hand press against the lips and cheeks, directing the pressure from low down near the floor of the tray, inward and upward against the outer flange, so as to carry the plaster that has been forced outside the flange, upward against the labial and buccal surfaces of the border.

MUSCLE MARKING OF THE PERIPHERY

While still supporting the impression, instruct the patient to produce buccal and labial muscular tension on the peripheral plaster margins, in order to indicate distinctly the position and form of muscle tendons and labial frenum.

All of these steps should be carried out quickly, before the plaster has set to any appreciable extent, for if allowed to set too hard, the muscle markings will not show distinctly. Usually all of the details as outlined can be carried out in from thirty to forty seconds.

Steady, moderate and uniform pressure maintained on the floor of the tray with the index and middle fingers of both hands, until the plaster has become well hardened, is essential.

The hardness of the plaster is determined by breaking some of that remaining in the bowl. When it breaks with a clean fracture, and without crumbling, the impression is ready for removal.

DISLODGING THE IMPRESSION

If the impression is correct and well adapted, it should adhere to the tissues firmly, and require considerable effort to effect its removal. An impression that requires but slight effort to dislodge it can rarely be relied upon to serve as a basis for an accurately fitting denture.

To break the adhesion, the index finger is passed backward inside the cheek opposite the buccinator muscles, and pressure made outward and upward on them. These regions on either side are the natural air valves to the vault portion, and with some slight traction on the handle, at the same time the buccal muscles are lifted as described, the adhesion of the impression will be broken without much difficulty. Should this method fail, instruct the patient to cough, and at the same time press upward on the tray handle. The sudden muscular contraction occurring in the soft palate lifts these muscles up from the distal margin of the impression, and at the same time forces the air in between the tissues and the plaster.

REMOVAL OF THE IMPRESSION

When loosened, the impression is dropped down, clear of the border, and rotated out of the mouth in much the same manner as it was introduced, but with reversal of movement, and without the necessity for distending the oral angle with the finger.

In edentulous cases where decided undercuts are present, it is advisable to oil the tray before introducing the plaster, and when the impression is ready for removal, dislodge and remove the tray first. The impression can then be weakened by cutting, so as to be removed in pieces, thus preventing injury to the tissues that, in some cases, would most certainly follow its removal as a whole.

INSPECTION OF THE IMPRESSION

On removal, the impression should be carefully inspected to see that all essential surfaces have been copied, and that it is intact. If fractured at any point, the broken parts are recovered, placed in their respective positions, and held there by melting a little wax along the external fracture line.

The treatment of the impression and the production of the cast will be described in a subsequent chapter.

Edentulous Lower Cases in Plaster

SELECTING THE TRAY

The tray in these cases should be of such size that the crest of the alveolar process will occupy a central position between the outer and the inner flanges. The usual eighth of an inch space allowance for impression material should be present. The flanges should not impinge on the buccal, labial or lingual

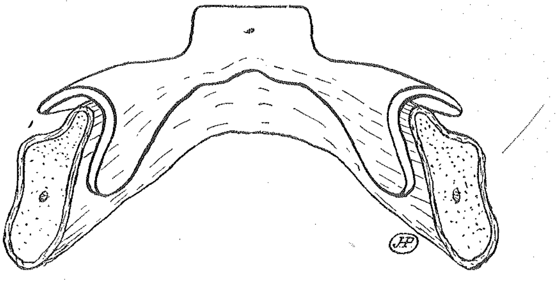


Fig. 20.—Lower Tray Adapted to Border Showing Uniform Space for Impression Material

muscles or franæ. This requirement is essential in order that their subsequent movements may be unrestricted.

When considerable absorption of the border has occurred, either uniform or unequal, a preliminary impression in wax or modeling compound should be taken, the excessive surplus trimmed away, and this modified impression used as a tray.

Frequently, by extending the lingual wings of lower dentures distally, when the shape of the mandible permits, and muscular attachments do not interfere, much greater stability of the substitute is assured. If such a plan is feasible, a tray with deep lingual wings should be selected, or if the tray at hand most suitable in other respects is deficient in this, additions of suitable length to carry the impression material against the desired areas should be made with wax or compound, and tested in the mouth before attempting to take an impression.

The tendency in selecting trays for lower cases is to choose one with too wide buccal and too narrow lingual flanges. The plaster is mixed as described for upper cases. It should be distributed in the tray in a uniform layer about one-fourth of an inch thick, confining it within the tray flanges.

POSITION OF PATIENT

The position and elevation of the patient in the chair should be about the same as in taking impression of the upper arch.

POSITION OF OPERATOR

The operator should stand on the right side, somewhat in front of, and facing the patient. Some prefer to lower the chair a trifle below the point designated, and stand back of

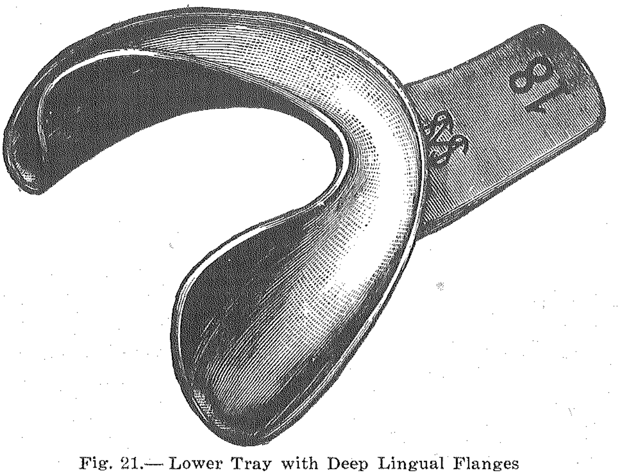


Fig. 21.— Lower Tray with Deep Lingual Flanges

the patient during the manipulative procedures. The first described position is to be preferred in most cases, for, as before stated, the line of vision is less obstructed and the hands have more freedom of movement than when the operator stands behind the patient.

INTRODUCING THE TRAY

The operator holds the inverted tray between the thumb and index and middle fingers of the right hand, the thumb beneath and the index finger on the handle, the middle finger resting on the right side, just back of the first finger. The index finger of the left hand distends the right angle of the patient's mouth. The left angle of the tray is inserted in the left angle of the mouth, while with a deft rotary movement the tray is brought into position over the border.

When the operator assumes the position back of the chair, the right angle of the tray is inserted in the right angle of the mouth, while its left angle is rotated into position through the left angle of the mouth, which is being distended with the operator's left index finger.

SEATING THE IMPRESSION

The technic of carrying the impression to place is as follows — the operator standing in front of the patient: The tray being centralized, the index fingers are placed on either side of the body, the thumbs under the mandible, and pressure applied to carry it partially to position. Now place the thumb of one hand under the mandible, the index finger across the tray body to steady it, and grasp the cheek well back with the thumb and index finger of the other hand and pull outward, to draw any folds of the cheek or buccal muscles outward that may have been caught under the tray margins.

Reverse the hands and carry out the same procedure on the opposite side. Grasp the lip in a similar manner, drawing it out from under the tray margin. Instruct the patient to lift the tip of the tongue up and touch the high part of the vault. These movements clear the tray margins of all abnormal muscle folds. With thumbs under the mandible and index fingers on the sides of the tray, the latter is forced down to place. Now steady the tray by placing the index and middle fingers of one hand across it from side to side, thumb under the mandible, and with the other apply pressure on the outer side of the cheek and lip to force the surplus plaster along the flange margins into close contact with the border.

Reverse the hands and carry out similar steps on the opposite side. With each free hand, in turn, pass the index finger around the periphery of the lingual flange margin to adapt the plaster in this location also, particularly under the tongue and along the disto-lingual surfaces.

"MUSCLE MARKING" THE IMPRESSION

Steady the tray with both hands and instruct the patient to exert active muscular effort with cheeks, lower lip and tongue, to indicate clearly in the plaster the muscular attachments. As before stated, the time required to carry out all of these several steps ought not to exceed thirty or forty seconds, for the final *muscle marking* must be accomplished while the plaster is still soft and capable of yielding to moderate pressure.

REMOVAL OF THE IMPRESSION

Lower impressions require a little longer time for hardening than do uppers, because of the excess of moisture present, the saliva usually accumulating in excessive quantity and retarding the crystallization somewhat.

When well hardened, the impression is loosened by gently pulling the lips and cheeks away from the outer flange. Traction up and down on the tray handle is made at the same time, and the air finds its way readily between impression and tissues.

Should the lingual wings extend downward and outward, the anterior part of the impression should be raised above the border and the tray carried back a short distance. As the space between the lingual borders widens constantly from before backward, this brings the flanges into more open territory. By tipping or lifting one side of the tray higher than the other and rotating the elevated side forward, the impression can be disengaged and rotated out of the mouth, usually without fracture. Inspect it carefully before allowing the patient to rinse the mouth, and if fractured, recover the broken pieces, place in position, and lute with wax.

PARTIAL IMPRESSIONS OF THE MOUTH IN PLASTER

Partial cases are those in which some but not all of the natural teeth are missing. Substitutes designed for such cases contain a less number of teeth than are usually placed in full dentures. For obvious reasons, therefore, an impression of such a case, although usually involving as much area as an edentulous one, is termed a *partial impression*.

While partial impressions may be secured in plaster alone, as a rule a preliminary impression in wax or modeling compound, corrected before introducing the plaster by freely enlarging the impressions made by the teeth, and cutting away the excessive surplus, will yield more accurate results than plaster alone.

In practically all cases of partial impression work where plaster alone is used, the tray, having been previously oiled on the inside, is removed as soon as the plaster has set.

The operator, being familiar with the undercuts present and spaces between the teeth, cuts the impression in suitable places to weaken it, so that with a little effort it may be fractured and removed in pieces. Sometimes the breaking of one or two pieces is sufficient to release the impression so that it will come away in very nearly a whole condition. Again, when teeth and spaces alternate, the teeth being long and having constricted crevices, the impression must be broken in a number of pieces to effect its removal. In all cases an effort should be made to break away all areas that, if not disconnected, would either injure the tissue or be marred or destroyed in the removal of the impression. If the fractured pieces are not too small, and are of reasonable thickness, presenting clean-cut fractures, the impression may be practically restored, even though broken in many pieces. The accuracy of the impression depends on how perfectly the broken parts are reassembled.

The wide flange trays designed by Dr. Angle are intended for carrying the impression material, not only against the labial, buccal and lingual surfaces of the teeth, but for holding it in contact with these surfaces of the alveolar border as well. When a tray with narrow flanges is used in partial cases, the necessity for using wax or modeling compound as a preliminary impression material for increasing the width of the flange is apparent.

CLASSIFICATION OF COMMONLY OCCURRING PARTIAL CASES

Partial cases may be grouped into six general classes, according to the teeth lost:

Class I.— Posterior teeth on both sides missing; anterior teeth in place.

Class II.— Posterior teeth on one side missing; opposite and anterior teeth present.

Class III.— Anterior teeth missing; posterior teeth on both sides in place.

Class IV.— Anterior, and posterior teeth on one side missing; posterior teeth on opposite side in place.

Class V.— Teeth and spaces alternating with more or less regularity.

Class VI.— An occasional tooth missing.

Impressions of Partial Cases

Combination of Modeling Compound and Plaster — Class 1

SELECTING THE TRAY

A tray of the flat-bottom type, with flanges of moderate width that will not impinge on the muscles, is best adapted to this case. Place sufficient softened compound for a regular impression in the tray, building it up thicker where the teeth are missing than anteriorly. The compound should be disposed in the tray to conform as nearly as possible to the surfaces being copied, and be reasonably soft.

TAKING THE PRELIMINARY IMPRESSION

Introduce filled tray in the mouth, centralize and press up slightly. Steady with one hand and draw lip and cheek muscles outward to prevent them from folding inwardly, and press to place.

Steady the tray and apply finger along buccal and labial surfaces, to secure sufficient height and peripheral adaptation.

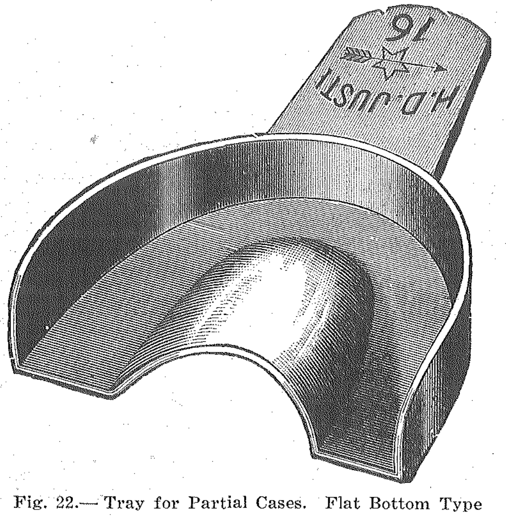


Fig. 22.—Tray for Partial Cases. Flat Bottom Type

Instruct patient to exercise buccal and lip muscles freely to indicate their position. Chill with cold water applied with napkin, sponge or syringe, or with cold air, and remove.

PREPARING THE PRELIMINARY IMPRESSION FOR THE PLASTER

Trim off excessive surplus buccally, distally, and peripherally. Enlarge freely, both labially and lingually, the impressions made by the teeth. Frequently the larger part of the anterior portion of the impression is removed to give greater bulk to the plaster which surrounds the teeth.

TAKING THE FINAL IMPRESSION

Mix the plaster to medium consistency, place in the tray to the depth of an eighth of an inch or so, quickly introduce in the mouth, partially carry to place, centralize and press it up against the teeth so they will occupy about the same relation to the tray flange as in the first impression.

Steady the tray firmly, draw the lip over the labial flange, and the buccal muscles away from the impression margin.

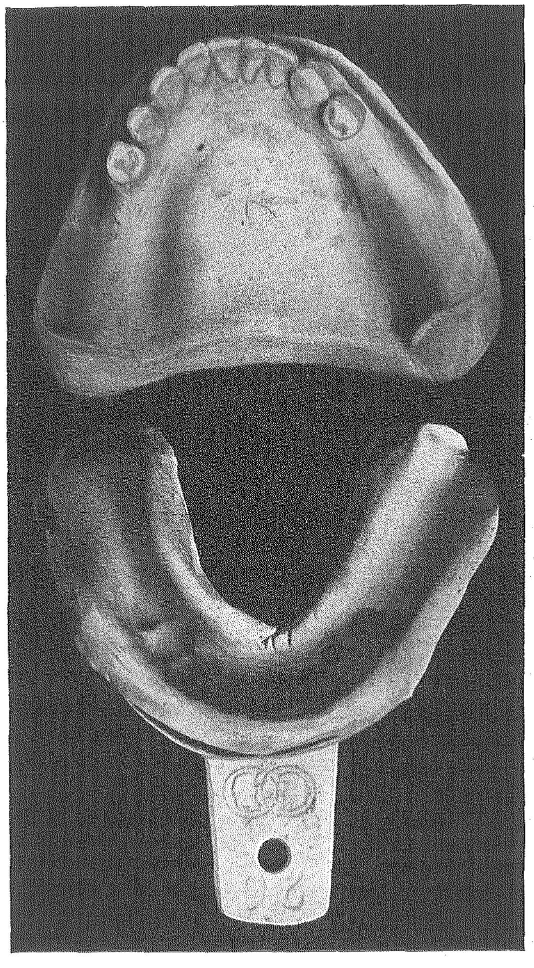


Fig. 23.— Preliminary Impression in Modeling Compound

With slight vibratory movement and moderate pressure, carry the tray to place.

With outside pressure against the lips and cheeks, adapt the plaster which extends above the compound margin to the border, holding the tray firmly while doing so. Instruct the patient to exercise the buccal and labial muscles freely and vigorously.

REMOVING THE IMPRESSION

When set, traction on the tray handle will loosen the impression, although if the teeth are long, considerable force may be required to dislodge it, since in most cases the plaster impression must necessarily be fractured. On removal, place the impression within convenient reach on the bracket, and recover the fractured pieces before permitting the patient to rinse the mouth. As each piece is removed it is placed out-

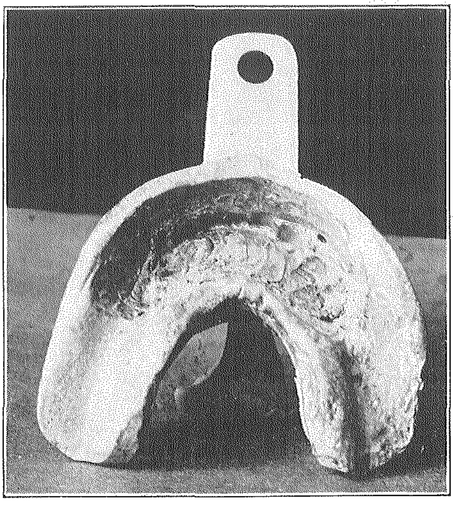


Fig. 24.— Preliminary Impression Enlarged to Receive Plaster for Final Impression

side of the impression periphery, but as near to its proper position as possible, to simplify the adjustment of the several parts later.

ASSEMBLING THE FRACTURED PIECES

The fractured surfaces of both the impression and the pieces are cleared of small adhering particles with a moderately stiff camel's hair brush. Care should be taken to clear the general surfaces of the modeling compound matrix of debris at the same time. The character of the fracture determines the order of assembling, those pieces in the deepest portion of the tray or compound matrix being usually first placed in position.

The pieces are luted together by applying a little wax to the fracture lines at various points, usually outside, in such manner as not to form an accretion to the impression proper and thus change its form. Wax does not adhere firmly to damp plaster unless the latter is well heated. To effect a good union of the pieces, a spatula is heated almost to redness and applied to the small piece of wax already placed on the fracture line. The spatula should be laid against the plaster so as to heat it quite hot. The wax in the meantime is melted and penetrates the substance, thus cementing the pieces together much more firmly than when the union is superficial.

Class 2

BICUSPIDS AND MOLARS OF ONE SIDE MISSING

A flat-bottomed tray, similar to No. 16, is selected, and wax or compound heated and adjusted for a preliminary impres-

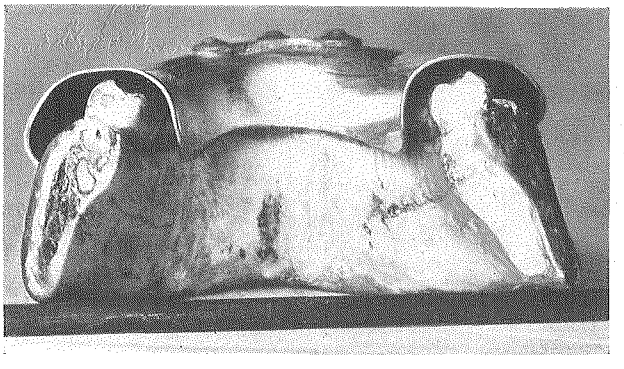


Fig. 25.— Angle Tray Adapted to Border and Natural Teeth

sion, placing it thicker on the one side where the teeth are missing than elsewhere, to make up for loss of teeth and tissues.

The general steps for securing the impression are similar to those in Class 1. When removed, the impression material is freely cut away around the impressions of the teeth, both labially and buccally, as well as lingually, to give ample space for the plaster which is to enclose them.

Class 3

ANTERIOR TEETH MISSING; BICUSPIDS AND MOLARS ON BOTH SIDES PRESENT

The same general style of tray is selected as in the preceding case. Wax or compound for preliminary impression is introduced in the form of rather a wide roll extending from labial flange, over vault portion, to distal margin of tray.

The impression, when taken, will not extend out to the buccal surfaces of the teeth, nor will it usually be necessary to include them in the preliminary impression, since the tray flange is usually wide enough to support the plaster against the buccal surfaces of the teeth and the adjacent gingival margin of the border as well. However, if it is necessary to secure an impression of the entire buccal surfaces of the border, the tray flange can be increased in width by spreading the preliminary impression material over the entire tray.

Class 4

ANTERIOR AND POSTERIOR TEETH ON ONE SIDE MISSING; THE OPPOSITE POSTERIOR TEETH IN PLACE

The same general style of tray can be used as in the preceding class. The compound should be thicker on the side where the teeth are missing. The preliminary impression is obtained, trimmed and enlarged at the proper points, and the final impression secured in plaster.

Class 5

TEETH AND SPACES ALTERNATING WITH MORE OR LESS REGULARITY

Teeth and spaces alternating, in impression work, usually requires that the impression will be broken into several pieces in order to effect its removal. Such a case always requires special care to secure accurate results.

The usual routine described for the preceding cases is applicable here, although with a deep-sided tray of the Angle type, oiled inside to prevent the plaster adhering, will often times prove more satisfactory than the combined impression. In fact, the Angle tray can be used for most any of the partial cases described, either with plaster alone, or combined with wax or modeling compound. The one serious objection to its use is due to the very wide flange, preventing ease of finger adaptation of the impression material.

Class 6

AN OCCASIONAL MISSING TOOTH

These cases are handled in a similar manner to the preceding class. A preliminary, compound or wax, impression is taken, enlarged and used as a receptacle for the plaster.

Frequently, however, where teeth and spaces alternate throughout a considerable extent of the arch, a properly selected Angle tray, oiled to more readily part from the impression, and with plaster alone used as the impression material, will prove as satisfactory as the combined use of compound and plaster. The vault adaptation can, in most instances, be much improved with wax or compound additions On removal of the tray, the plaster which fills the spaces is notched and pried apart, to release the impression.

TO BREAK AN IMPRESSION ALONG DEFINITE LINES

Strips of sheet wax are attached edgewise to the floor of the tray, and so adjusted as to pass into the spaces where the teeth are missing. These strips, if properly adjusted, will serve to divide the plaster in a similar manner, but more effectively than can usually be done by notching with a knife. By inserting the knife blade into the wax and prying slightly, the impression can easily be broken.

TAKING IMPRESSIONS OF ELONGATED AND LOOSE TEETH

It is frequently necessary to secure an impression of one or more elongated or loose teeth, which if taken in the ordinary manner would very likely result in injury to the already weakened peridental membrane of the tooth, or at least cause the patient some discomfort.

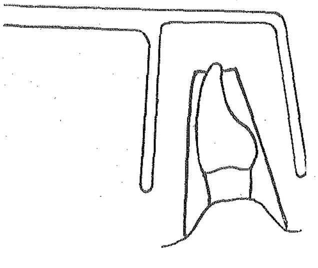


Fig. 26.— Sectional View of Plaster Cores, Natural Teeth, and Impression Tray

The following method, if carried out as detailed, is convenient, accurate, and practically painless:

Mix a small amount of plaster of medium consistency, and apply to the lingual surfaces of the loose teeth and as much of the process as the final impression should cover in this area.

If other teeth are present, it may sometimes be best to extend the impression so as to include them for subsequent support. Now mix some plaster of medium consistency, and with the point of a spatula apply to the lingual surfaces of the teeth, making such additions as to give reasonable thickness to the body of the impression. The plaster should be forced into the embrasures and extend from where peripheral plate line will rest to the incisal edge. Should the embrasures be open, the plaster contained in them, which is forced labially to the point of shortest diameter of the space, should be removed with excavators, so that this half of the impression may be removed lingually without difficulty.

When set, this portion is removed and trimmed smoothly, so as to flare from gingival to incisal or occlusal surfaces. It is then entirely coated with separating fluid and returned to its former position in the mouth. Another mix of plaster is applied to the labial or buccal surfaces, securing good adaptation to those surfaces, and against the lingual body of plaster presenting in the embrasures and at the incisal or occlusal surfaces. When the plaster is hard, insert the point of an instrument between the two halves, carefully pry them apart, and remove. Trim them so that when again returned to the teeth and set in position, they form a truncated cone, the base of which rests against the alveolar process, the smaller end coming even with or covering the incisal or occlusal surfaces, as the case demands. Usually the two pieces will be retained firmly in position without tying, but they can be ligated together if necessary. In trimming, reduce the pieces labio or bucco-lingually as much as possible, yet without weakening them, so that there will be no excessive bulk to interfere with the next step.

Now fit a tray over this matrix, or in reality the *core-to-be,* and see that it also conforms elsewhere to the tissue to be included in the impression. Either plaster or modeling compound can be used for the impression material, as the case requires. The impression is obtained in the ordinary manner, and removed. When the matrix or core has been properly flared, the impression will part from it without difficulty. The two halves of the matrix are now removed from the teeth they enclose, placed in their respective positions in the impression, and luted firmly with wax.

This method is especially valuable in taking impressions of teeth in pyorrhea cases. It is also capable of application to a variety of difficult conditions that are frequently met with in practice.

IMPRESSIONS IN MODELING COMPOUND

When manipulated properly, in well selected cases, modeling compound is a most reliable impression material. By reference to the "Indications for the Use of Plaster," it will readily be seen when to avoid the use of modeling compound.

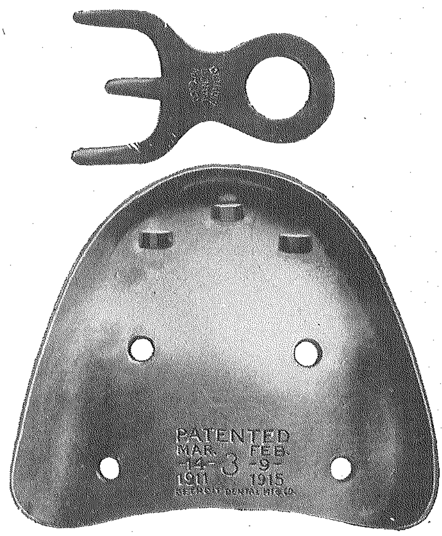


Fig. 27.— Palatine View of Kerr Tray Removable Handle

In probably 70 per cent of edentulous cases presenting, compound can be used to better advantage than plaster.

FULL UPPER EDENTULOUS CASES IN MODELING COMPOUND

The fitting of the impression tray differs in no respect from the fitting of a tray where plaster is used, except that the distal extension of the vault portion, so commonly required for plaster, is unnecessary when compound is used. Narrow flange, close-fitting trays of the Kerr-Greene type are especially indicated, although other forms of trays can often be used to advantage. The compound selected should become plastic at a low temperature, and harden quickly.

The Perfection Compound made by the Kerrs of Detroit fulfills the requirements better, perhaps, than any other material on the market. It is furnished in the form of cakes for impressions, and also tracing sticks for making additions when necessary to the periphery, or any area of the impression.

The amount of compound required for an impression, when the tray is close fitting, is very slight, usually less than one-half a cake.

SOFTENING THE COMPOUND

The modeling compound is thoroughly warmed, preferably in hot water, removed, and the moisture taken up with a towel or napkin. With the fingers it is formed into a ball, working the wrinkles from above, underneath. This ball is then set

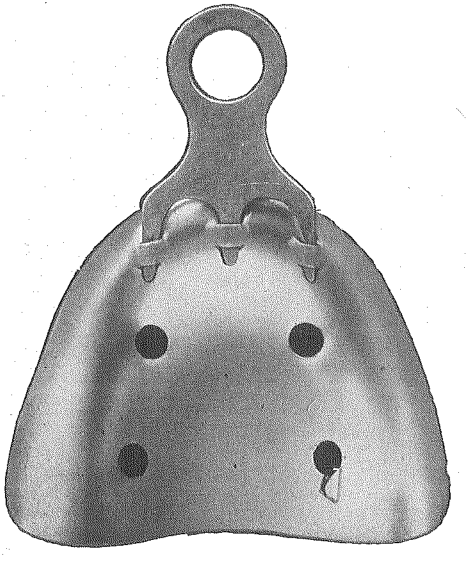


Fig. 28.— Lingual View of Upper Tray

in the center of the vault portion of the tray, and with the fingers the compound is disposed against the flange so as to assume the general form of the impression. Or the compound may be worked out in a sheet of more or less uniform thickness, and disposed evenly in the interior of the tray. The former method is to be preferred, as a perfectly smooth impression surface is readily secured, while with the latter method, creases are apt to form while adjusting the material.

The tray is heated around the flange and maxillary portion, over a small frame, to cause the compound to adhere to it slightly. The tray is inverted and the surface to be impressed is reheated over the flame, to render it soft and plastic. It should then be quickly dipped in warm water to prevent the compound sticking to the tissues while passing through the lips.

INTRODUCING THE FILLED TRAY

The tray is then introduced in the mouth by the same method of procedure as outlined under the head of "Full Cases in Plaster." In fact, almost the same technic is followed with compound as with plaster, viz.: centering the tray; partial seating of the impression on the ridge; drawing out the lip and cheeks from the flange margin; carrying the impression to place under pressure; forcing the peripheral surplus in close adaptation to the tissues, particularly along the distal vault portion. The index and middle fingers of both hands can be applied to the compound which extends distally beyond the tray margin, to lift up and hold it in contact with the palatine tissues. These fingers can alternately support the tray, and develop adaptation of the compound to the tissues from one tuberosity to the other.

When the adaptation is completed, moderate pressure is maintained on the central portion of the tray, and the impression chilled with cold water, applied with syringe or small sponge or napkin.

On removal, the impression is inspected closely to see that all essential areas have been copied. The excessive peripheral surplus is then trimmed away and the sharp angles caused by the cutting smoothed off. Should there be any slight deficiency at any point, a little heated compound applied with the tracing stick and the impression returned to place and firmly seated will correct the error.

PERIPHERAL READAPTATION

The impression, as it now stands, even if the steps have been accurately carried out, is no better, and quite likely not as good, as an ordinary plaster impression.

The efficiency of modeling compound lies in the fact that with proper technic the soft areas of the mouth may be compressed, and a corresponding relief from pressure on the hard area be secured. As a result, the denture, when constructed, will bear uniformly on the hard and soft areas alike, and in those cases of prominent, hard raphæ, practically entire relief from pressure may be afforded.

To secure the compressive effect of the compound, the impression, on removal, is thoroughly chilled, the surplus trimmed away, and the entire impressed areas heated quite hot over a small Bunsen or alcohol flame, to the depth of about one-sixteenth of an inch. In this condition it is again returned to the mouth, properly seated, the muscles drawn outward, and steady pressure applied for two or three minutes. The amount of force necessary to apply varies from three to ten, or even fifteen pounds, according to conditions. Extremely soft, spongy, but not resilient, tissues are copied better with moderate, while harder areas require a greater amount of pressure.

DISTRIBUTION OF THE PLASTIC COMPOUND UNDER MAINTAINED PRESSURE

When the layer of softened compound is of uniform thickness and is sufficiently plastic, under continued pressure the material gradually flows from the hard to the soft areas, compressing the latter and relieving the pressure on the former, until a sort of equilibrium is established. If care is taken in carrying out the technical details, the finished denture will have a similarly uniform bearing on the tissues, which will add greatly to its stability.

At the time of forcing the impression up against the tissues, the excess compound is naturally moved from the interior of the tray, externally and over the flange margin. The tendency is for the compound to curl outward, away from the process. It therefore becomes necessary to readapt the periphery of the impression to the border, to seal against the ingress of air. This step is accomplished as follows:

PERIPHERAL READAPTATION

On removal of the impression the second time, it is chilled and the peripheral margins, buccally, labially, and lingually, are reheated. It is again returned to the mouth and seated. With the index finger the softened margins are firmly pressed into close contact with the border, buccally and labially first, correcting the vault portion last. Sometimes, however, the adaptation of this margin is carried out as a separate, final step. Only the periphery is softened in this rim adjustment, since if the whole impression is reheated, the effect of the previous compressive steps would be lost and adaptation would be impaired.

The impression can be tested as to adaptation by having the patient make muscular effort to displace it or by biting on something to see if it can be tipped. The removable handle trays of the Greene type are very convenient for testing the stability of the impression. They are also, on account of their small size and generally correct form, especially adapted to work in edentulous mouths with compound, either alone, or combined with plaster.

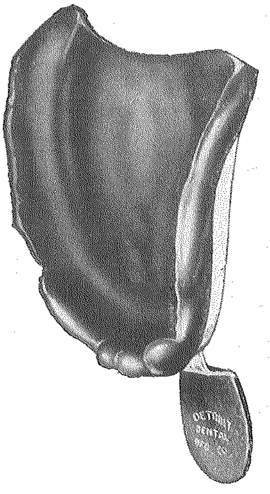


Fig. 29.— An Upper Impression Showing "Muscle Trimmed" Margins

If the impression is readily displaced by the patient's efforts — can be thrown down in laughing, speaking, biting, or even coughing — the adaptation is not perfect, and an effort should be made to determine the weak point and correct it.

A SUMMARY OF STEPS IN MODELING COMPOUND IMPRESSION WORK

To summarize, the steps for compound impression work are as follows:

Examination of the mouth.

Selection and adaptation of tray.

Heating and adapting modeling compound to tray.

Introduction into mouth, and centering tray.

Partial seating of the impression.

Steadying tray while lip and cheek muscles are pulled outward from tray margin.

Carrying tray to place under medium pressure.

General adaptation of peripheral surplus.

Muscular exertion by patient to indicate location and extent of muscular attachment.

All of these manipulative details should be quickly carried out, so that the last step mentioned may be accomplished while the compound is still capable of yielding under the stress of, and being indented by, the lip and cheek muscles.

On removal the impression is chilled, the surplus moisture absorbed, the impressed areas heated to a depth of one to one and one-half millimeters, and the tray returned to the mouth. It is correctly seated, and steady pressure applied for two or three minutes, or until fairly well hardened.

Remove, chill, soften the peripheral margin to the depth of about two millimeters, and return to the mouth.

Adapt labial and buccal periphery to the process, and the distal margin of the vault portion to tissues, using finger pressure, applied directly to the compound rim.

Test stability; if satisfactory, remove, heat the periphery to a slight depth, and quickly return to the mouth for final muscular adaptation by the patient.

Now remove the impression, again examine the vault portion of the mouth to determine the extent of the hard area, and with a scraper relieve that portion impressed by the raphe to the depth of one-fourth to one millimeter, depending on the condition of soft tissues.

Return to the mouth for final trial. As before intimated, the best way to test an impression is for the patient to subject it to every muscular action the denture will be subjected to, as well as its resistance to tipping stress. In no case will the cast derived from an impression be more accurate than the impression itself. It therefore follows that if an impression is easily dislodged, the resultant denture will be even more readily dislodged than the impression.

IMPRESSIONS OF LOWER EDENTULOUS CASES IN MODELING COMPOUND

The general details of handling modeling compound, as just described for upper, applies in many respects to the lower cases as well.

The fitting of the tray; heating and placing the compound; introduction into the mouth; centering; partial seating; drawing the tissue folds out from under the tray margin; forcing the impression to place; steadying tray while general adaptation to the border is secured by pressure on lips and cheeks, are similar in detail to upper cases.

The adaptation of the compound against the lingual surfaces should be carefully wrought out. When the steps have been carried out as just mentioned, the tray should be held firmly in place and the compound adapted to the lingual border with the fingers, being especially careful to secure as perfect adaptation against the lower disto-lingual tissues as possible. The final test for the depth of impression is obtained by contraction of the mylo-hyoid muscles.

On first introducing the impression, the patient should elevate the tongue while the operator directs the compound into correct position with finger pressure. When adapted, the compound is chilled, the impression is removed, and the excessive surplus is trimmed away. The impressed areas are then reheated and the impression again returned to the mouth. After drawing the muscles from under the tray margins, pressure is applied to force the compound from hard to soft areas, as previously outlined, peripheral adaptation with finger pressure is secured, and the impression is chilled and removed.

A method for securing close peripheral adaptation of lower dentures to the process, with relief from pressure on the crest of the border, is suggested by Dr. J. W. Greene. A stream

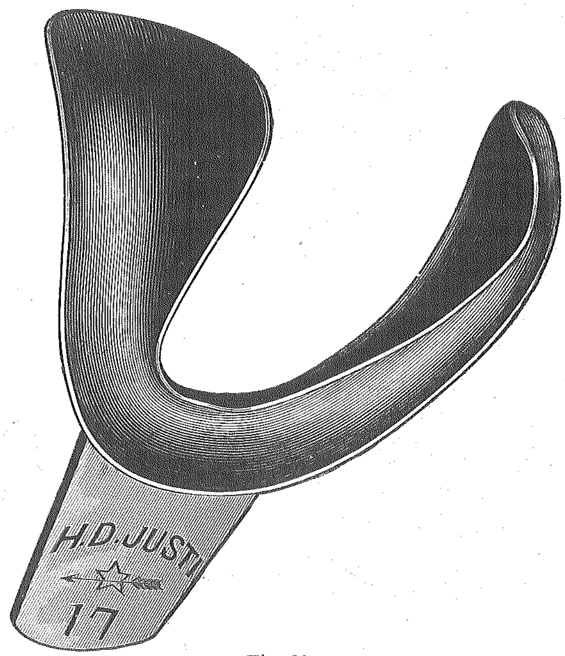


Fig. 30

of hot water from a small-spouted vessel is allowed to run through the deepest part of the impression until the compound in this location is thoroughly softened, care being taken not to heat the edges. The entire impression is then quickly dipped in hot water so as to soften all of the impressed areas to a slight extent. The impression is then quickly returned to the mouth, and with a springy or "wave like" motion, it is lightly pressed down upon the border, chilled and removed.

PARTIAL IMPRESSIONS IN MODELING COMPOUND

There are few partial cases, indeed, where modeling compound will meet the requirements as well as plaster. Almost without exception in the class of cases under consideration, undercut surfaces are present, which can only be copied by an unyielding material that will break on removal, or by taking a sectional impression which can be separated along predetermined lines.

Modeling compound can be used to advantage in sectional work, the character and extent of the undercut surfaces determining the form and number of the sections. The manner of procedure is as follows:

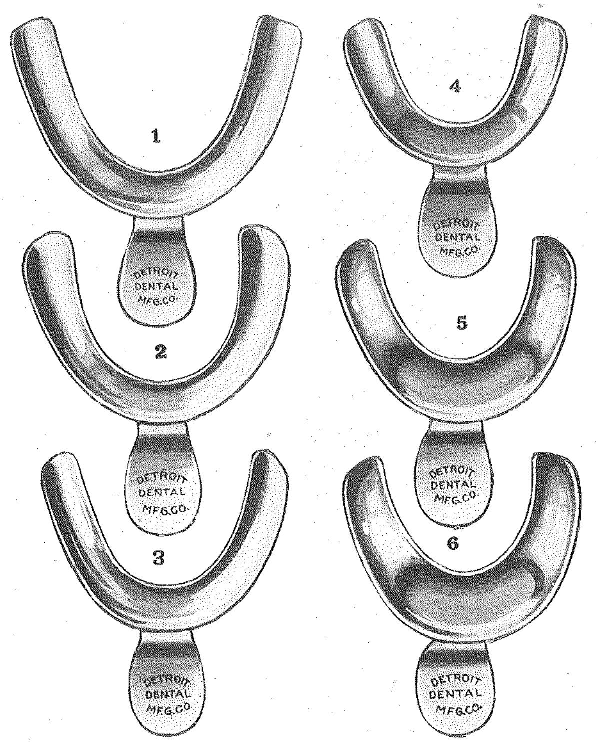


Fig. 31.— Various Sizes of Narrow Lower Trays Suitable for Badly Absorbed Borders

The form of the first section is decided upon. Compound is applied slightly in excess of what is needed to form this part. When cool, it is properly shaped and those surfaces of the first section which form contact areas with the second section, are varnished with shellac, and before it has become dry thin tin-foil is spread evenly over them and laid down smoothly. When this first section is chilled and the tin-foil slightly oiled, the next section can be adapted to it, and by quickly chilling the latter no change of form will occur in the first section.

The two or more sections necessary to inclose teeth with constricted necks, fill undercut spaces, or open embrasures, should be so trimmed as to permit the impression proper, in which they are finally inclosed, to separate from them without distortion. On removal of the impression, the sections are separated and placed in their respective locations in the matrix formed by them in the impression. They may be held firmly in position by luting a little wax along the joints. Either compound or plaster may be used for the general impression material in these cases of "coring." If the former is used, the entire core should be covered with foil and oiled, and the manipulative procedures carried out rapidly, so that the inherent heat in the sectional material may not soften, and the pressure in placing it distort the impression. With plaster, as an impression material, the oiling of the cores is sufficient.

CHAPTER VIII

TREATMENT AND FILLING OF IMPRESSIONS

PRODUCTION OF CASTS

As previously stated, the degree of success attained in denture construction depends on the development of three essential requisites, viz.: *usefulness, good looks* and *comfort.*

The realization of two of these, usefulness and comfort, depends primarily upon the impression and the cast derived therefrom, since the latter gives the reverse form to the denture. The necessity, therefore, for accuracy in impression taking and cast construction is imperative, for, if the foundation is faulty, the superstructure will fail. A defective impression invariably yields an imperfect cast. It does not follow, however, that a satisfactory impression will always yield a perfect cast. The accuracy of the cast depends upon the care and precision exercised in its production.

The technique of cast construction is similar, whether the impression is of plaster or of modeling compound. The details differ slightly. Each class will be taken up separately, and the important details noted.

TREATMENT OF PLASTER IMPRESSIONS IN EDENTULOUS CASES

Certain preparatory steps must be carefully carried out in the impression before the cast is produced:

First — The impression should be examined closely to see that it is intact. If broken, the pieces should be placed in correct position, firmly luted with wax, and the impression itself secured in the tray.

Second — The scraping of those parts impressed by the hard areas of the mouth, as detailed in a previous chapter, should be carefully executed, and the impression freed from debris with a clean sable brush.

Third — A staining medium which will penetrate to the depth of 1 to 2 mm. should be applied to the exposed surfaces, so that in cutting the impression to weaken it, in removal from the cast, the stained portion will indicate the near approach to the line of demarkation between the two, and thus prevent injury from the knife.

Fourth — A separating medium must be applied to the impression to prevent the plaster constituting the cast from becoming so firmly adherent to it that the two cannot be separated without defacing the cast.

The reason why a second addition of plaster adheres to one previously hardened, unless steps are taken to prevent, is due to the fact that plaster crystallizes in setting and the crystals are grouped so as to leave many spaces between, as has been previously shown. The face of an impression presents just such a formation. It has also been shown that in a fresh mix of plaster, the granules of the half hydrate are actually dissolved in the water, and that in and from this solution the crystals of di-hydrate form.

Where such a mixture is applied to a surface of plaster previously set, the solution, to a certain extent, is taken up by, and fills some of the interspaces in the hardened plaster, and there crystallizes. These crystals are in reality so many irregular points projecting from the freshly set plaster, extending in various directions into the face of the previously set mass, thus anchoring the two bodies of plaster together.

In separating the two, many of these projecting crystals are necessarily broken, and in breaking, the faces of both masses are more or less injured. Sometimes the two masses adhere so closely as to render separation impossible without destroying the cast and impression as well. The remedy lies in literally waterproofing the surface of plaster against which the fresh mix is to be cast, which prevents the plaster in solution from entering the spaces referred to.

The selection and proper application of suitable staining and separating mediums is therefore of the greatest importance where the production of accurate casts is desired.

STAINING FLUIDS

A staining fluid should be capable of penetrating either moist or dry plaster to a depth of 1 or 2 mm. for reasons before stated. Since its purpose is to stain only, it should be absorbed by the plaster to which applied, without forming a film on the surface.

A thin alcoholic solution of orange shellac is a most excellent medium for staining. If used thin, quite a dark tinge may be imparted to the impression by applying two or three coats without glazing the applied surfaces. Each application should be allowed to dry before the next is laid on.

An aqueous solution of some of the analine colors is frequently used, but, unless carefully handled, will stain the fingers, and is difficult to remove. Coloring matter is sometimes added to the separating medium, the idea being to convert it into a staining medium as well.

Most separating mediums, however, do not penetrate the plaster to any appreciable depth, and therefore the stain is confined very closely to the line of demarkation between the impression and the cast. The stain applied to an impression in this manner will not give sufficient warning when cutting the impression away, and in partial cases especially, the cast is very liable to be injured. The aqueous solutions to be described later may, by adding a suitable pigment, be effective both as a separating and staining medium.

SEPARATING MEDIUMS

The preparations used for separating purposes are known under various names, as *separating* or *parting* mediums, fluids, varnishes, etc. They may be procured of the supply houses, or compounded in the laboratory with very little effort.

REQUIREMENTS

To accomplish the desired result, a separating medium to be used in cast production particularly, should possess certain requisite qualities:

First—It should be impervious to moisture, after being applied to plaster and allowed to dry.

Second—It should not modify the areas covered to any appreciable extent, and hence, should be effective when applied in an extremely thin film.

Third—It should present a smooth, glazed surface when dry, so as to produce a correspondingly smooth surface to the cast.

Fourth—It should have sufficient cohesiveness to stick to the applied surface, and not become adherent to the cast.

Fifth—It should dry or harden quickly, and not combine chemically with the plaster, or be subject to deleterious change itself.

CLASSIFICATION OF SEPARATING MEDIUMS

A simple classification of the separating mediums in common use are here presented:

Alcoholic solutions
Ethereal solutions
Aqueous solutions
Oils

Alcoholic Solutions

SANDARAC VARNISH

Sandarac is a resinous exudate from the *Thyia Articulata* of the pine family, which grows in northern Africa. The gum exudes from the tree in the form of small globules, called tears, ranging in color from pale yellow to brown. The light variety is considered the best, and selected tears of this color should be used in making the varnish for separating purposes. It combines in various proportions with alcohol, but if too small a percentage of the latter is used in its composition, or if the alcohol is allowed to evaporate, the varnish becomes too thick for use in accurate cast production. If from any cause it is too thick, the addition of a little alcohol will, after standing a time, reduce it to proper consistency.

Sandarac and alcohol in the following proportions make a satisfactory varnish for separating purposes:

Selected light sandarac..................	6 oz.
Grain alcohol	24 oz.

Digesting in a water bath of moderate temperature will aid in dissolving the gum.

It is not advisable to add a pigment to this varnish in order that it may serve as a staining medium also. Sandarac varnish does not penetrate the surface of plaster to any appreciable depth, and the stain will not extend beyond the depth penetrated.

The best plan is to stain the impression, as before suggested, with thin shellac, which readily penetrates, and after it is dry, apply the sandarac. If of proper fluid consistency, one coat of sandarac is sufficient. If rather thin, two coats should be applied, allowing the first to dry before making the second application, and the second should be dry before making the cast.

ETHEREAL SOLUTIONS

Under this division two substances will be described which are dissolved in ether, viz.: collodion and soap.

COLLODION

Collodion may be procured at any drug store, or it can be compounded in the dental laboratory. It is made by dissolving gun cotton in ether, using enough of the latter to make a thin, syrupy liquid. Since gun cotton is highly inflammable and ether also, to a lesser extent, care must be exercised in making the solution to keep it away from a flame. The impression should be stained, as previously described, before using collodion as a separating medium.

ETHEREAL SOAP

Ethereal soap is frequently used in the class of work under consideration. A fine quality can be procured from drug houses, and if used properly on a previously stained impression, will serve as a good separating material.

Aqueous Solutions

BORAX AND SHELLAC

A saturated solution of borax in water will dissolve shellac, producing a fluid capable of staining the impression. This is really the only separating medium that combines both staining and separating qualities so as to get the desired results. It can be compounded in the dental laboratory as follows:

Water in large-mouth bottle............	1 gal.
Borax	½ lb.

By applying heat (water bath) and stirring occasionally, the water becomes saturated. A little excess of borax remaining in the bottom of the vessel will do no harm, and insures full saturation of the water.

To this solution add ½ lb. of ordinary brown shellac in flakes, and let stand a few days. It will be gradually dissolved, and the liquid will assume a purplish tinge, due to the action of the borax on the shellac. The solution of the shellac may be hastened by the application of moderate heat, and also by stirring occasionally. A white scum arises to the surface of the fluid, which should be removed before bottling. By siphoning the liquid out of the bottle, neither the scum on top nor the excess of borax and shellac in the bottom will be disturbed. The best quality of medium is produced by allowing the solution to stand a week or more, stirring occasionally, before siphoning into bottles. It should be kept tightly corked when not in use, to prevent evaporation of the water.

In using this as a separating medium, it should be applied freely and quickly with a fair-sized brush, bathing the entire impression surfaces with the liquid. The brush should be used to distribute it evenly at first, and before it begins to thicken, to take up the surplus. The first application is absorbed by the plaster without leaving a decided film, and in this manner the impression is stained. When dry, a second coat is applied and also allowed to dry before producing a cast. The final coat should, and if properly applied will, present a smooth, glazed, thin, uniform layer on all surfaces covered, and enable the impression to be readily removed from the cast. The first mention of this solution that the writer is aware of appeared in Gorgas, Ed. 1895.

SOAP SOLUTION — AQUEOUS

Soap lather serves as a good separating medium when applied to a shellac stained impression. The soap should be worked well into the surfaces so as to fill the interspaces between the crystals, after which practically all excess should be removed with clear water and a clean brush. In partial cases, special care must be taken to free the impression of the teeth from the lather, or the air contained therein will prevent the settling of the cast plaster into the matrices, or impressions of the teeth.

WATER AS A SEPARATING MEDIUM

By thoroughly saturating a plaster impression with water, no other separating medium need be applied. The impression must be filled while saturated, and separated from the cast as soon as the latter has set. Very good results can be secured in this manner, if the precautions mentioned are observed. If, however, the impression and cast are not separated very soon after the latter has set, a union of the two occurs which will inhibit separation without injuring one or both.

OILS

Oils are not good separating mediums under any circumstances, although commonly used for flask separation, and sometimes in impression work. The surface of the cast plaster contains many minute air bubbles not present when some of the other mediums mentioned are used. Lard, sperm and the paraffin oils are usually used for this purpose. When employed as a separating medium, the impression should be previously stained with shellac.

GENERAL REMARKS

A thorough understanding of the physical nature of plaster and of the separating mediums in use is essential in securing accurate results. Carelessness in applying a medium to an impression usually results in an imperfect cast.

Care and attention to details is just as necessary in the class of work being considered, or in any of the other essential details of denture construction.

A chain is only as strong as its weakest link, and therefore an imperfect cast, regardless of how accurately all other details are carried out, will result in the finished denture proving more or less disappointing to both patient and prosthetist.

FORMS FOR CASTS AND MODELS

All casts, whether full or partial, upper or lower, should have flat bases with sides either parallel or slightly converging from the base to the peripheral face outline. The flaring form is essential when the cast is to be used as a model.

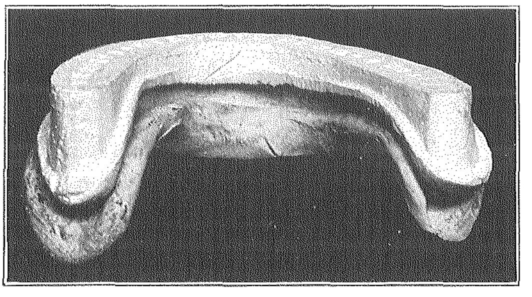


Fig. 32.— Testing Kerr Lower Metal Form to Impression Previous to Filling with Plaster

The central palatine portion of upper and floor of lower casts should be about one-half an inch thick to give stability throughout the various steps to which they are subjected in denture and die construction. In general the peripheral outline of casts should conform to those of the alveolar arches. In trimming, the peripheral surplus of plaster should be reduced, so as to bring the sides close to the reflection of the labial and buccal tissues, so that later on, in waxing and flasking, there will be no excessive surplus to interfere with these steps. The crescent shape so frequently given lower cases is not recommended because of the liability of the cast to break in removal of the impression, and later on, when detaching the cast from the occluding frame. This form may be adopted when the Kerr metal forms are used in conjunction with plaster.

CASTS FOR CELLULOID CASES

In constructing casts for celluloid cases, they should be made sufficiently thick and of a coarse variety of plaster, or some harder material, to withstand heavy stress. Spence's Plaster Compound makes a very resistant and satisfactory cast for celluloid cases, much better than any grade of plaster procurable. Casts for this class of work are made of the same general form as previously described.

Magnesium oxy-chloride is also an excellent material for casts for celluloid work, but is extremely difficult to remove from the denture.

CASTS FOR PLASTIC METAL BASES

Cast metal base plates are formed by casting aluminum, tin, tin alloys, or gold into matrices composed of some refractory investment compound. The usual materials used are finely ground silex, asbestos, pumice stone, marble dust, soapstone, etc., combined in varying proportions with sufficient plaster to fill the voids between the granules, and thus act as a cementing medium. The refractory material is incorporated to prevent cracking of the investment when heated, and because less change in form will occur when and while heated, than with plaster alone. Casts for this class of work are of the same general form as those previously described.

CASTS DESIGNED FOR MODELS IN THE PRODUCTION OF METAL DIES

In shaping a cast for a model it should possess certain characteristics:

First — Its sides should flare outward from face to base, at an angle ranging from 75 to 80 degrees from the horizontal, to facilitate its easy removal from the sand matrix.

Second — It should be as thin as possible to be consistent with strength, since, according to brass and iron molders, thin patterns or models are less apt to distort the matrix in removal than thick and bulky ones.

Third — The base should be flat, to afford a firm foundation for the model in packing the sand matrix.

Fourth — The base should bear such relation to the vault portion that the inclination of the latter upward from the deeper or alveolar portions of the matrix shall be uniform and highest at the distal margin. If the central vault portion is higher than the distal margin of the matrix, a dome-shaped space in the die results, in which gases accumulate and find vent through the partially solidified metal. This frequently causes so serious a defect as to render the die worthless. This danger is obviated by so forming the base of the model as to raise the anterior higher than the posterior portion. It may also be obviated by packing sand under the anterior portion of

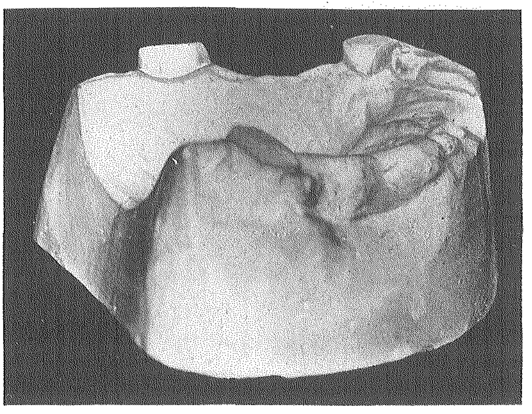


Fig. 33.— Plaster Model Showing Projections of Trimmed Teeth

the model and elevating it in this manner, before placing the molding ring. The better plan is to develop the correct form of the model in plaster.

CASTS DESIGNED FOR MODELS FOR PARTIAL DENTURES

Models for partial cases are given the same general flaring form as those for full cases. In addition, the teeth must be cut off squarely about one-sixteenth of an inch from the gin-

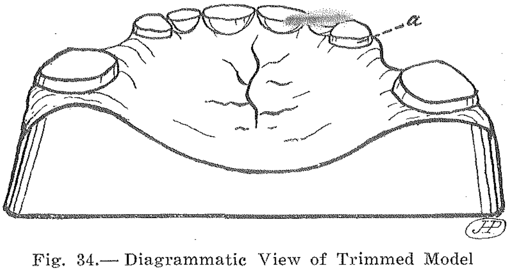


Fig. 34.— Diagrammatic View of Trimmed Model

gival line. This is necessary, first, because the general contour of the teeth will not permit of their withdrawal from the sand matrix without distorting the latter. Second, it permits the plate to be reflected against the tooth surfaces, thereby strengthening it. If reduced to the length suggested, the removal of the model from the sand can in most cases be accomplished readily.

In lower partial cases when the anterior teeth are present, these teeth on the model should have only their incisal thirds removed. When the die is secured and the base is swaged, the latter should be allowed to extend up over the cingulæ, to afford stability to the denture and protect the gums from stress, as well as to guard against the ingress of food between the teeth and substitute in this location.

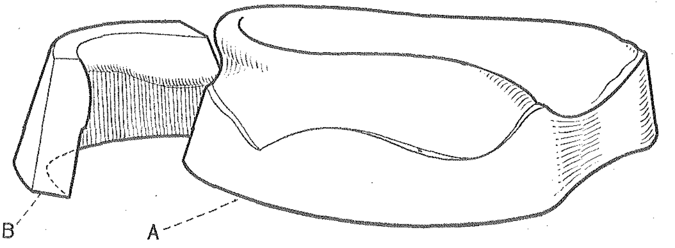
UNDERCUT AREAS

Any depressions or decided undercuts on the labial or buccal surfaces of the model, not involving areas covered by the denture, can be eliminated by filling in with plaster or hard wax and giving such surfaces the proper flare for withdrawal from the matrix.

The outer surfaces, as well as the bases of models, should be finished with fine sandpaper to render them smooth, and the entire model varnished with two or three coats of shellac evenly applied.

CORES

A *core* is an addition of investment compound, or some refractory material, which, when built against an undercut surface on a model and properly trimmed, is used for develop-

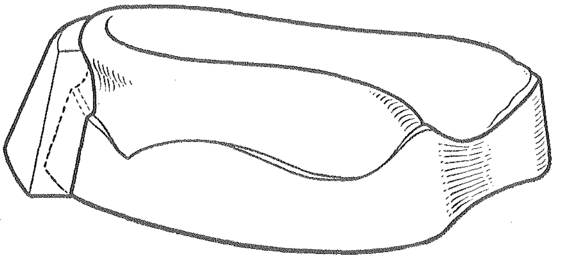


A. MODEL B. CORE

Fig. 35

ing the negative of that surface in the sand matrix, and furnishing a form against which the die may be cast. The constructive steps are as follows:

The varnished model is oiled over the area to be covered by the core. The investment compound is mixed to a thick consistency and applied to the undercut surface of the model, extending it from the base to near the crest of the border, and slightly beyond the undercut area at either end. It should be from 6 to 8 mm. thick. If too thin, it is liable to warp in drying, or break when in use. If too thick, it will interfere with the centering of the model in the molding ring. When set, it is trimmed so that its outer surface is parallel with the flaring side of the model it covers. The ends, as well as the sides, should converge slightly, from base to crest. The upper portion of the core, where it finishes against the border, should present a right angle to this surface, and thus give the core



MODEL WITH CORE IN POSITION

Fig. 36

a flat seat in the sand matrix. When trimmed and sandpapered it is removed from the model and the moisture driven off at moderate temperature to prevent warping. The surface is rendered smooth by rubbing soapstone into it. When finished as described, it is returned to the model and is ready for use.

CONSTRUCTION OF CASTS — GENERAL REMARKS

The construction of the cast is ordinarily spoken of as "pouring the impression." The term is incorrect and misleading as well, for the reason that plaster intended for casts and in the flasking of cases should never be so thin as to be readily "poured" from the bowl.

Plaster of such consistency, when set, is inherently weak, low in density, and less resistant to stress than is the case when the mix is thicker. This is due to the fact that when thin, an excess of water is present and occupying space that should contain calcium half hydrate. When crystallization sets in, the plaster in solution in the water is gradually taken up to complete the crystals partly formed, and to form the nuclei for other crystals.

The half hydrate solution is thus constantly being depleted of its calcium sulphate in the building up of new crystals, with no corresponding diminution in the bulk of water. In other words, when set and the excess water has evaporated, the mass will contain fewer crystals and more spaces than will a mass of similar bulk mixed to proper consistency.

A cast produced from a thin mix of plaster, as before stated, will be less resistant to stress than a denser one, and when subjected to heavy pressure, as in the closure of an over-packed flask, will yield, the crystals breaking under the load.

DELETERIOUS PROPERTIES OF PLASTER

Special care should be exercised in the mixing of plaster for any purpose to have it of proper consistency; also in avoiding excessive stirring, which induces needless expansion. It should be sufficiently plastic to conform to all irregular surfaces by slight jarring, but not so thin as to pour readily. Disregard of the peculiar properties of this most sensitive material, viz.: its tendency to expand, its susceptibility to compression under load, and the deleterious action of heat and moisture upon it, results in manifold errors and mishaps that lead to impaired adaptation and frequent failures in denture construction.

The recognition by many of these deleterious properties of plaster has resulted in greater care being exercised in manipulative procedures than was formerly displayed, as well as in the introduction of more stable and resistant materials for casts. Among these may be mentioned Spence's Plaster Compound — a mixture of plaster, Portland cement, and other substances for controlling expansion. This compound is much less compressible, while its expansive index is lower, than the best grades of plaster.

MATERIALS USED FOR CASTS

The materials commonly used for casts for both vulcanite and other cases are here presented in order, ranging from those having the greatest to those showing the least resistance to stress:

a. Magnesium Oxy-chloride.
1. Spence's Plaster Compound.
2. Coarse Building Plaster.
3. French's Regular Plaster.
4. French's Impression Plaster.
5. Ordinary Commercial Plaster.

DELETERIOUS EFFECT OF ACCELERATORS ON CASTS

Plaster casts containing accelerators such as common salt or potassium sulphate have a greater affinity for moisture and soften more quickly in the vulcanizer in the presence of heat and moisture, than do those from which these substances have been omitted. Therefore, to avoid danger of distortion of casts in vulcanizing, *Impression Plasters* should not be used for casts, as they contain accelerators — usually potassium sulphate. The fourth class, therefore, for causes detailed, is unsuited for cast production.

The fifth class mentioned is usually a plaster of uncertain quality, sometimes over or under burned, containing impurities which render it more or less granular, and of uncertain density when set.

FINAL TREATMENT OF THE IMPRESSION

The impression having been properly prepared by relieving, staining and varnishing, as previously described, should be immersed and allowed to remain in water for a minute or two, while a camel's hair brush is passed over its surface to dislodge the air bubbles present. It is then removed and freed from the excess water by throwing it out or passing a good sized pellet of absorbent cotton lightly over the surfaces. The idea is to moisten the surfaces of the impression immediately before filling, so that the cast material will flow freely over all areas, and that the face of the cast, when set, will be smooth and free from air spaces.

MANIPULATION OF SPENCE'S PLASTER COMPOUND

This material is slow setting and therefore can be mixed very thick. The instructions are to use four ounces of the compound to one of water. The first step is to place three ounces of the compound in the bowl and add the full amount of water (one ounce) to it. Thoroughly mix until it becomes soft and uniformly plastic throughout, then add the other ounce, a little at a time, working each portion in well before making the next addition. The essential point in mixing this material, as in plaster, is to distribute the water evenly through the mass, so that each particle and granule may have an equal proportion to any other.

FILLING THE IMPRESSION

Since the mass is thick and plastic — much like putty — only a small quantity should be placed in the impression at a time, and by jarring and finger pressure, forced to place. The entire impression is filled in this manner, a little at a time, and the form of the cast developed with the spatula, squaring up the sides and making the base flat. The cast should be about one-half inch thick in the central portion to afford necessary strength.

In lower casts the space between the lingual portions of the impression should be bridged across with the compound. This may be accomplished with the spatula, or by placing the impression on the bench after the deeper portions have been filled, and packing the lingual space with a compact mass of moist paper; a temporary support will thus be afforded the material while being bridged over and in setting.

Another method often resorted to is to bridge over the lingual space with a sheet of wax before filling the impression. This should be fitted neatly and luted firmly to the lingual margins of the impression, so as not to interfere with the development of the areas on which the denture is to rest.

MANIPULATION OF PLASTER IN CAST CONSTRUCTION

Fill the bowl about one-third full of water, and into this sift French's regular dental plaster until the free water is all taken up. By adding the plaster slowly, as it settles into the water, solution takes place quickly, and but little stirring will be required to render the mix homogeneous. It should be stirred slightly, but not to excess. The plastic mass should be stiff enough to require jarring to settle it to place.

FILLING THE IMPRESSION WITH PLASTER

A portion is placed near the central part of the impression and the tray grasped in the fingers and tapped on the edge of the bench to settle the plaster in the deepest portions. If the impression has been broken in a number of pieces and luted, it is sometimes best to use the fingers which grasp the tray as a cushion in jarring the plaster to place, to prevent the impression or the pieces from becoming detached — a mishap which sometimes occurs if the vibration is sharp and rapid. Additions of plaster are made and the vibration continued until the entire impression is filled and the cast given its proper outline with the spatula. Care should be taken in forming the cast to avoid excessive bulk, either in thickness or peripheral outline, as the surplus peripherally impedes the removal of the impression and must eventually be cut away, while a thick base interferes with proper mounting of the cast on the frame, and later on in flasking, it must be reduced to centralize the case in the flask. Lower casts are produced in the same manner described in the use of the Spence compound.

CASTS OF PARTIAL CASES — SPENCE'S COMPOUND

In filling partial impressions with Spence's compound, the material should be forced into each tooth matrix with a suitable square end instrument, but care must be taken to avoid marring the impression in doing so. Each matrix is filled, and the compound as it is placed in the impression is jarred and pressed to place, to make a compact union with that already packed. The general form of the cast should be the same as for full cases.

CASTS OF PARTIAL CASES — PLASTER

The plaster mix for partial should be of about the same consistency as for full impressions. If too thick, it will be

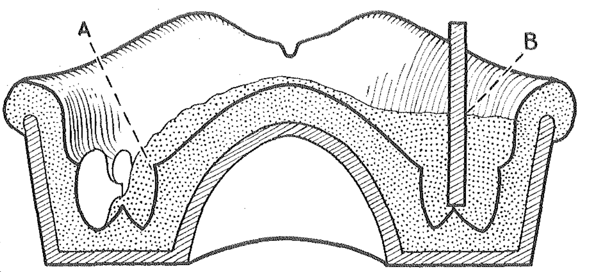


Fig. 37.— Partial Impression Showing Application of Strengthening Pegs of Wood

difficult, if not impossible, to fill the matrices of the teeth, while if too thin, the teeth on the cast will be frail and easily broken, because of the imperfect density of the plaster.

In introducing the plaster into the impression, the first portion should be placed near, but not over, one of the tooth matrices, and by inclining the impression somewhat and jarring, the plaster will flow down one side of the matrix, spread out and settle over the bottom, and then rise up the opposite side until the opening is filled. Each matrix should receive individual attention in order that a perfect cast of each tooth may be obtained. If an attempt is made to fill several matrices at once, the plaster it liable to flow too freely into some of the openings, confining the air in the deeper portions, and thus result in an imperfectly filled impression.

STRENGTHENING ISOLATED PLASTER TEETH ON CASTS

Oftentimes when the natural teeth are long and isolated, the plaster teeth can be materially strengthened by inserting a small piece of orange wood in each matrix, while the plaster is yet plastic, and before the impression is entirely filled. The small round Japanese toothpicks of orange wood are well adapted to this purpose, being of suitable size and especially tough. The sharp point should be cut off, the stick cut to suitable length, usually an inch, and placed conveniently at hand before filling the impression. The advantage of wood over metal pins is that in cutting off the ends of the plaster teeth in flasking, the wood will cut as readily as the plaster, while metal pins must be cut very carefully, or the plaster teeth enclosing them will be fractured.

Casts from Modeling Compound Impressions

Preliminary Treatment for Cast Production

EQUALIZING DENTURE BEARING BY SCRAPING HARD AREAS OF THE IMPRESSION

Since the character of the material used, and the manner of manipulation followed in taking impressions in modeling compound, tend to relieve pressure of the denture on the hard, and increase its bearing on the soft, areas of the mouth, it is not necessary to scrape the areas impressed by the hard tissues to the same extent in modeling compound as in plaster impressions. Some slight relief, however, in most cases will prove beneficial, and with the variation just stated, the instructions given in reference to the treatment by scraping of plaster impressions, apply to the class under consideration.

TREATMENT OF THE SURFACE OF THE IMPRESSION

Modeling compound impressions are waterproof, and therefore no separating or staining mediums are needed, as in plaster work. The impression, however, should be dipped in water, the air bubbles dislodged with a brush, and the excess moisture removed with absorbent cotton. No free water should be allowed to remain in the deeper portions, for if present it will reduce the density of the plaster in the cast in that area, and weaken it, as previously explained. While the impression can be filled without moistening, a smoother surface to the cast will be produced if this precaution is taken.

Exception to this method of treatment must be made when magnesium oxy-chloride is used. The impression should be given a thin film of sandarac varnish, the latter allowed to dry, and the surfaces not moistened previous to filling.

FILLING THE IMPRESSION — FULL CASES

The mix of plaster should be made in the same manner, and of similar consistency to that used in plaster work. If any variation is made, the mass should be thicker, since the impression can be tapped sharply in settling the contents to place, without danger of dislodging it from the tray, and a comparatively thick mix can be readily adapted to full upper or lower impressions with ease.

FILLING THE IMPRESSION IN PARTIAL CASES

As previously stated, modeling compound is not a suitable material for partial cases unless the sectional method is employed, but if used for impression purposes, the casts are produced in the same manner as from partial impressions in plaster. Isolated plaster teeth should also be strengthened in the same manner as outlined.

TIME REQUIRED FOR PLASTER CASTS TO SET BEFORE REMOVING THE IMPRESSION

From fifteen to twenty minutes' time should be given the plaster cast to harden before removing the impression. If this step is carried out too soon, the face of the cast is liable to be marred by handling, since it takes some time for the plaster to develop a reasonable degree of hardness. On the other hand, the separation should not be delayed too long, since at the beginning of crystallization expansion sets in rapidly, and continues in a gradually decreasing ratio for twenty-four hours or more.

WARPING OF THE IMPRESSION AND CAST

As previously stated in the consideration of plaster, when an impression is allowed to remain in the tray and the cast in the impression for some time, both will be more or less warped. To obviate this difficulty as much as possible, the tray and impression should be removed as soon as the plaster constituting the cast has hardened sufficiently to permit.

REMOVAL OF THE TRAY

The first step in separating the impression and cast is the removal of all excess of the impression material extending over the outer surfaces of the labio-buccal flange of the tray. This is easily accomplished by paring it off with a suitable plaster knife.

The cast and margins of the impression are then grasped with one hand, avoiding contact with the tray flange, when, by tapping the handle, and if necessary the flange, the tray and impression will readily separate.

REMOVAL OF IMPRESSIONS — FULL CASES

With a sharp knife carefully pare away the impression opposite the alveolar crest until the staining medium indicates the near approach to the cast. The paring should extend from one tuberosity around the crest of the border to the opposite side.

A few light taps on the buccal and labial portions of the impression, followed by inserting the point of the knife between the latter and the cast at the peripheral line of junction, will break away the outer portions of the impression.

By tapping the vault portion and inserting the point of the knife at the line of demarkation distally, the remainder can be removed without difficulty. If, however, the rugæ are prominent, and the vault is deep and narrow, it will be best to cut a V-shaped groove mesio-distally through the central vault portion and practically divide it. The groove should be carried deep enough to disclose the stained area. A slight prying movement on either half will cause fracture, when they will come away readily.

REMOVAL OF THE IMPRESSION — PARTIAL CASES

The same steps as to removal of the surplus of the impression from the tray, and the tray itself, as previously described in full, apply to partial cases as well. The removal of the impression from the cast, however, requires more care and necessitates the fracturing of the impression into smaller pieces, to obviate the breaking of the teeth from the cast.

First — The impression opposite the occlusal and incisal portions of the teeth should be carefully pared away until the stained area opposite each tooth, and cusp as well, is plainly visible. If the cusps of the teeth are particularly sharp and well defined, to avoid breaking them, the paring may be carried along the mesial and distal slopes of the cusps until the stained areas present two nearly unbroken lines, indicating the position of the buccal and lingual marginal ridges. This practically separates the labio-buccal portion from the body of the impression.

CUTTING V-SHAPED GROOVES TO WEAKEN THE IMPRESSION

Second — A V-shaped groove is usually cut opposite each cuspid tooth and eminence perpendicularly, if not already cut in removing the impression from the mouth, extending from incisal to peripheral margin. The plaster which fills the voids occasioned by missing teeth should be carefully divided with the knife mesio-distally at the points of shortest diameter of the spaces. This permits the labial or buccal sections of plaster to be removed in an outward direction, and the lingual portions to be removed inwardly later on, without engaging with, or marring the adjacent teeth.

If sheets of wax have been attached to the floor of the tray in fitting, so as to enter the spaces, these of themselves par-

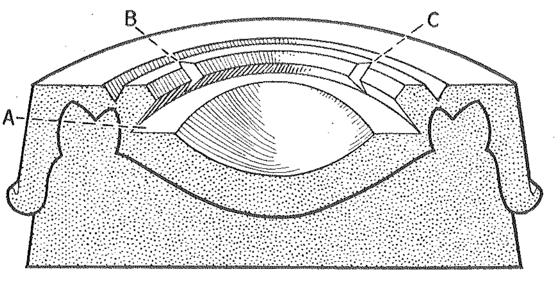


Fig. 38.— Partial Impression Partly Grooved for Removal

tially divide the impression where placed, and facilitate the cutting with the knife. The sections should be tapped lightly to start them, or the point of the knife may be applied and slightly pressed into the peripheral line of junction of the cast and impression. By prying outward, the sections will come away readily, thus exposing the labial and buccal surfaces of the teeth.

Third — A V-shaped groove is cut around the lingual surface of the impression, near the occlusal third of the teeth, and divided perpendicularly opposite each tooth. These sections are then removed one at a time, which, when completed, exposes the occlusal and a portion of the lingual surfaces of the teeth.

Still another groove is cut entirely around the lingual surface of the impression, the apex of which is directed toward the gingival area, and the plaster divided in sections as just described, which when removed will leave the teeth entirely exposed.

Fourth — The central or vault portion still requires removal. If the vault is flat and no undercuts are present, a few light taps followed by a slight prying movement at the line of junction of the impression with the cast posteriorly, will dislodge it. When the vault is deep, the better plan will be to divide the remaining portion into two or three sections and remove them separately. If the point of the knife has been well under control, the removal of the impression, when carried out in detail as described, will result in a cast with unbroken teeth or cusps, and unmarred surfaces.

REMOVAL OF MODELING COMPOUND IMPRESSIONS FROM CASTS

Modeling compound impressions, both full and partial, can be removed from casts by the application of either dry or moist heat, preferably by softening in hot water. The tray, impression and cast are placed in a pan of water, and the latter heated sufficiently to render the compound plastic, but not excessively soft. The tray is first removed and the compound at the peripheral margins peeled away from the buccal and labial surfaces of the border, drawing it occlusally and incisally and away from the cast. But little difficulty will occur in removal in full cases, unless the compound has been overheated, in which case it will adhere to the cast. In removing the impression in partial cases, time should be given for the heat to penetrate through the compound and render it plastic throughout. If this precaution is not observed and an attempt is made to remove the compound from the voids or spaces, fracture of some of the teeth, in most instances, will occur.

Should any of the compound adhere to the cast in various places, as it frequently does, it may be readily removed by heating some dry compound in the Bunsen flame until quite sticky, then dip the cast in warm water, first to slightly soften the undetached compound, and second, to prevent the heated mass from adhering to the cast. The dry, heated compound is firmly pressed against the adherent pieces and quickly withdrawn, reheating it in the flame each time, if necessary, to keep it adhesive, until all of the remaining portions are removed.

SPECIAL MATERIALS USED FOR CASTS IN VULCANITE WORK

It is a well-established fact that when plaster is subjected to stress, or compressive force, the surface crystals, or those first taking the load, crush and break down, when the stress passes the modulus of resistance of the material.

It has also been demonstrated that the force ordinarily exerted in closing an overpacked flask is far in excess of that which plaster can stand without the crystals crushing and the face of the cast becoming distorted.

The effect of such distortion, be it small or great, on casts against which vulcanite or celluloid dentures are molded, is to impair, if not altogether destroy, the adaptation of the dentures to the oral tissues.

Two ways are possible for lessening if not entirely overcoming the danger of distortion of dentures, due to yielding of the plaster casts under the influence of excessive pressure, heat, and moisture, during vulcanization.

The first of these does not require the use of any special materials other than those commonly employed in the dental laboratory. The method of technic differs in some respects from that usually followed in such procedures, the variations being noted under the *closing of flasks,* preparatory to vulcanizing.

The second plan requires that the cast be constructed of a material harder and more resistant to stress, and to deleterious influences in general, than is plaster.

Several materials, capable of withstanding much greater crushing strain than plaster, may be made use of, the properties of one of the most important of which will now be considered, since its value when properly manipulated is unquestioned.

Artificial Stone

OXYCHLORIDE OF MAGNESIUM

Several years ago the idea occurred to the writer that because of its density, smoothness of surface, and imperviousness to water, the materials used in the manufacture of artificial stone might be employed in cast construction, and the problem of denture warpage be solved, or the difficulties resulting therefrom greatly reduced.

From data furnished by the late Prof. Vernon J. Hall many experiments were made with various materials, particularly with the oxide and chloride of magnesium. The first experiments, conducted with chemically pure products, were unsuccessful. Attention was then given the commercial products, since these were extensively used in various industrial lines. From the first, difficulties were encountered, due principally to fracture lines forming in the mass in hardening. In some cases very perceptible contraction was noticeable.

Fracture was later found to be due to the presence of carbon dioxide in the oxide of magnesia. Its presence may be accounted for in two ways. Magnesium oxide is produced usually by burning magnesium carbonate, just as calcium oxide or lime is produced by burning calcium carbonate. In both cases the carbon dioxide is driven off when the process is properly conducted. Unless the calcination is thorough all of the CO_2 will not be eliminated. Again, the oxide of magnesia may be properly prepared, but if left exposed to the air, it will take up moisture and carbon dioxide, and gradually return to the carbonate. From whatever source it may come, its presence in the oxide of magnesia renders the latter worthless for cast construction. The remedy consists in recalcining the mixed oxide and carbonate above a red heat, to expel the CO_2, or if this is not practicable, discard it for a better grade of material.

Contraction in the hardened mass, noticeable in the space seen between the impression and cast when the latter has hardened, is the result of using an under-saturated solution of the chloride, the liquid with which the powdered oxide is combined. By increasing the strength of the liquid to full saturation, adding crystal chloride until there is a slight excess in the bottom of the stock vessel, contraction can be overcome.

The length of time required for setting — about twelve hours — is considered an objection by some, but the advantages gained in more perfect adaptation of the denture to the oral tissues and in increased density of the vulcanite far outweigh the disadvantages mentioned.

Advantages of Oxychloride of Magnesium

The principal advantages of oxychloride of magnesium for casts in vulcanite work are these: hardness, density, smoothness of surface and an extremely low expansive index, less than one-fourth that of the best grades of plaster. It is sufficiently impervious to moisture and heat to maintain its form without crushing, even under heavy pressure. The writer has vulcanized two baseplates on the same cast, both of which showed satisfactory adaptation to the oral tissues. At the end of the second vulcanization, the cast, although permeated with moisture, was quite hard and resistant to stress and on evaporation of the moisture appeared much harder than casts constructed from the best grades of plaster before vulcanization.

Rubber of any shade vulcanized in contact with oxychloride of magnesium is hard, dense, elastic, capable of taking a high polish, and on account of the density of the cast is practically free from nodules.

Partial dentures vulcanized on casts of this material show all the characteristic lines and fine surface markings of the teeth and tissues against which it is molded as clearly as an accurate plaster impression can reproduce them, because the cast is not changed or defaced in the slightest degree by manipulative procedures.

EXPANSION

In tests made for expansion, the greatest movement registered, from the buccal face of one tuberosity to the corresponding opposite surface, was 15/10,000 of an inch, against from 60/10,000 to 100/10,000 of an inch in casts made from the best grades of plaster.

COMPRESSION

Comparative compression tests on blocks of plaster and of magnesium compound, set over night, showed the following result: size of blocks 1½x1½x½ inches; area of plunger, ¼ inch. In the plaster blocks, the plunger began sinking into the block at twenty pounds, and under continued pressure penetrated about ⅛ inch, the block breaking at 100 pounds.

The magnesium blocks showed no perceptible compression up to 1,000 pounds, at which point they suddenly crushed. In one-inch cubes, the oxychloride of magnesium will stand a crushing strain of nearly 5,000 pounds, according to Major Gilmore, U. S. A.

MATERIALS USED FOR CAST CONSTRUCTION

The following instruction in reference to procuring and handling the magnesium materials for casts covers the essential points to be kept in mind.

MAGNESIUM OXIDE

There are two varieties of magnesium oxide, known as the *light* and *heavy* oxide. The difference, which is one of specific gravity and not of chemical constitution, is brought about by the manner in which the magnesite ($MgCO_3$) is burned. In "Cements, Limes, and Plasters," E. C. Eckel says: "If $MgCO_3$ be strongly heated, the effect, as with lime carbonate, is to drive off the CO_2, leaving the MgO as a white solid. A curious and technologically important phenomenon connected with the temperature employed is to be noted. If the calcination is carried on quickly at a red heat the magnesia resulting will have a specific gravity of 3.00 to 3.07, while if the calcination is long continued or carried on at a higher temperature the resulting MgO will be much denser, possessing a specific gravity of 3.61 to 3.80."

For the construction of casts, the heavy oxide commercially known as *powdered magnesite,* or *calcined magnesia,* should be employed. To prevent its return to $MgCO_3$, by absorbing CO_2 and moisture from the air, as indicated by its becoming granular and lumpy, it should be kept in airtight containers, just as plaster must be protected in damp climates.

MAGNESIUM CHLORIDE

Magnesium chloride is a crystalline, deliquescent substance, having much the appearance of sea salt. It is obtained in several ways, a common source being by heating magnesium ammonium chloride ($MgCl_2$ NH_4 Cl) to about 460° C. The ammonium chloride volatilizes, leaving anhydrous $MgCl_2$.

The ordinary commercial product, instead of the chemically pure chloride, is suitable for use in cast construction; some of the commercial products occasionally contain HSO_4 as an impurity. When present, in the chloride solution, it will in time render the hardened mass of oxychloride somewhat soluble in water. The sulphuric acid can be eliminated by adding barium hydrate to the chloride solution. When the resulting precipitate, barium sulphate, ceases to form, it indicates that the acid has been neutralized. From 6 per cent to 10 per cent by weight of the reagent compared with the chloride is required. This method of neutralizing the acidity of the magnesium chloride solution is more strongly indicated when the oxychloride material is to be wrought into work of a permanent character and is not as essential for vulcanite casts, since the latter are destroyed after vulcanization, in removal from the dentures. After two years almost constant use of magnesium oxychloride, the writer has not found it necessary to purify any commercial chloride solution, but has frequently been obliged to re-calcine the oxide to drive off the CO_2, as previously mentioned.

PREPARING THE MAGNESIUM CHLORIDE SOLUTION

In the average dental practice but a comparatively small amount of magnesium oxychloride will be used in the course of a month, so the preparation of a large quantity is not advisable. It is a better plan to make up one or two quarts of the liquid chloride, renewing the solution from time to time as needed. In this way the quality of the liquid can easily be kept up to standard.

To make the solution, put 2 pints of water in a clean two-quart glass bottle, and add the crystal chloride until complete saturation of the water is effected. The visible test of full saturation of the water appears in the presence of undissolved crystals of chloride in the bottom of the vessel.

A half-inch layer of crystals in the bottom of the vessel at all times will do no harm and will keep the solution fully saturated. If the crystals disappear, add more until the usual amount of excess is restored, and if they increase, due to evaporation of the water, add more of the latter. After full saturation of the water has occurred, the liquid should not be shaken up nor the crystals disturbed in decanting off a portion for use.

MANNER OF MIXING THE OXIDE WITH THE CHLORIDE SOLUTION

Place a sufficient amount of the chloride solution to form a cast in the plaster bowl and sift in the oxide just as plaster is manipulated, stirring much more vigorously and for a longer time than when plaster is used. Additions of the oxide are made from time to time and the stirring continued until the mass is sufficiently thick to stand alone. This is an extremely important requirement, for when too thin the oxychloride overflows the bounds of the impression and the cast can not be built up to proper form.

The object in vigorous stirring is to eliminate all air that may be in the powdered magnesite and to coat every granule with a film of the liquid. The tendency of all beginners in using this material is to slight the stirring, and economize on the powder, with the result that although the mass hardens well and is smooth, there is an excess of the chloride present and the cast will more readily fracture under stress than when the material is thickly mixed. It is also inclined to soften more readily during vulcanization.

TREATMENT OF IMPRESSIONS

To get an absolutely smooth surface to a cast of this material it is necessary to have a smooth surface to the impression. This can best be secured by treating either plaster or modeling compound impressions with a varnish having a sandarac base. Gilbert's Imperial Varnish fulfills the requirements well.

In filling modeling compound impressions with plaster the surfaces are merely moistened with water to accelerate the flow of plaster over the impressed areas. With oxychloride, although moisture on the surface of the impression would insure ease of introduction, its presence would eventually deteriorate the surface of the cast, rendering it softer and less resistant to stress than when the impression is dry.

Modeling compound impressions are varnished because unless so treated the compound is at times extremely difficult to remove from the oxychloride cast.

FILLING THE IMPRESSIONS

The impression is filled with oxychloride mixture in much the same manner as with plaster, with this exception: Since the face of the impression is dry, for reasons previously stated, to prevent the formation of creases in the cast where two or more additions of the mixture may meet, it is best to apply each subsequent addition to an area already covered, and by vibration let the mass last added settle down and push the margins of that already adapted over the uncovered areas of the impression.

In partial cases, impressions of teeth should be filled with a small tamper to avoid the confinement of air in the matrix.

The mass of oxychloride should be built to the proper form of the cast, being careful to avoid any excess, since when set, it is very difficult to cut with a knife. By adjusting a bead of wax on the periphery of the impression to outline the extreme margins of the cast, and by building the material to this bead much annoyance will be averted later on.

GENERAL REMARKS

By mixing from 50 to 80 per cent of clean sand with 50 to 20 per cent of the oxide of magnesium a harder and much more resistant mass will result than if the oxide and chloride alone are used.

By filling the impression partially with oxychloride mixture and inserting a previously selected metal model form (Kerr's) an extremely small amount of the material will be required and the peripheral outline, as well as the depth of the cast, will be kept within minimum limits, since the oxychloride need not cover the metal form on these surfaces.

The material should not be disturbed by attempting to remove the impression until thoroughly hardened. It usually requires about 12 hours to set. Should the mass have spread out over the sides of the impression much more than is desirable it may be trimmed peripherally in four or five hours after mixing without endangering the cast.

Thorp's applied Chemistry has this to say in reference to the chemical reaction which occurs in combining the oxide and chloride of magnesium:

"When highly claimed magnesia is treated with a strong solution of magnesium chloride it dries in a few hours to a hard mass of oxychloride, capable of receiving a high polish. A sample prepared in this manner and hardened by six months' exposure to the air was found to consist of a mixture of $Mg\,C\,O_3$ with a compound of $Mg\,Cl_2\ 5\ Mg\,O\ 17\ H_2\,O$. On heating to 180° C. it was converted into $Mg\,Cl_2\ 5\ Mg\,O\ 6\ H_2\,O$. By prolonged treatment with water the whole of the magnesium chloride was extracted and the compound $2\ Mg\,O\ 3\ H_2\,O$ left.

"This residual hydrate is a compact solid as hard as sandstone and possessing a brilliant surface.

"Magnesia cement is used very extensively as a binder in connection with briquetting in the manufacture of artificial building stones, tiles, grindstones, and emery and polishing wheels. Its binding quality is very considerable and it is very plastic and cheap.

"A good mixture for this use consists of:

"25 parts magnesia (93 Mg O).

"25 parts magnesium chloride (45 per cent solution).

"50 parts water.

"About 5 pounds of this mixture will serve to cement 95 parts of stone, emery, etc. The resulting blocks are very solid and harden thoroughly in a few hours."

(Eckel. Cements, Limes, and Plasters.)

HISTORY

In 1853 M. Sorel, an eminent French chemist, discovered that zinc chloride when mixed with zinc oxide formed a cement. This is essentially the basis of our oxychloride of zinc cements today, but it was not introduced to nor used by the dental profession until many years after its discovery.

Shortly after this discovery Sorel found that the chlorides and oxides of several other metals possessed similar properties.

The most important and valuable combination he discovered was that the oxide and chloride of magnesium united to form a substance as hard as stone. Further, that by combining coarsely crushed rock, as marble, granite, limestone, etc., with a small percentage of the oxychloride of magnesium the resulting mass would stand an enormous strain before crushing.

The value of this discovery was immediately recognized and made use of in the industrial field in the production of artificial stone known as Sorel's stone.

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CHAPTER IX

BASES FOR ARTIFICIAL DENTURES

In prosthetic procedures, that portion of a denture which rests upon the oral tissues, and to which the teeth are attached by various means, is called a *base*.

Requisite Properties of a Denture Base

The material selected for a base for an artificial denture should possess certain requisite properties:

First — It should be rigid, in order to retain its form under stress.

Second — It should be dense and non-porous.

Third — It should be free from action by oral secretions or food products.

Fourth — It should be odorless and tasteless.

Fifth — It should be a reasonably good conductor of thermal changes.

Sixth — It should be readily adapted to the die or cast of the mouth.

Seventh — It should be capable of taking and retaining a high polish.

Two general classes of materials are utilized as bases for artificial dentures. The first consists of metals, as gold and its alloys, platinum, aluminum, and various alloys of tin. The second class consists of plastic vegetable substances, as vulcanite, gutta percha, and celluloid.

Gold Bases

Pure gold, because of its softness and lack of rigidity, is not used as a base for artificial dentures, except in special cases, and then only when combined with gold of a lower carat. Twenty carat gold is most commonly employed in denture construction, although 18K gold is frequently used. The objections to the latter are on account of its greater rigidity, which renders it more difficult to conform to the die, and its tendency to discolor in some mouths.

Twenty carat gold plate more nearly fulfills the requirements mentioned as a base than any of the other materials employed for this purpose, except platinum. Its beautiful, rich yellow color, freedom from taste, odor or oxidation, or tendency to discolor, its rigidity in comparatively thin sheets, its high conductivity and the ease with which it can be polished, place it in the front rank of materials used for dentures. The principal objections to its universal use are due, first, to the difficulty in securing close adaptation to the oral tissues, as a result of the sequent steps of construction, and, second, to the expense involved in the production of such substitutes. It could and should be used for bases in many cases where dentures of the less expensive class are now constructed, particularly in partial cases.

In addition to the advantages mentioned, gold combines the greatest strength with the least bulk, of any other base.

Platinum Bases

The oral tissues under a well adapted platinum base retain their normal tone, while but little change occurs in the bony processes. It has been noticed in porcelain crown and bridge work, the frame work of which is composed of platinum, that the tendency for food to accumulate or placques to form on exposed or partially protected platinum surfaces, is decidedly negative as compared with alloyed or pure gold in similar situations. This is supposed to be due to some unknown, inherent quality in the platinum itself, not possessed by other metals, which tends to preserve hygienic conditions, even under adverse circumstances. Whether this view is correct or not, the fact remains that when platinum base dentures are well adapted and free from mechanical causes of irritation, the tissues remain remarkably healthy and normal under such substitutes.

In addition to the peculiarly benign effect of platinum on the oral tissues, this metal possesses practically all of the good qualities ascribed to gold. In color it is bluish-white. It is practically infusible under the ordinary blowpipe flame. It may be used as a base plate in the same manner as gold is employed, the teeth being attached either by soldering, or with vulcanite. An alloy of platinum and iridium, which is harder and more resistant than platinum itself, would be preferable, however, since pure platinum is slightly softer and more easily bent than 20K gold of equal thickness.

The usual method followed in making use of platinum in denture construction is in conjunction with porcelain. The teeth are first attached by soldering, the porcelain, which gives the denture its contour, being subsequently fused around them and over the base, blending with teeth and base to form a homogeneous mass. The advantages and disadvantages of continuous gum dentures will be discussed when dentures of this class are described.

Aluminum Bases

Aluminum is frequently used as a base for artificial dentures in both cast and swaged form. It is the lightest of all of the metals, is a good conductor of thermal changes, and is non-irritating to the tissues.

Since this metal can not be soldered successfully, it requires considerable care to develop the means for attaching the teeth to the base with vulcanite in swaged base dentures. When the base is produced by casting, this difficulty is easily overcome, the necessary anchorage for the vulcanite being formed in the wax model and reproduced in the casting process.

Cast base aluminum dentures are inclined to disintegrate in some mouths, due largely to castings of this metal being of more or less imperfect density. When examined under a magnifying glass, many minute spaces are disclosed. When broken, and the fractured surfaces are examined, these spaces are present and can be seen in the body of the casting, as well as on the outer surfaces. The use of a pure aluminum, with proper technic in casting, will largely overcome this difficulty.

For various reasons, however, a swaged base is usually more satisfactory and less inclined to irritate the tissues than a cast base.

Tin Alloy Bases

Alloys of tin and cadmium, tin and bismuth, and other similar combinations, are frequently used in the production of bases for lower substitutes, to give weight to the finished dentures, and by gravity assist in their retention. When properly constructed, they are non-irritating to the tissues and serve well the purpose for which they are intended. Care should be taken, however, in the construction of dentures of this class to avoid excessive weight, on account of the tendency of such substitutes to tire the mandibular muscles and produce irritation of the soft tissues.

Vulcanite Bases

Because of the slight expense involved and the comparatively simple technical details attending its manipulation, vulcanite is very extensively used as a base for artificial dentures. When proper care is exercised, most efficient and serviceable substitutes for the natural teeth can be produced when this material is used as a base.

ADVANTAGES

First — Better adaptation can be secured with vulcanite than with any other basic material.

Second — Ease of manipulation in the constructive steps.

Third — Inexpensive, first, as to cost of material, and second, as to production; consequently dentures of this type are possible for persons of moderate means.

DISADVANTAGES

First — Vulcanite is a poor conductor of thermal changes.

Second — In order to have the inherent strength to resist stress, vulcanite bases are necessarily more bulky than metal bases.

Third — Vulcanite decreases the acoustic properties of the palatine vault to a greater extent than do metal bases.

Fourth — Unless special care is exercised in finishing the palatine, as well as all surfaces of vulcanite dentures, inflammatory conditions of the mucous tissues frequently ensue. Such conditions have been erroneously ascribed to other causes, some of which will be discussed later.

Thermal Conductivity of Various Denture Base Materials

Vegetable substances, as compared with the metals, are poor conductors of thermal changes. The following table by Prof. R. von Wardroff (slightly modified) on the conductivity of various substances, gives the conductivity of vulcanite, as well as of the metals used in denture construction. "The coefficient of thermal conductivity of a substance indicates the amount of heat energy, measured in calories, conducted from one face to the opposite face of a centimeter cube of the substance, when one of the faces is maintained one degree hotter than the other. The amount of heat energy conducted is proportional to the difference in temperature between the opposite faces."

"A calorie is the amount of heat energy required to raise the temperature of a gram of water one degree Centigrade."

Silver at zero C..................	1.00000=1	
Copper at zero C.................	1.00000=1	
Gold at zero C....................	.73200=¾	(Approx.)
Aluminum at zero C..............	.34300=1/3	"
Platinum at zero C...............	.11500=1/9	"
Paraffin at zero C................	.00061=1/166	"
Vulcanite at zero C...............	.00040=1/250	"
Beeswax at zero C................	.00009=1/1111	"

Silver being rated as 1, gold transmits only ¾, aluminum 1/3, platinum 1/9 and vulcanite 1/250 calories in the same length of time.

Cause of Oral Inflammatory Conditions Under Vulcanite Bases

Several theories have been advanced as to the cause of inflammatory conditions frequently arising from the wearing of vulcanite dentures, the principal ones of which are as follows:

(1) Lack of proper conduction of thermal changes to, and radiation of heat from, the oral tissues.

(2) Deleterious effects of coloring matter in vegetable bases.

(3) Mechanical irritation.

(4) Unhygienic conditions.

CONDUCTIVITY OF THERMAL CHANGES

While there is a marked difference in the rate of conductivity of the metals and the vegetable bases, there is no evidence to prove that the noticeable deficiency of vulcanite in this respect is directly responsible for the troubles sometimes ascribed to it.

Possibly in rare cases, particularly when other active causes are present, the oral mucous membrane may be influenced by, and its general tonicity impaired through, the nonresponsive medium of a vulcanite base. However, the fact that many hundreds of thousands of vulcanite dentures are being worn with comfort, under which no inflammatory conditions of the mucous membranes have developed, is evidence in itself that the percentage of cases due solely to poor conductivity is extremely small.

Many cases of so-called *rubber sore mouths* have come under the observation of the writer. Some of these were corrected by the substitution of metal base dentures of continuous gums, gold or aluminum, and others with gold-lined vulcanite dentures. The largest percentage of cases presented were satisfactorily relieved on the introduction of properly fitted and finished vulcanite cases. In no instance that can now be recalled was there a recurrence of the inflammatory conditions, which would undoubtedly have occurred had the primal cause been due to non-conductivity.

DELETERIOUS EFFECT OF COLORING MATTER IN VEGETABLE BASES

The red, pink, brown and maroon rubbers, as well as celluloid and zylonite, are usually given their tints by the addition of varying proportions of vermilion or the sulphuret of mercury, Hg.S. The idea has been advanced that during the process of vulcanization some of the sulphuret may fail to unite closely with, or it may be expelled from, the rubber, thus leaving the pigment comparatively free or only weakly combined with the base. After introduction and use of the denture, the vermilion becomes an irritant to the tissues and the inflammatory conditions mentioned follow. Again, it has been thought possible that the comparatively free sulphuret by the action of the fluids of the mouth, which are sometimes slightly acid, may be converted into mercuric chloride or corrosive sublimate, a decided irritant, and the conditions mentioned be thus produced. These ideas, however, are unproven theories and can not account for the fact that inflammatory conditions sometimes develop under dentures of black vulcanite which contain no mercury or other irritating pigment of any character, and sometimes under metal base dentures as well.

The more logical explanation of the conditions under consideration is that they are due to rough or defective surfaces of the denture, as well as to lack of hygienic attention to the mouth and denture on the part of the patient.

MECHANICAL IRRITATION

The negative form of the mouth is given to a vulcanite denture by molding the rubber while in a plastic state over a cast of plaster, or some similar material, and holding it in contact with the cast, under pressure, while hardening.

As has been mentioned before, the manner of crystallization of plaster results in the formation of minute spaces between the crystals. When examined under a magnifying glass, the surface of a plaster cast presents many minute irregularities. In addition to the spaces between the crystals, there are other and larger spherical spaces, due to the presence of air in the plastic mass itself, and also to air being caught between the latter and the impression surface in filling. These spherical spaces are sometimes quite numerous, some visible, and others lying just under the surface of the cast, obscured by a thin film of plaster.

Under the pressure exerted in closing the packed flask, the rubber is forced into the visible as well as some of the obscured irregularities and spherical spaces, and in vulcanizing, hardens in the irregular form thus assumed.

When the case is vulcanized, removed from the flask, thoroughly cleaned with a scrub brush, and examined, that portioned moulded against the surfaces of the cast will be found irregular and nodular, as a result of the conditions mentioned. Unless thoroughly removed and the surfaces highly polished, these nodules and irregularities become mechanical sources of irritation, frequently sufficient to set up inflammatory conditions.

Hyperæmic conditions and oftentimes traumatic injury frequently develop at local points, under a vulcanite denture. The cause may nearly always be traced to some defect in the denture at that point, either from roughness, undue pressure, or imperfect adaptation. Sometimes obscure spiculæ are present in the palatine vault, and the pressure of the denture on the mucous tissues overlying these points causes discomfort, and frequently marked inflammation develops. Sharp, uneven points in the process, resulting from recent extraction, are also sources of irritation. Such conditions develop under metal base, as well as vulcanite dentures.

UNHYGIENIC CONDITIONS

Lack of care of the denture on the part of the patient is a most common source of inflammatory conditions of the oral mucous membrane. Mucous plaques seem to form on, and particles of food to become attached more readily to, vulcanite than to metal base dentures. The reason for this is obvious. A metal base as a rule is usually smoothly finished, while vulcanite is seldom given the high polish it is capable of taking on.

The rough surfaces on the palatine portion of a denture, previously referred to, furnish a favorable location for the formation of plaques in which micro-organisms flourish. Dr. G. V. Black called attention to this fact many years ago, and stated his belief that the by-products of the bacteria were largely responsible for many cases of *rubber sore mouths.* These plaques often form in protected locations on reasonably well-polished vulcanite, and occasionally on metal, base dentures, if the patient does not cleanse them thoroughly and regularly.

Most of the disadvantages ascribed to vulcanite can be greatly reduced, or practically eliminated, if proper care is observed in the construction of dentures of this material, and they are given proper care by the patient.

Celluloid Bases

Celluloid is a mixture of gun cotton, camphor gum, oxide of zinc, and vermilion. As prepared for dental purposes it comes moulded in blanks of various sizes. A blank is placed in the flask matrix, subjected to heat, and the flask closed under heavy pressure. If imperfections are present in the cast, the negative of these will be reproduced in the denture. The avoidance of such imperfections is the first consideration; the second, equally as important, is their removal from the denture, if any are present. Otherwise, similar irritation of the oral mucous membrane is liable to occur, as in vulcanite cases.

Celluloid is not as resistant to wear nor to the action of the oral fluids as vulcanite. Alcohol acts on it somewhat, and in some mouths it discolors badly. It is of a beautiful pink shade and occupies a place between porcelain and the best quality of pink vulcanite, in its resemblance to the natural gum tissues. When carefully manipulated and properly finished, it is an excellent base for temporary dentures, and in some mouths will prove satisfactory for permanent substitutes. It is capable of taking an extremely high polish, which however, is soon lost if abrasive powders are used in cleansing it.

When properly finished, the tissues retain their tonicity under celluloid fully as well as under metal base dentures. As a matter of fact, if reasonable skill is exercised in the technical details, good substitutes can be produced with any of the materials here described; while on the other hand, poor technic with the best materials is productive of indifferent results, if not positive failure.

CHAPTER X

SWAGED METAL BASE DENTURES

Swaging is the process of adapting or conforming metal, usually in sheet form, to a carved, cast, or prepared harder object called a die, by means of blows or pressure.

Swaged metal bases of gold, platinum or aluminum, such as are used in denture construction, are given the reverse or negative form of the mouth by swaging a plate of suitable thickness between a metallic die, and a counterdie of metal or some other material which fulfills the purpose of a metal counterdie, as rubber, soap, clay, etc. In case any of the latter named substances are employed, they must be confined within a suitable receptacle.

In the production of a swaged, metallic base denture, therefore, a die fulfills a similar purpose to that of a plaster cast in the production of a plastic base denture.

Comparative Results in Adaptation of Swaged, and Vulcanite Bases

As a general proposition it is more difficult to secure as close an adaptation of a swaged metal base to the oral tissues, as can be secured when vulcanite is employed. This statement is based on the fact that in the production of dentures with metal bases, a greater number of constructive steps must be carried out than are required in the production of vulcanite dentures.

SEQUENT STEPS IN SWAGED BASE DENTURE CONSTRUCTION

a. An impression of the mouth is secured.

b. From the impression a cast of the mouth is obtained, which, by proper trimming, with additions if necessary, and final varnishing, is converted into a model.

c. By imbedding the model in molding sand and withdrawing it, a sand matrix is formed.

d. A die is produced by casting molten metal in the sand matrix.

e. By imbedding all but the face of the die in sand, and casting a lower fusing metal over the exposed portion, a counterdie is obtained.

f. A baseplate is produced by swaging a sheet of metal of the required character and thickness between the counter-die and die, until the plate metal closely conforms to all surfaces of the latter.

g. Wiring the periphery and lingual surface of the base and attaching anchorages for the vulcanite.

h. Includes the general steps of occluding the teeth, waxing, flasking, packing, closing the flask, vulcanizing and finishing the case.

In carrying out each one of the sequent steps mentioned, except (e), some loss of detail or departure from the true contour of the oral tissues to be covered by the denture, is liable to occur, which may impair the adaptation of the finished product. If more than one error occurs, the tendency is to increase, rather than diminish, any previous defect, while in the end any one, or the several errors combined, may seriously impair or entirely destroy the adaptation of the denture.

SEQUENT STEPS IN VULCANITE DENTURE CONSTRUCTION

In the sequent steps of vulcanite denture construction, it is necessary to carry out (a), the first part of (b), and (h), as detailed; (c), (d), (e), (f) and (g) are neither necessary nor applicable. Thus it is seen that of the eight general steps carried out in the production of swaged metal base dentures, but three are required to produce vulcanite substitutes.

The intermediate steps, unnecessary in vulcanite work, but essential in the swaging process, require the greatest care in execution, to avoid errors. The principal mishaps liable to occur in these intermediate steps are as follows:

(c) Distortion of the sand matrix in removal of the model.

(d) (1) Distortion of the sand matrix in pouring the molten die metal.

(2) Accumulation of steam or gas in the matrix, causing roughness and imperfections in the die.

(3) Warpage of the die, due to contraction in cooling.

(f) (1) Marring the high points on the face of the die in adapting the plate with the horn mallet, and subsequently in swaging.

(2) Spreading or splitting of the die under hammer blows or pressure.

(3) Failure to secure perfect adaptation of the baseplate to the face of the die.

(g) Distortion of the plate in soldering, in attaching the rim wires and anchorages for the vulcanite.

All of these steps, if carefully carried out, may be completed without perceptible errors occurring, and the adaptation of the baseplate to the oral tissues may, on trial, be found satisfactory, yet under (h), in the final closing of the flask, when overpacked and subjected to undue pressure, the adaptation of the denture is frequently impaired or destroyed.

The excess rubber in the overpacked matrix, in closure of the flask, forces the baseplate against the supporting plaster, and if excessive stress is applied, causes distortion not only of the foundation on which it rests, but bends the baseplate as well. The warped condition the denture thus assumes becomes permanent after vulcanization.

This brief summary of the commonly occurring errors which tend to impair the adaptation of swaged base dentures is not intended to disparage the utility of substitutes of this type, nor to discourage their more general production, but rather to emphasize the need of accuracy in technical procedures. When properly constructed, the usefulness, beauty and comfort of swaged metal base dentures — their general excellence, in fact, is thoroughly established and unquestioned.

Appliances and Accessories Used in Die and Counterdie Construction

The necessary appliances used in the production of dies and counterdies are as follows:

1. Molding flasks.
2. Molding sand.
3. Sieve.
4. Talcum powder.
5. Straight edge.
6. Laboratory knife.
7. Heating appliances.
8. Melting ladles.
9. Die metal.
10. Counterdie metal.
11. Whiting and alcohol.
12. Sable brush.

MOLDING FLASKS

The ordinary molding flasks are band-like, slightly tapering rings of cast iron, open at both ends. Peripherally, they conform to the outline of the alveolar arches. They vary in size, the usual set consisting of a nest of four rings, ranging from 4 to $2\frac{1}{2}$ inches in diameter, and $2\frac{1}{4}$ inches in depth. The smallest flask, which corresponds in size and general outline form to the base of the average model, is used for confining the metal within the base outline of the die, and thus increasing its depth, to avoid spreading or splitting during swaging.

Various forms of special flasks, such as the Bailey, Lewis, and Hawes flasks, are also in common use. The two former are designed to increase the depth of the die over that of the model, while the latter is intended to obviate the use of cores, when undercuts are present on the labial or buccal surfaces of the model.

MOLDING SAND

Sand of the finer variety, such as is used by brass or iron molders may be used to advantage in the laboratory. It is

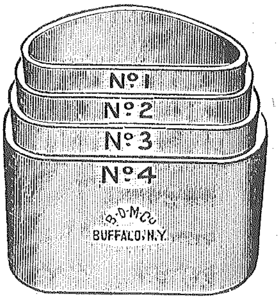


Fig. 39.—Nest of Molding Rings

rendered moist and workable by spraying occasionally with water, just enough being incorporated to render it cohesive. An excessive amount of moisture present would develop an excessive quantity of steam in casting, and result in imperfections in the die. The sand should be sifted, thoroughly worked with the hands, and allowed to stand a short time be-before use, to develop uniform density and cohesiveness, or *temper*, as it is called.

The supply houses furnish prepared molding sand, such as "Chase's," a combination of fine sand with oil, and "Calcar," a combination of marble dust with glycerin or oil. With moderate use, these prepared sands give good service, last a considerable length of time, and are more convenient to use than the common sand. Used frequently, they soon deteriorate and lose the cohesive property, because of the burning out of the oil or gylcerin. The addition of a small quantity of the latter, and the thorough sifting and working of the mass will restore cohesiveness.

THE SIEVE

It is essential that sand of any variety should be kept free from lumps, foreign substances and particles of metal that may become detached from the die and counterdie in casting. For this purpose a No. 20 mesh sieve should be kept at hand, and before forming the matrix, the sand should be run through it once or twice. This treatment not only removes debris, but renders the sand more workable by disseminating the drier particles among the damper portions, and develops its cohesive property as well.

TALCUM POWDER

The model, which should be flaring, smooth, varnished and perfectly dry, is dusted and thoroughly rubbed with soapstone to prevent the sand from adhering to it. The excess should be removed with a soft brush before imbedding the model in sand.

THE STRAIGHT EDGE

A straight edge of metal or wood is used for striking off the excess sand that extends above the molding flask after packing. Since this surface of the sand becomes the base of the matrix and must support the weight of the molten metal in casting, it should set flat at all points upon the bench on which it rests, so that it will not yield or break under the weight of the molten die metal.

THE LABORATORY KNIFE

A straight blade knife is used for removing a tapering section of sand, beginning at the ring margin and slightly increasing in depth to the periphery of the model. This trimming is necessary to free the model at its periphery and allow it to drop from the sand without fracturing the matrix margins.

HEATING APPLIANCES

A burner capable of developing a considerable amount of heat is an essential factor in laboratory procedures. It is a time and money saver as well. The very common method of placing the ladle over an ordinary Bunsen burner and applying the blow-pipe flame directly on the die metal to more rapidly fuse it, is to be discouraged, since this procedure induces oxidation and deterioration of the metal in a very short time. The application of the blow-pipe flame underneath the ladle is not objectionable, further than that it is usually unnecessary, if sufficient heat is developed by the burner.

MELTING LADLES

Ladles used for melting the die metal should be of cast iron or stamped from heavy iron of not less than one-eighth inch in thickness. Ladles of this type are preferable to those made of thin sheet metal, first, because, being thicker, they absorb and retain more heat, thereby accelerating the fusing of the metal, and second, because of their greater rigidity. There should be a lip or spout on the side, through which the molten metal may be directed in a small stream while pouring

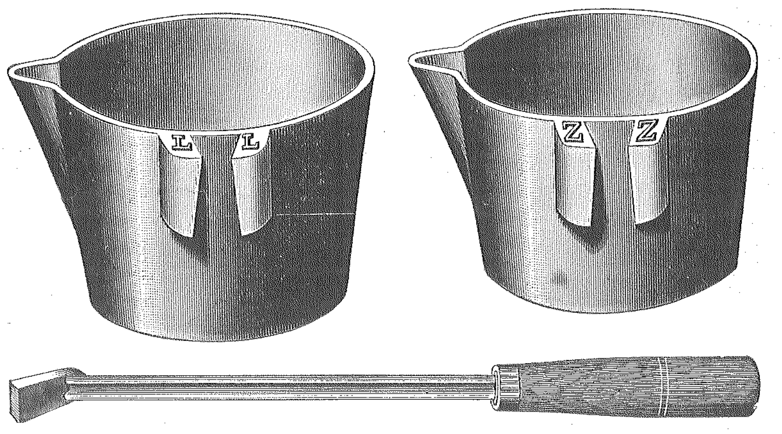


Fig. 40.— Melting Ladles

it into the matrix. Ladles used for melting zinc should be coated inside with whiting until the iron is thoroughly oxidized, to prevent the zinc from alloying with it. The alloy of zinc and iron, if it is allowed to form, is taken up by the molten zinc, which is thus rendered harder, while the ladle sides are gradually reduced in thickness by the constant alloying process, and are eventually perforated.

Die Metal

A metal used for die purposes should possess certain requisite properties.

First — It should neither expand nor contract in assuming a solid state.

Second — It should fuse at a moderately low temperature.

Third — It should be sufficiently hard and resistant to stress so that the high points and general surface markings of the die will not be defaced or battered down in swaging the plate.

Fourth — It should be cohesive, so as to maintain its form without splitting or spreading under pressure or hammer blows.

Metals Most Commonly Used for Dies

Zinc, Babbitt's metal, Melotte's metal and a variety of alloys similar in composition to the latter, are used for die purposes.

ZINC

Zinc has long been used and is still very extensively employed in the making of dies for dental purposes. It fuses at the highest temperature and is the hardest of any of the metals or alloys commonly used for dies for prosthetic purposes. Its fusing point is 419.4 deg. C. In cooling, it contracts perceptibly and oftentimes warps to a marked degree, depending on the form of the matrix in which it is cast.

For years it has been known that plaster expands in setting and zinc contracts in cooling. From these facts, the axiom was deduced that the expansion of the plaster model compensates for the contraction of the zinc die. This certainly would be a simple solution of the problem if the amount of contraction in the die equaled the expansion of the plaster model, and if the factor of warpage could be eliminated. Since there is no correlation of the movements, however, the absurdity of the axiom is apparent.

Shrinkage of Metals in Passing from Liquid to Solid State

The following table from Kent's "Engineers' Pocket Book" on the shrinkage of castings is as follows:

Cast Iron	1/8	inch per linear foot — 1 inch sectional area.
Brass	3/16	" " " " " " " "
Steel	1/4	" " " " " " " "
Malleable Iron	1/8	" " " " " " " "
Zinc	5/16	" " " " " " " "
Tin	1/12	" " " " " " " "
Aluminum	3/16	" " " " " " " "
Britannia	1/32	" " " " " " " "

Larger or bulkier castings shrink slightly less proportionately, while smaller ones shrink more than the amounts indicated in the table.

A die of zinc derived from a sand matrix 2½ inches across from one buccal surface to the other shrinks about 1/16 of an inch, while a plaster model, in which the expansive movement is high, expands less than 1/64 of an inch. In cooling, the tendency of the metal is to rest on the dome, or that portion of the matrix which gives form to the palatal vault of the die, and for the borders to draw inward from the sides and upward from the base of the mold. The warpage thus resulting decreases the height of the palatine vault and reduces the buccal diameter, in many cases, to such an extent as to require the construction of a more accurate die on which to finish the base.

When zinc dies are used, it is the common practice to cast two, and frequently three, as a preliminary step in swaging a denture. It also frequently occurs that a baseplate, when adapted to one, will fit neither the other dies nor the plaster model from which they were derived. It is then a problem as to which die most nearly represents the true oral contour. This can only be determined by trial of the base in the mouth, after swaging on each die separately.

To partially overcome the errors occurring in the use of zinc, as well as other dies, the following steps are recommended:

Treatment of Plaster Models to Arrest Expansion

First — As soon as the plaster cast from which the model is to be formed has set sufficiently hard to permit, the impression should be removed and the cast converted into model form by trimming and additions, as required. The moisture present should then be expelled by applying moderate heat. Overheating tends to both warp the model and disintegrate the plaster. The varnish should be applied last, since, if applied before heating, it prevents the ready evaporation of the moisture. Drying the model in this manner stops the chemical action, and hence expansion in the plaster, which otherwise would continue for twenty-four hours or more.

Second — When the sand mold is secured, the molten die metal is cast into it at as low a temperature and in as thickly liquid a condition as may be, and yet be plastic enough to insure its becoming adapted to all portions of the matrix. In other words, thorough evaporation of moisture from the model, if driven off soon after the cast is constructed, lessens its expansion, and filling the matrix with the die metal, poured at as low a temperature as possible, reduces contraction and lessens warpage. If cast while overheated, the metal assumes a decidedly crystalline structure, is very brittle on hardening, and contracts perceptibly.

Zinc dies, after cooling, may be annealed and rendered much tougher and more cohesive if heated to a temperature of between 100 to 150 deg. C. If heated much above 150 deg. C. they again become very brittle. This process of annealing is resorted to in the production of sheet zinc, the cast ingot being heated as above indicated and passed through rolls until reduced to the required thickness. The malleability imparted to it by annealing is retained on cooling.

BABBITT METAL

Babbitt metal is an alloy of copper, tin and antimony in varying proportions. It was designed by the man whose name it bears — Isaac Babbitt — as an anti-friction metal for bearings. As commonly compounded it is too soft for die purposes, but when combined in the proportions suggested by Dr. L. P. Haskell, the alloy is non-shrinking, resistant to stress, nearly equal to zinc as to hardness, fuses at a lower temperature, and is superior in other respects. Dr. Haskell's formula is as follows:

Copper	1 part
Antimony	2 parts
Tin	8 parts

This Babbitt metal fuses at 260 deg. C., casts well, and copies accurately the surfaces against which it is poured, if of proper fluid consistency. The antimony present, which under ordinary conditions expands in cooling, eliminates to a great extent, if not altogether, any tendency of the alloy to contract in passing from the fused to the solid state. A die made of Babbitt metal therefore more nearly represents the form and proportion of the plaster model than does one made of zinc. Its comparatively low fusibility is also a decided advantage. For these reasons, principally, the use of Babbitt metal for dies is gradually increasing.

Haskell's Babbitt metal, properly compounded, can be procured of the supply houses. If it is deemed advisable to make it in the laboratory, the following directions by Hall will aid in producing a well-alloyed product: "Melt the copper and half of the tin, then add the antimony and the remainder of the tin. Stir vigorously and keep the surface of the alloy covered with powdered charcoal."

When melted repeatedly, and especially at high temperatures, Babbitt metal deteriorates, owing to the formation and retention within the alloy of some of the oxides of the component metals. These oxides may be partially removed and the metal restored to working condition by heating to a high temperature, adding scrap beeswax, stirring thoroughly, and skimming off the dross as it accumulates on the surface. Covering the surface of the molten metal with fine charcoal and stirring well also removes some of the oxides present.

Dr. Haskell recommends the addition from time to time of a little tin for restoring the fluidity of the alloy, since by repeated fusing some of the latter metal is lost by oxidation and volatilization.

As previously intimated, all die metals and alloys, if overheated, deteriorate rapidly. Care should therefore be observed to remove the metal from the fire before the entire mass is in a molten condition. The heat absorbed by the already melted metal is usually sufficient to melt one-fourth, and frequently one-half, its bulk of the still unfused portion after removal from the fire. This plan obviates overheating, and consequent excessive oxidation. It also insures smoother castings, since the metal being poured at low temperature generates less gas or steam on coming in contact with the sand matrix, than when overheated.

MELOTTE'S METAL AND OTHER FUSIBLE ALLOYS

A class of metallic compounds known as *fusible alloys* or *triple alloys* are much used for die purposes in crown and bridge construction, and occasionally as dies for dentures. These alloys are not as hard as zinc or Babbitt metal, but on account of their low fusibility and the sharpness of castings produced, they are very serviceable and much used.

The triple alloys contain three metals, usually tin, lead and bismuth, in varying proportions. Bismuth has the property of expanding, imparting hardness, and reducing the fusing point of the alloy considerably below the mean fusing point of the three metals, which is 272 deg. C. When alloyed, the metals melt at about 100 deg. C.

Another class of alloys similar in character to the triple alloys, but composed usually of four metals, are also in common use. These, in addition to the metals mentioned, contain antimony or cadmium, both of which, like bismuth, have the property of reducing the fusing point of the alloy of which they are a part. They also expand in cooling, and when incorporated, impart this property to alloys, resulting in the production of sharp castings. The low fusibility of this type of compounds permits of their being poured into fresh plaster impressions direct, without the necessity for drying out the latter. Such castings as a rule are very sharp, well defined, and of reasonable hardness.

COMPOSITION OF FUSIBLE ALLOYS

Name.	Tin.	Lead.	Bismuth.	Antimony.	Cadmium.	Melting Point.
Melotte's	5	3	8			100° C.
Newton's	3	5	8			95° C.
D'Arcet's	1	1	2			93° C.
Dalton's	3	5	10½			92° C.
Onion's	2	3	5			92° C.
Rose's	3	8	8			79° C.
Wood's	1	2	4		1	71° C.
Clinché	48	32.5	9	10½		
Richmond's	20	19	48		13	65.5° C.
Hodgen's	3	5	8	2		106.6° C.

The fusible alloys, being hard and more or less crystalline, lack the cohesiveness of zinc or Babbitt's metal. Dies for full dentures, composed of such alloys, should, therefore, be made sufficiently thick to prevent fracturing under hammer blows. When used under hydraulic or screw pressure, a die of moderate thickness will resist stress without change, if its base and that surface of the press on which it rests are flat.

COUNTERDIE METAL

A counterdie should be composed of a softer metal than the die of which it is the complement. This is essential for three reasons:

First — If the die and counterdie were of equal hardness, both must yield in swaging, the die becoming slightly smaller and the counterdie slightly larger, in order to make room for the interposed plate. Such change in the die and its consequent effect on the baseplate would impair, if not altogether destroy, the adaptation of the latter to the oral tissues.

Second — The tendencies of a die and counterdie of equal hardness to *shear*, or at least reduce in thickness, the plate being swaged over opposite parallel surfaces, as on the buccal surfaces of prominent tuberosities, is very marked. This tendency is not apparent when the counterdie is composed of a softer metal than the die.

Third — A somewhat yielding counterdie opposed to an unyielding die carries the plate into the inequalities of the die, with its irregularly disposed surfaces, better than if the two were of equal hardness.

A counterdie is usually made by pouring molten metal over the face of a die. To prevent fusion of the face of the die, and consequent union of the two masses of metal while casting, the counterdie metal should, as a rule, melt at a lower temperature than that of the die; the die should be cold, and the counterdie metal should be poured at as low a temperature as possible.

When melted, the casting of the counterdie metal should be deferred until it begins to thicken around the sides of the ladle, when it may be cast against the face of the die in a semi-liquid condition.

Lead is used for counterdies with zinc dies, the difference in the fusing points of the two metals being 92 deg. C. An alloy of 7 parts lead and 1 part tin is used for counterdies with Babbitt metal dies, the difference in the fusing points of the alloys being about 50 deg. C.

Both die and counterdie can be made from the same alloy in the bismuth compounds, the only precautions necessary to observe to prevent union being to have the die cold, and to allow the metal for the counterdie to assume a pasty condition before casting. A square-end tamper pressed against the plastic mass immediately after casting will force it against the face of the die, and insure close adaptation of the former to the latter.

Usually, however, the fusible alloys are used in conjunction with some swaging device or press. In such cases, only the die or the counterdie is formed of the fusible alloy, the plate to be swaged being adapted between the metallic form on one side, and some yielding material on the opposite side, such as soft rubber, moldine, damp tissue paper, or modeling compound. Such methods, however, are only adapted to the swaging of the purer and thinner forms of gold plate, or of pure platinum.

WHITING AND ALCOHOL SOLUTION

A solution of whiting (precipitated chalk) and alcohol is essential for coating the surface of a die previous to casting the counterdie. A solution of whiting in water will fulfill the same purpose, but alcohol is much better, as this solution, when applied, dries immediately, while the aqueous solution does not. A little gum arabic added to the solution will impart adhesiveness to the film when applied dry, and prevent exposure of the metal surfaces by the rubbing off of the film, should anything come in contact with the die face. Carbonizing the die is also recommended, but the process, although effective, is a filthy one and soils the hands unnecessarily.

BRUSHES

A medium-sized sable or soft bristle brush is very useful for removing soapstone or sand from the model, and for cleaning up the outer surfaces of the matrix generally before removing the model.

CHAPTER XI

TECHNIC OF DIE AND COUNTER DIE CONSTRUCTION

FORMING THE SAND MATRIX

The table or laboratory bench should be covered with a large sheet of clean paper, to assist in recovering the sand after the die is cast.

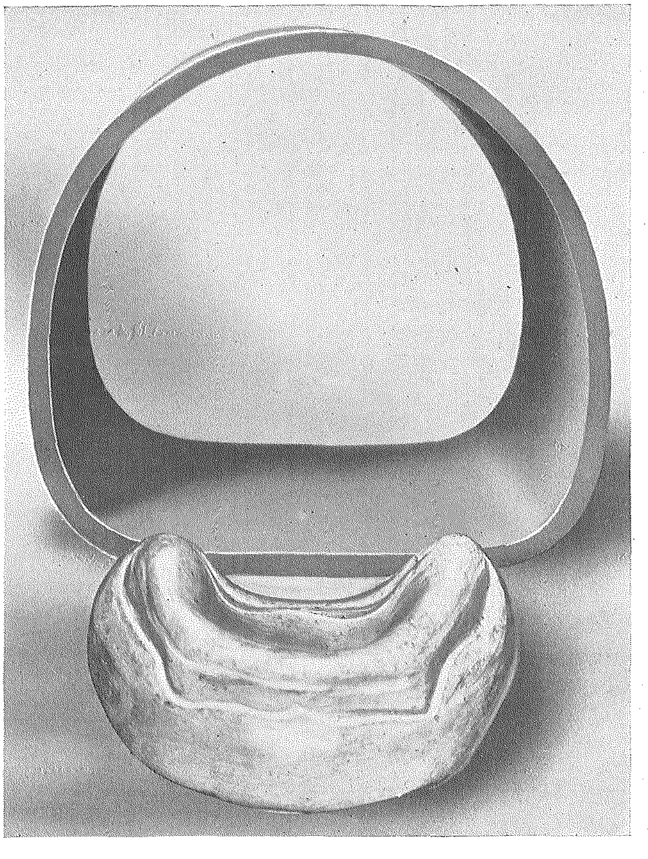


Fig. 41.— Molding Ring and Model

The model, having been prepared as previously described, is placed on the paper, face up, the largest molding flask of the nest of four placed over it, the large end down, and so adjusted that the model will occupy a central position within

Sifted sand is now filled in the molding flask until even with the face of the model, and packed into the space between the latter and the flask periphery. The pressure on the sand should be light at first, so as not to move the model from its central position. As soon as the model is firmly fixed in place, the sand should be still further compressed, until firm and compact, special stress being exerted to force it outward against the flask walls. More sand is added, and with the fingers pressed compactly against the flask walls until the packed portion stands slightly above the crest of the model. The sand in the vault or central portion of the model, which is not yet compressed, should cover this area at this stage to a depth of about one-half an inch.

Careful, uniform pressure with the fingers should be made on the sand over the central area of the model, sufficient to

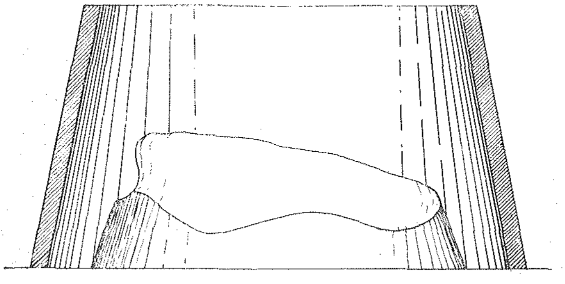


Fig. 42.— Sectional View of Cast and Molding Ring

bring the granules in fairly close contact, without rendering the surface too dense or compact, or wedging the sand too tightly between the lingually inclined walls of the model. If too loosely packed, the sand will lack cohesion and be disturbed in pouring the molten metal into the matrix. If too densely compressed, the gases or steam generated by the hot metal coming in contact with the moisture or oil in the sand can not escape through the densely packed matrix as rapidly as formed. It then finds its way out between the matrix walls and the die, or forms vent holes through the die itself, in either case causing roughness and imperfections of the latter.

When the sand is wedged too tightly in the vault portion of the model, it frequently fractures and parts from the matrix when the model is withdrawn.

The remaining space in the flask is filled and compressed until the sand stands above the margin. The straight edge is now passed over the top of the flask and the surplus sand struck off. The flask is inverted and that surface from which the excess sand was struck now becomes the base of the matrix.

The upper surface of the packed flask shows the base of the model surrounded by the sand. (See cut, page 142.) A thin V-shaped section beginning at the flask periphery and extending to that of the model is sliced off with the knife, so as to expose the angle of the model base, and thus clear it from the matrix margins. By lifting and tipping the flask, the detached sand will fall off. The finer particles can be

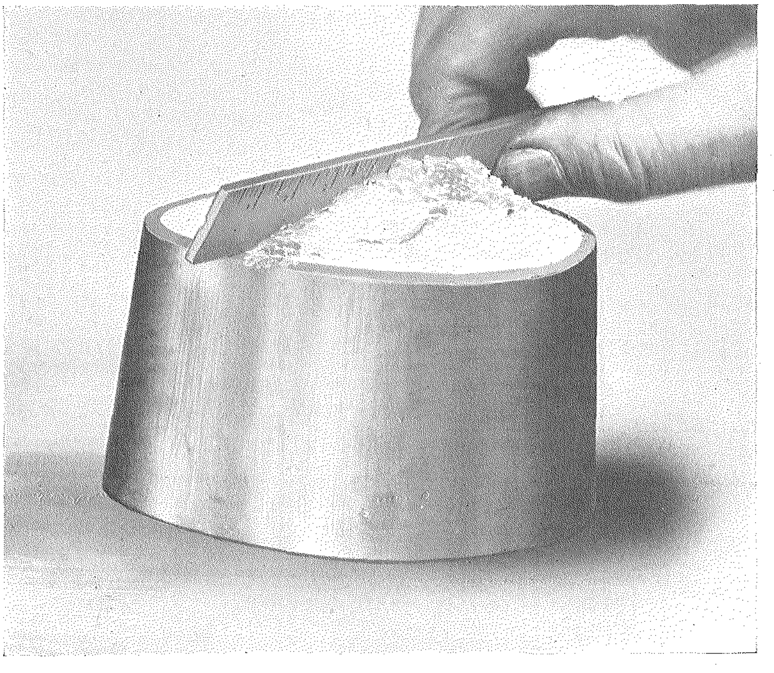


Fig. 43.— Removing Excess of Sand from Packed Ring

removed with the brush, and by gently blowing them from the surface.

REMOVAL OF THE MODEL FROM THE MATRIX

When properly flared, dried, varnished and rubbed with talcum powder, the model can usually be removed from the matrix without difficulty. Unfavorable conditions, principally due to some peculiar form of the model itself, are sometimes present. In such cases, the exercise of extreme care is necessary to avoid distortion of the essential surfaces of the matrix in removing the model. The adhesion of the sand to the surfaces of the model, as the result of compression in packing, must be overcome or broken, when, if no undercuts are present, the model will come away readily.

The following is the usual order of removal of the model from the matrix, ranging from the simplest methods to those requiring careful attention:

1. Gravity — Weight of model sufficient to dislodge it.
2. Tapping base of model to break sand adhesion and rotating.

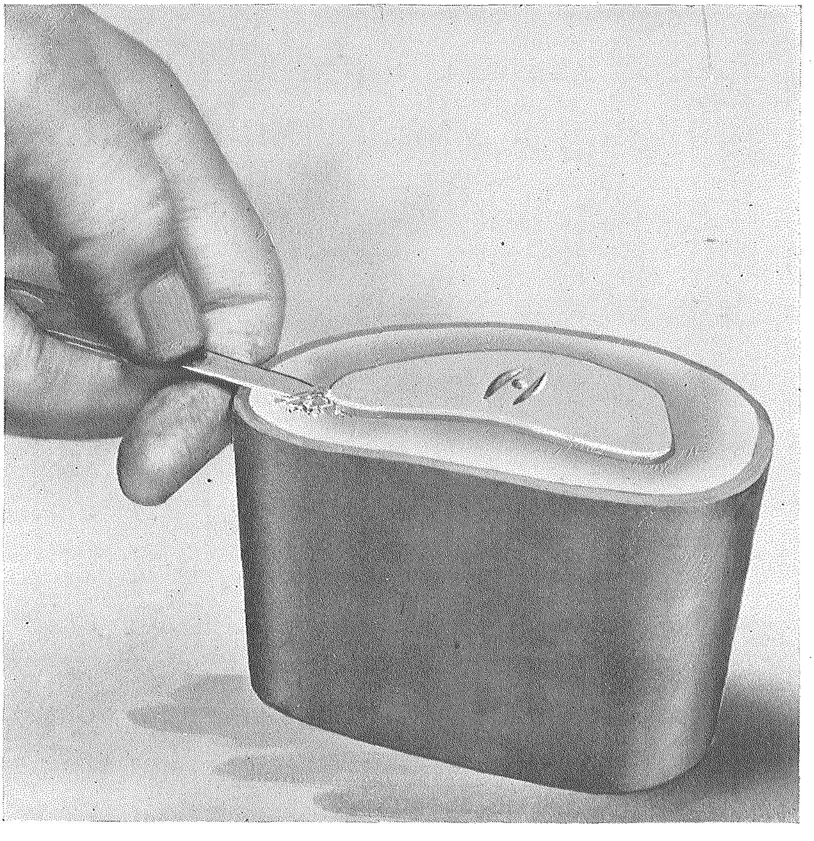


Fig. 44.— Removing Thin Section of Sand to Release Model Margins

3. Removal of model by rotation.
4. Vibration — Tapping the side of the flask.
5. Prying to break adhesion and rotating.
6. Tapping and lifting outward.
7. Removal of models with undercuts — cores.
8. Removal of models with undercuts overcome with Hawes flask.

REMOVAL OF THE MODEL IN LIFTING THE FLASK

When the form of the model is correct, the condition of the sand suitable, and the packing of the flask is of the proper density, the model will occasionally drop from the matrix in lifting the flask to invert it. This, however, occurs more often when the sand has been but loosely packed in the flask, or when the sides of the model are excessively flared. It may

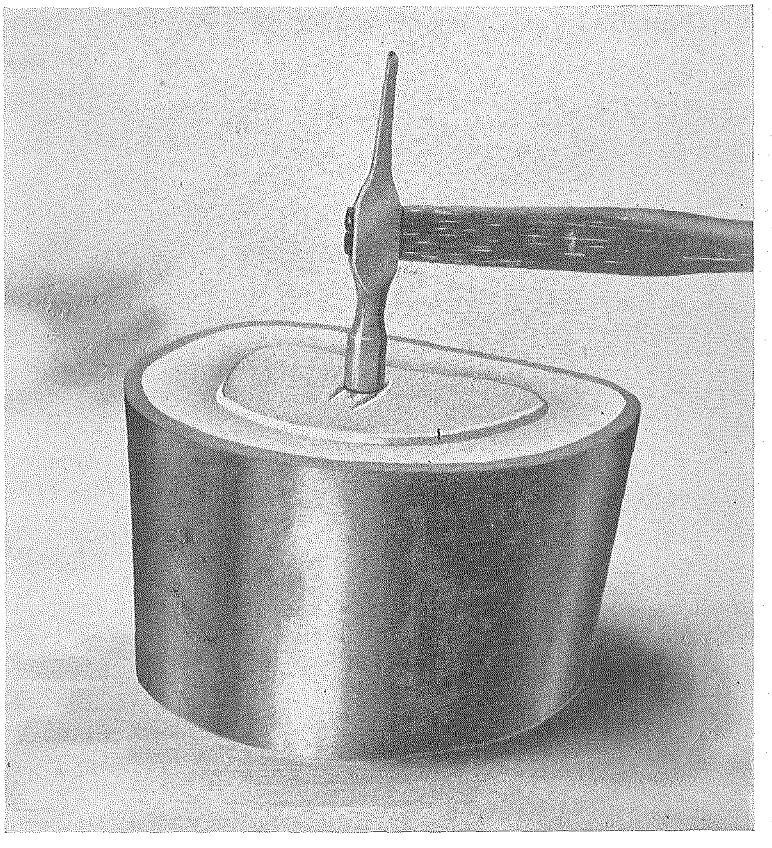


Fig. 45.— Breaking Adhesion Between Sand and Model by Tapping Base of Latter

occur, as before stated, under proper conditions. When the model drops out by its own weight, a close inspection of the matrix should be made to see that its several surfaces are smooth and the sand sufficiently compact to insure smooth surfaces to the die when cast.

TAPPING THE MODEL BASE TO BREAK ADHESION

A few light taps on the base of the model, near the center, with a small hammer or light instrument, will usually break the adhesion of the sand to the several surfaces. The tapping should not be sufficiently heavy to produce perceptible movement of the model in the matrix. Heavy or unequal tapping is liable to distort the sand and result in an imperfect matrix. By rotating the flask as will now be described, the model can usually be dislodged.

REMOVAL OF THE MODEL BY ROTATION

The flask is lifted from the bench, the base resting in the palm of the hand, the thumb against the flat side, when, with a

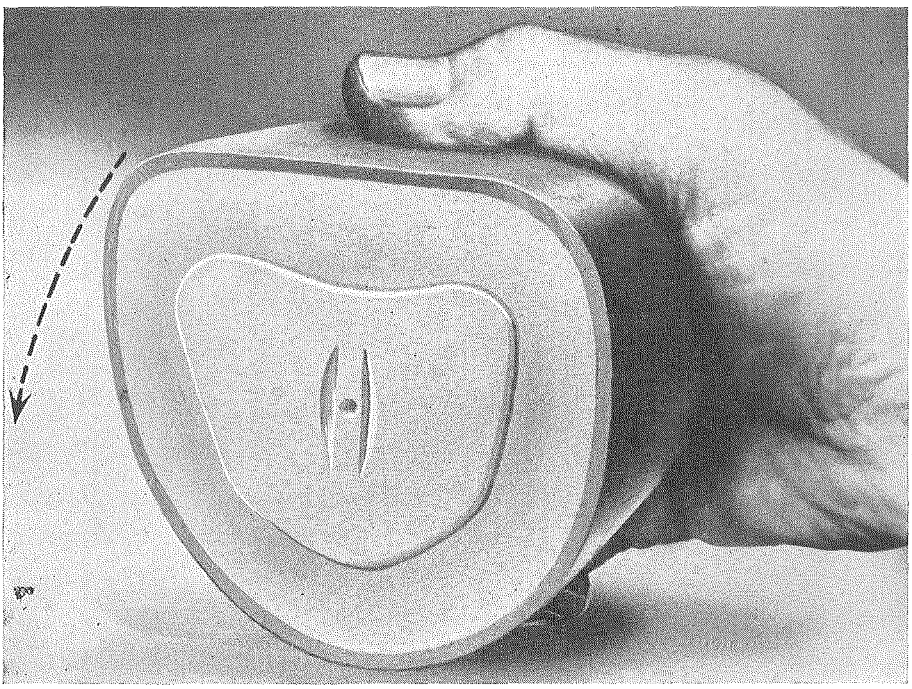


Fig. 46.— Rotating Model Out of Position

quick pronating movement, the model may be rotated outward. If it is not dislodged in this manner, the flask should be set on a clear surface of the bench, so that the sand base may be firmly supported over its entire area and the adhesion broken as follows:

BREAKING ADHESION BY PRYING THE MODEL

If the preceding steps fail to break the adhesion of the sand and free the model, it can be overcome by inserting the point of a knife against the back of the model, the blade resting on the flask margin, which will serve as a fulcrum, and with a slight prying movement lift the back of the model the least perceptible amount. Rotation of the flask should again be made, when the model will readily come away.

REMOVAL OF THE MODEL BY VIBRATION

A simple method of removal, frequently successful, consists in inverting the flask and tapping the sides lightly with a small instrument. The vibration thus produced will often be sufficient to dislodge the model. Vibration produced in this manner may also be applied in difficult cases after other means have been resorted to, for breaking the adhesion between sand and model.

REMOVAL OF THE MODEL BY GRAVITY

Occasionally, when the vault portion of the model is deep and the buccal, labial and lingual surfaces of the border at various points, particularly in the anterior portion, are nearly parallel with each other, it may not be possible to rotate the model out, as described, without distorting the matrix. In other words, the relationship of the several surfaces mentioned, to each other, requires that the model be removed in a line of direction approximately parallel to these surfaces, instead of attempting to rotate it out. Removal in such cases may be accomplished in two ways:

First — Tap the model base to break adhesion. Invert the flask, maintaining the model in position with finger pressure while doing so; place the inverted flask over the edge of the bench, holding it flat and moving forward until the model is well supported before releasing finger pressure, until finally the entire flask base rests on the bench; lift the flask, and if the model is still retained in the matrix, with a small instrument tap the outer side of the flask lightly. The vibration thus produced is usually sufficient to dislodge the model.

Second — Should the preceding steps fail to free the model from the matrix, it may be removed by direct traction. The projection of the model margins above the sand is so slight that it can not be accurately and carefully lifted from the matrix by grasping its periphery, so other means for grasping it must be provided. A small hole may be drilled in the center of the base, into which a taper instrument can be driven to serve as a handle (see page 146), or two grooves may be cut on either side of the center, about one-fourth of an inch apart (see page 147). The sides of the intervening section of plaster should be parallel to each other, thus affording means for grasping the base of the model centrally with a pair of tweezers.

While this method of removal is positive and can be applied to any model without undercuts, unless care is observed the matrix may be marred. To avoid error, the instru-

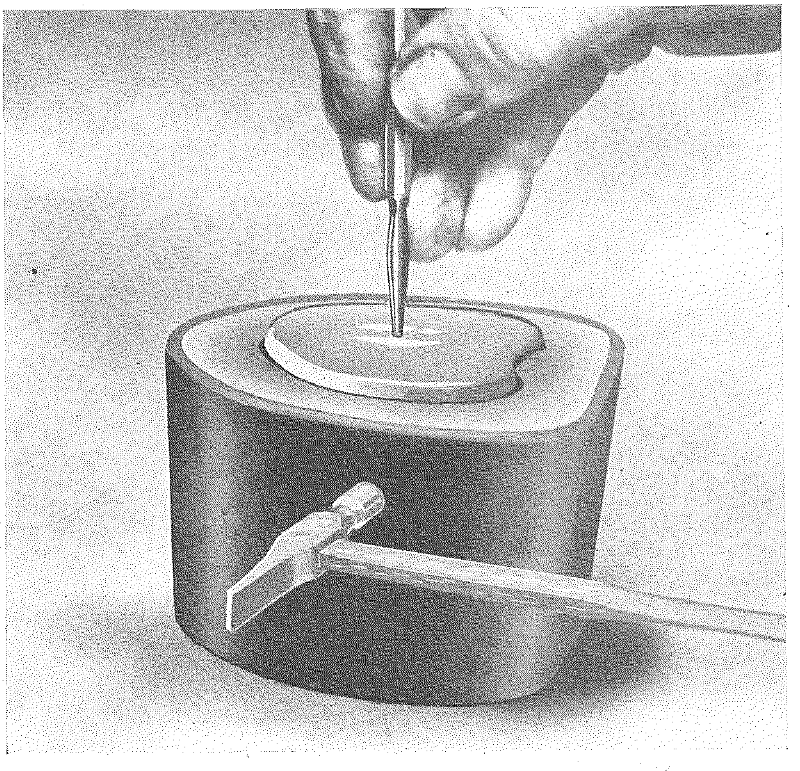


Fig. 47.— Releasing Model by Tapping Side of Flask

ment or tweezers must not be grasped too rigidly, while the line of traction must coincide with and be approximately parallel to the several surfaces to be released. Molders follow a similar method in removing patterns from the sand. To break adhesion and free the pattern, they usually tap the instrument which serves as a handle, sideways in various directions, while traction is at the same time applied for the removal of the pattern.

In prosthetic procedures, the instrument which serves as a handle in removing the model should not be tapped laterally, as the tendency would be to enlarge the matrix.

With a properly flared model having no undercuts, and the sand packed to proper density, the prying or lifting process for breaking the adhesion of the sand and dislodging the model, need seldom be resorted to. It should be borne in mind that the least possible manipulation of the model in effecting its removal will yield the most accurate matrix.

NECESSITY FOR THE USE OF CORES

Models having undercuts can not be removed from the sand without distorting the matrix, unless means are taken to overcome the difficulty. The usual method resorted to is by

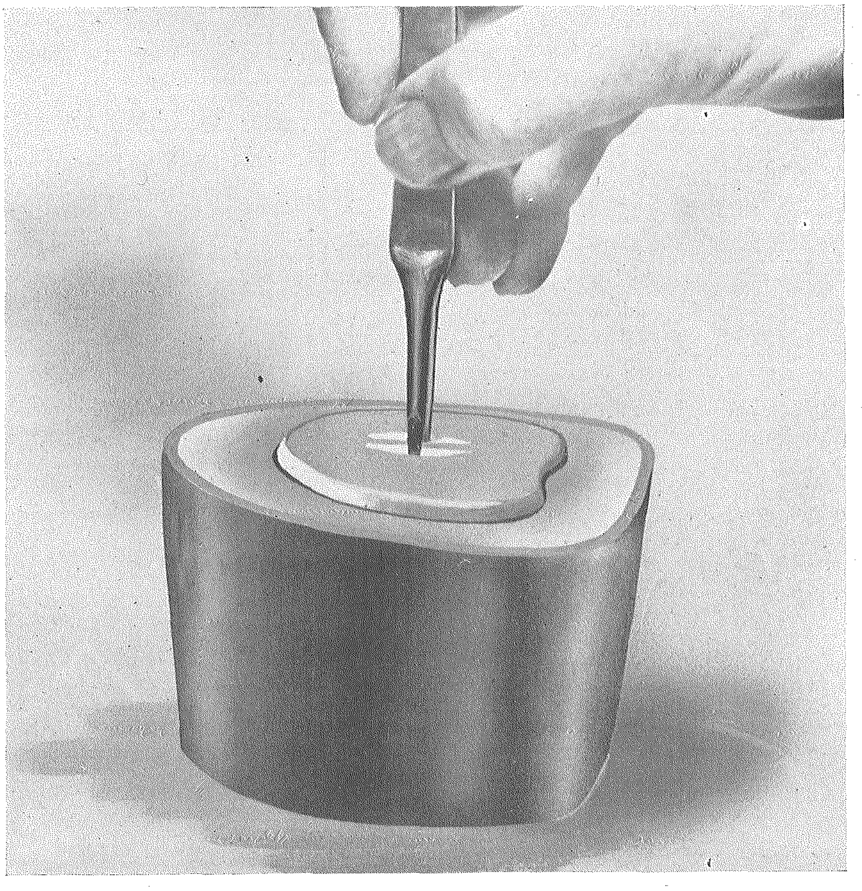


Fig. 48.— Lifting Model from Matrix

means of cores, the construction of which has been previously described.

A model having a core addition to its outer surface usually presents an unsymmetrical peripheral outline. In placing the molding flask over such a model, the former should be so adjusted that the model will occupy a central position, regardless of the form or position of the core.

Sand is packed around and over the model and core, care being taken to wedge the latter firmly against the model in the condensing process. Removal of the model and core from the matrix is effected by some of the methods described, usually by tapping and rotation.

After removal, the core is separated from the model, dried, and returned to its position in the matrix, where its inner surface completes the matrix wall and reproduces the reverse form of the undercut surface of the model.

Sufficient pressure should be made on the core in seating it in the matrix to wedge it slightly in the sand, so as to pre-

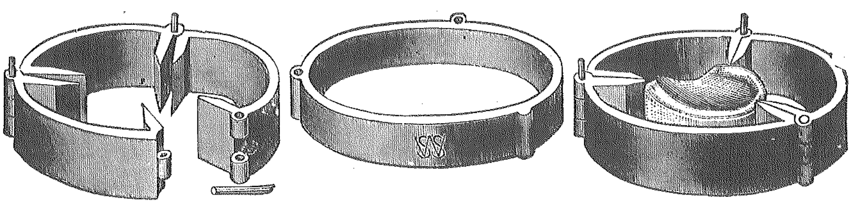


Fig. 49.— The Hawe's Flask

vent displacement, since, if not firmly attached, the molten metal, when introduced, on account of its greater specific gravity, will raise the core out of its position.

Construction of the Matrix in the Hawe's Flask

An accurate sand matrix may be secured from a model having external undercut areas, without the use of cores, by means of the Hawe's Molding Flask.

This appliance is cylindrical in form, five inches in diameter and three inches deep. It is divided into an upper and a lower section, held in proper relation by means of guide pins. The lower half consists of three sections hinged to open outward. Each section has a flange at either end, directed radially inward. When pinned together, the end flange of each section approximates the flange of the adjoining section, thus dividing the interior space of the flask into three partial sectors.

The model is placed between the three flanges of the lower section, its median line opposite one and its tuberosities opposite the two other points, respectively. The crest of the border should rise slightly above the level of the ring.

Sand is packed around the outer sides, into and above all undercut surfaces of the border, but not over the face of the model. Particular care should be taken to condense the sand firmly in each sector of the flask and against the model, so

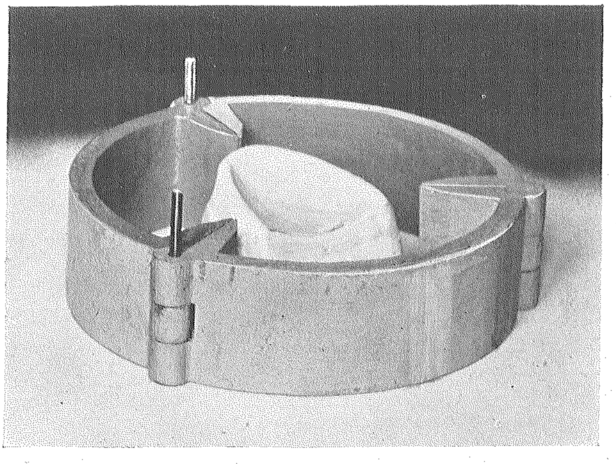


Fig. 50.— Lower Section of Hawe's Flask Showing Model in Position

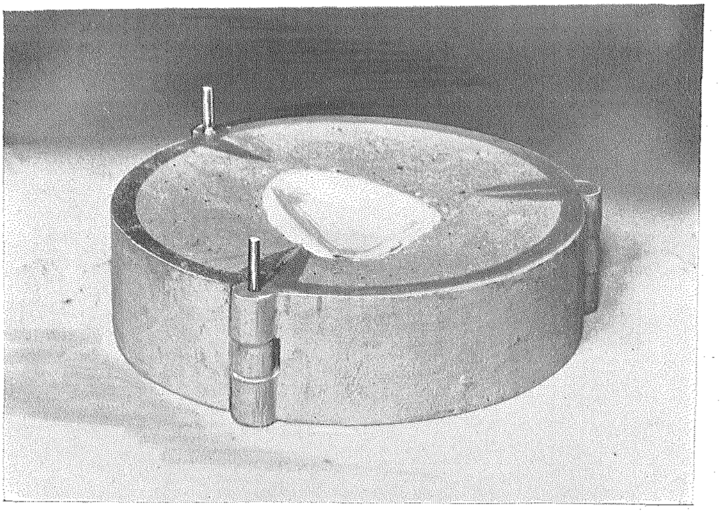


Fig. 51.— First Section with Sand Packed Around Model

that it will not be displaced in the subsequent steps of freeing the model.

Powdered charcoal is sifted over the packed sand and model face to prevent adhesion of the sand now to be added, the surplus blown off, the second section of the ring adjusted. In this the sand is packed and the surplus struck off in the usual manner. The upper half of the flask is now lifted off, inverted, and set aside so as not to disturb the sand surface which has copied the model face.

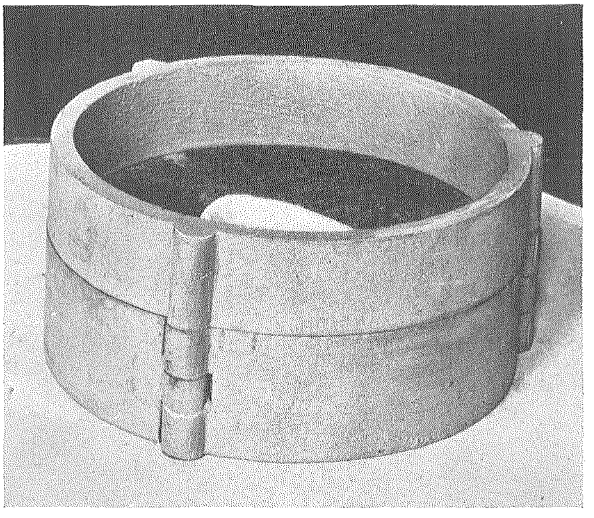


Fig. 52.— Second Section of Flask Set in Position

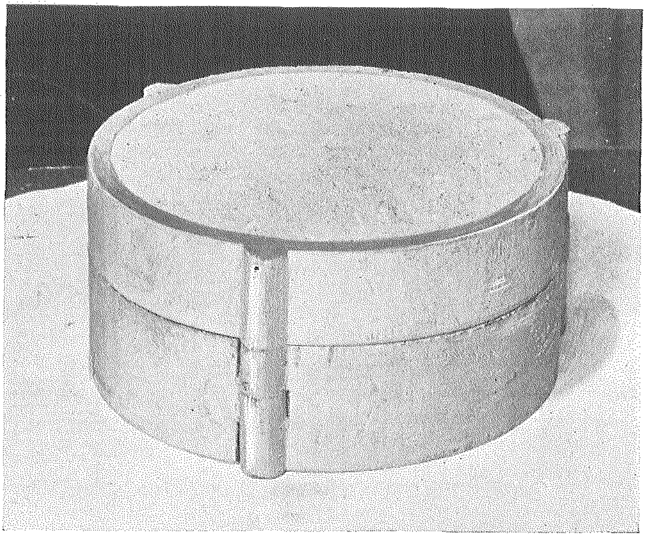


Fig. 53.— Second Section Packed

The model is removed by drawing the pin from one of the disto-buccal flange joints and carefully opening the ring. As the sectors separate, the sand between the flange ends and the model breaks with a clean fracture, and, on account of the flask form, the matrix is thus divided into three sections. The model is drawn out through the open side of the ring. When

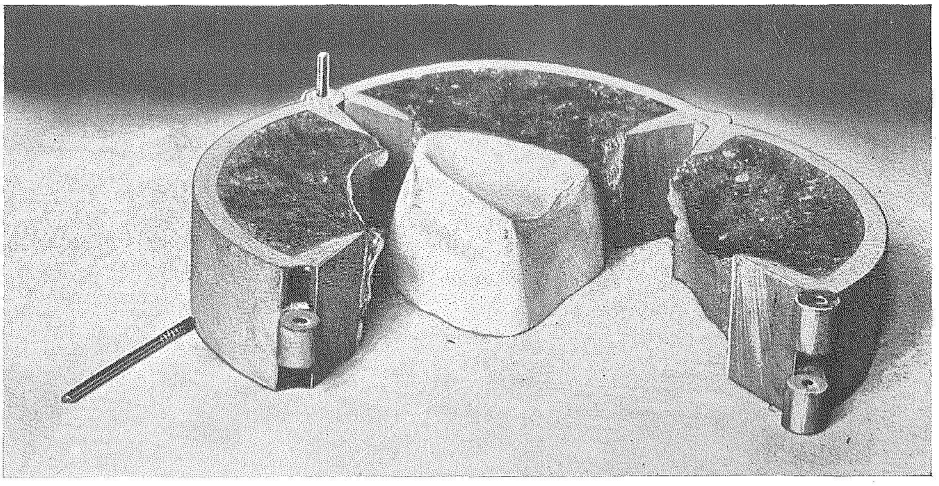


Fig. 54.—Upper Section Removed, Lower Section Separated, for Release of Model

the model is removed and the flask sections are brought together again, the fractured surfaces of sand are again readapted to each other as before, and form the continuous outer wall of the matrix.

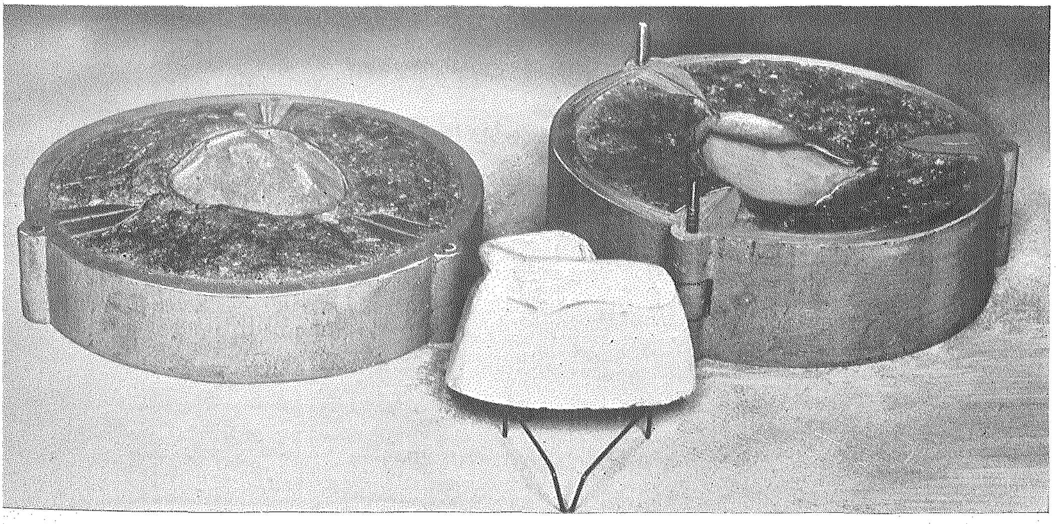


Fig. 55.—Model Removed, Sectional Part of Flask Closed

Special care should be taken to remove any sand that may have become lodged between the flask joints and flanges, for if allowed to remain, the sections can not be closed properly.

The pin removed in opening the flask is now slipped into its joint, and the inverted top half of the flask is lifted and carefully set in place on the sectional portion, the projecting pins guiding it to position. The entire flask is turned over, and if the steps have been properly carried out, the matrix will be found to be satisfactory.

Should a margin of sand along any of the sectional lines be broken lightly, it will seldom be found necessary to attempt restoration of the matrix, as the metal which will fill the opening can easily be removed from the die when cast.

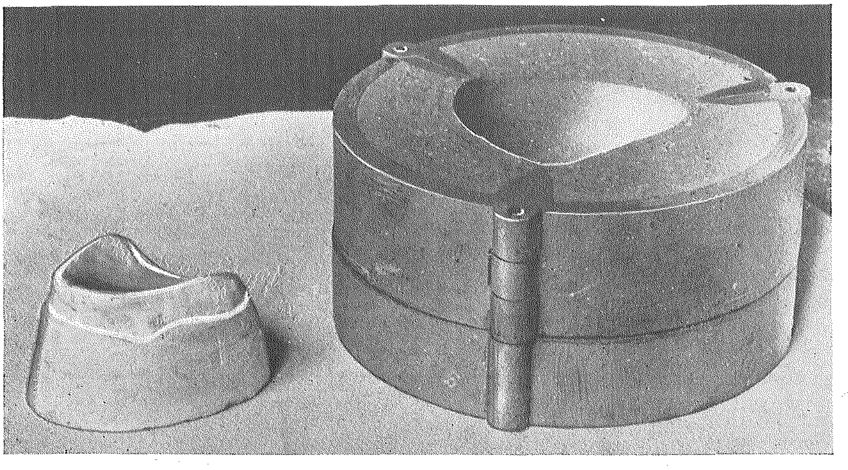


Fig. 56.— Upper Half of Flask Set and Case Invested for Reception of the Metal

The utility of this special flask, both for accuracy of results and the saving of time, is keenly appreciated by those who have used it. Unfortunately, its good points are unknown to many, and the core method, although less accurate and requiring longer time, is most frequently resorted to in cases of external undercut models.

EXAMINATION OF THE MATRIX

When, by whatever method, the sand matrix is formed, it should be closely examined to see that none of the essential surfaces have been disturbed; to see that the sand is sufficiently compact to insure smooth surfaces to the die when cast, and before pouring the molten metal, to see that no loose sand is present.

Forming the Die

MELTING THE DIE METAL

A satisfactory sand mold or matrix having been secured from the model, it is ready to receive the molten die metal. To conserve time, the ladle containing the latter is usually placed on the fire before making the matrix, since the production of the latter usually requires less time than is consumed in fusing the metal. The progress of fusion should be noted, however, and when about three-fourths melted, the ladle should be removed from the fire. The excess of heat absorbed by the metal up to this point is usually sufficient to effect the

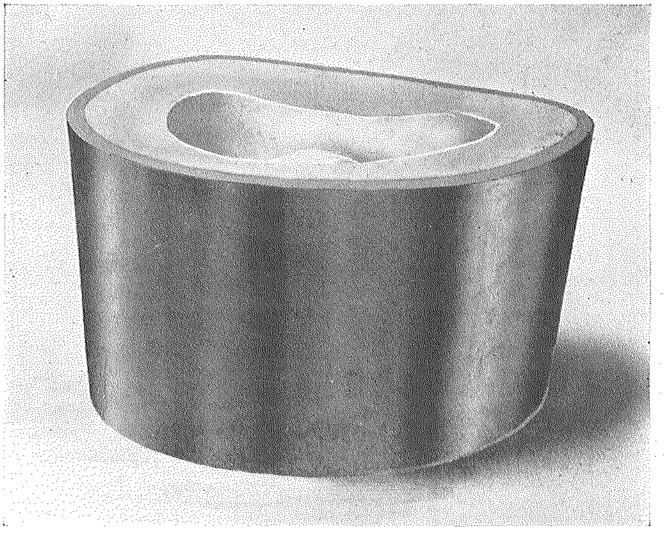


Fig. 57.— Completed Matrix in Sand

fusion of the unmelted portion after removal from the fire. This plan also lowers the temperature of the mass to somewhere near the proper degree for casting.

A thin spatula of soft wood should be used for stirring the metal and removing the oxides and impurities. If the wood burns or chars, it indicates that the metal is too hot to cast. The lower the temperature at which the metal can be introduced into the matrix and yet be sufficiently fluid to conform accurately to all irregularities, the less shrinkage of the die will occur. Also a less quantity of gas or steam will be generated in the matrix, and as a result a smoother die will be produced.

CASTING THE DIE

When the metal is melted, the oxides removed, and the proper degree of fluidity attained, the ladle is carried to one of the disto-buccal angles of the flask, and as close to the latter as possible without disturbing it by contact of the ladle lip.

The object in bringing the ladle close to the matrix is to prevent displacement of the sand which occurs when, in pouring, the metal falls from a considerable distance upon it.

Through the ladle spout a small stream of metal is directed into the back of the mold and the entire matrix is filled in this

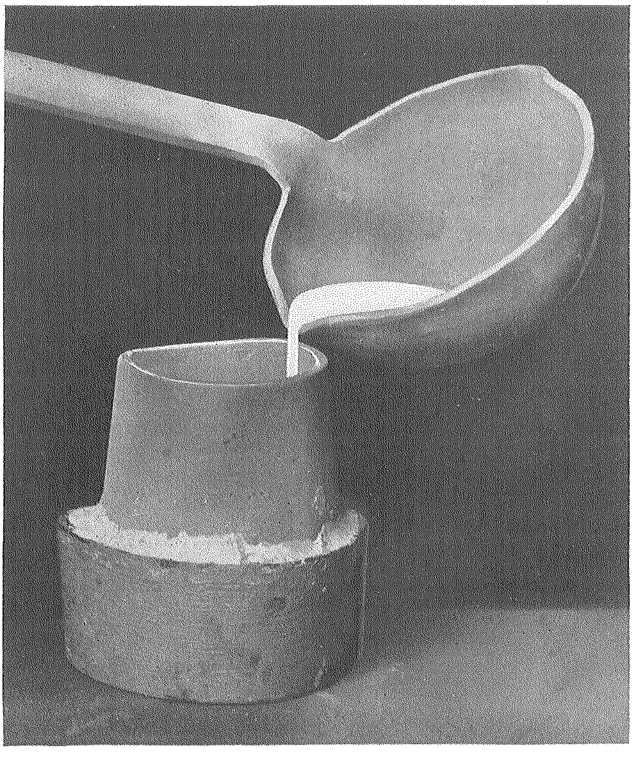


Fig. 58.—Small Ring Adjusted and Banked to Receive Additional Die Metal. Pouring the Die

manner, even with the sand margins. The ladle should be returned to the fire immediately in order to keep the remainder of the metal in a molten condition while adjusting the ring for increasing the depth of the die with additional metal. A flask ring, usually the smallest of the set, the periphery of which should be slightly greater than that of the matrix margin, is placed, large end down, and pressed slightly into the sand. Some sand should be quickly packed around its outer base to prevent the escape of the metal now to be added to the die.

The ladle containing the remainder of the molten metal is brought close to the edge of the small ring just placed and a sufficient amount of metal added to that first cast to give the die a depth of about 2 inches in its central part. This step can and should be carried out so rapidly that union between the first and second casts of metal will be effected and a solid one-piece die result.

When hardened, the die is removed by tipping the flask rings over and tapping to free the packed sand from the interior, while that on the outer surface of the die is scraped and brushed away. The die and flasks are usually cooled im-

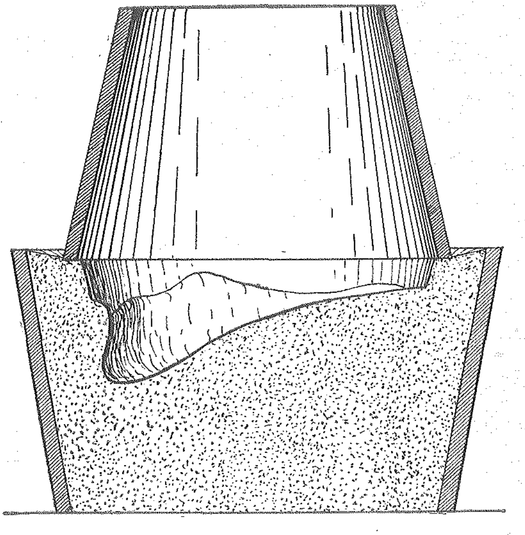


Fig. 59.— Sectional View of Small Ring Adjusted to Sand Matrix

mediately in water and wiped dry, preparatory to casting the counterdie. The die, however, will be more tenacious and less inclined to crack under the hammer blows if allowed to cool slowly.

INSPECTION AND CORRECTION OF THE DIE

Any projecting imperfection on the die due to holes in the sand matrix should be removed with scrapers, chisels or burs, if necessary, and the surfaces, where such defects exist, made to correspond with those of the model. Any serious defects in the die, when cast, either as accretions, holes or pits are liable to result in imperfect adaptation of the base when swaged. Such a die should be discarded and a perfect one secured.

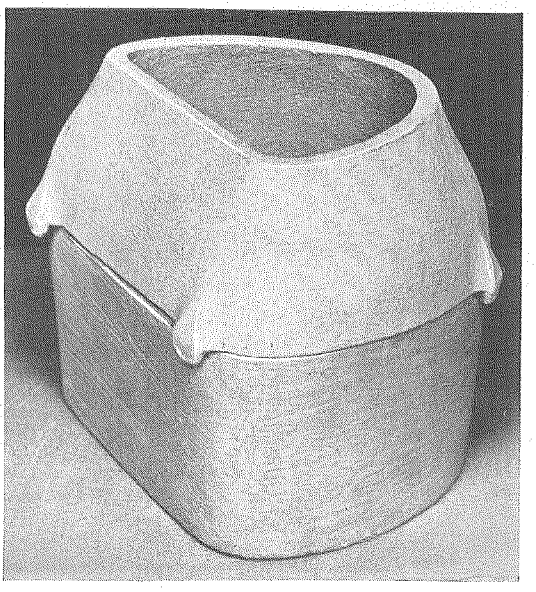


Fig. 60.— Bailey Flask

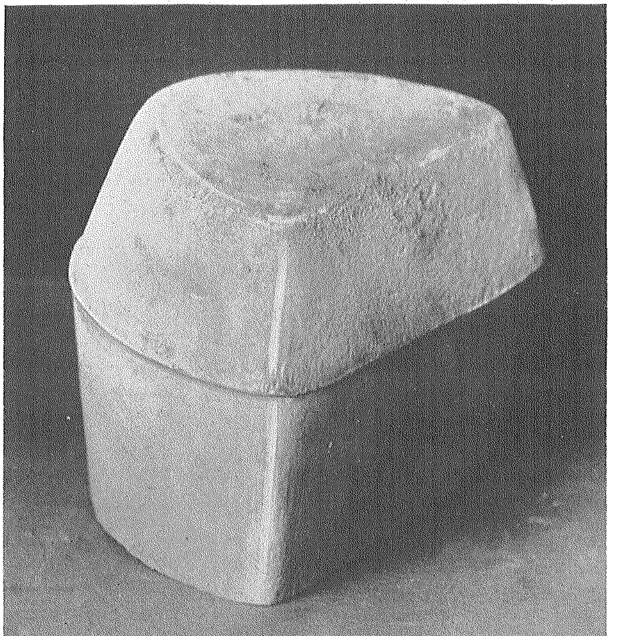


Fig. 61.— Die and Counterdie Produced in Bailey Flask

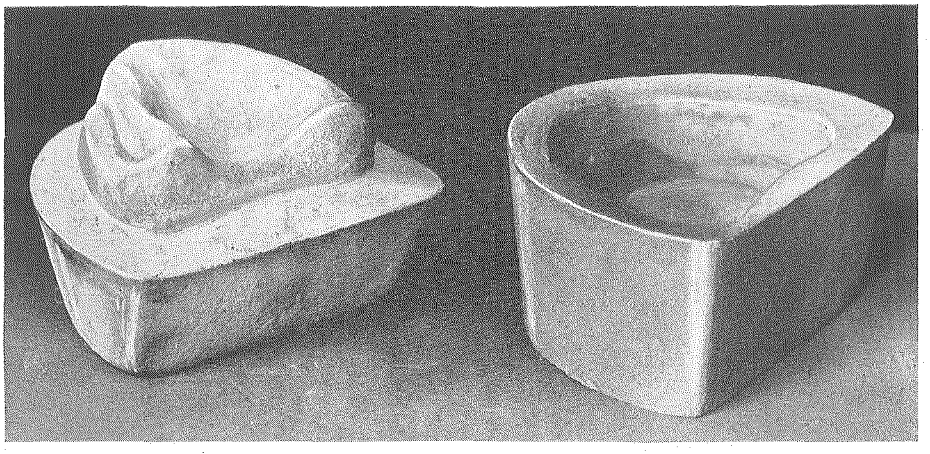


Fig. 62.— Die and Counterdie Separated

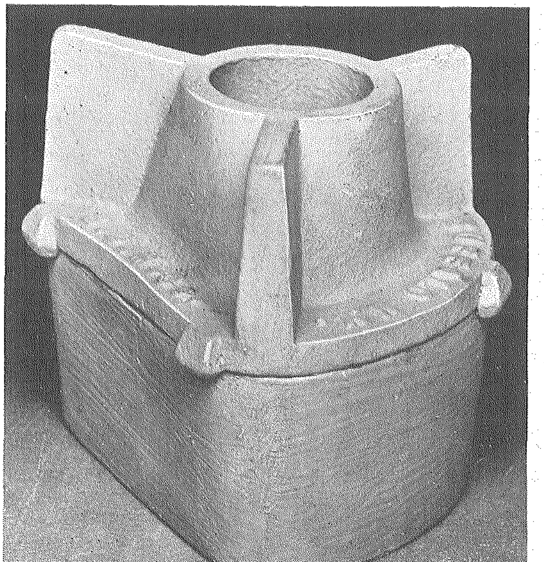


Fig. 63.— Lewis Flask

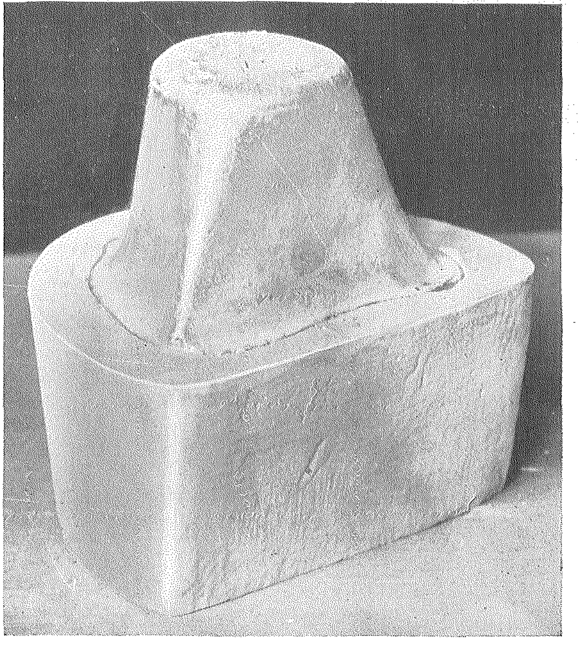


Fig. 64.— Die and Counterdie Produced in Lewis Flask

Fig. 65.— Die and Counterdie Separated

Construction of the Counterdie

PREPARATORY STEPS

The large flask in which the matrix for the die was formed is now inverted or placed small end down on the bench and partially filled with sand. In this the die is set and evenly centered to the ring. The depth of sand under the die base should be sufficient to raise the entire labial and buccal surfaces of the die border slightly above the upper margin of the flask.

The space between the flask walls and the die is now filled in with sand which should be firmly condensed and finished off evenly with the top margin of the flask, the inner margin of the sand terminating against the peripheral plate line on the die. This leaves only the essential surfaces of the die visible and standing above the general level of the sand and flask margin.

The exposed surfaces of the die are now carefully brushed to remove any adhering sand. In case of decided undercuts, sand is tightly packed into them at this time so as to preclude the counterdie metal, when cast, from entering such areas and later preventing the ready separation of the die and counterdie. Subsequently, when swaging, this defect of the counterdie is overcome by placing strips of lead or tin against the plate opposite the deficient area, the strips being of sufficient thickness to make up for the lack of contour in the counterdie.

The die is now coated with a solution of whiting and alcohol, to which a little gum Arabic is added to render it adhesive after the alcohol evaporates. The film of whiting practically obviates the tendency of the counterdie metal to unite with the die in casting.

A flask ring, corresponding in size with the one in which the die is imbedded, is adjusted peripherally to the latter, large end down, to form the matrix in which to cast the counterdie. A smaller ring, however, may be used for forming the matrix walls for the counterdie, when the die is of medium or small size. Such a ring reduces the counterdie peripherally and adds to convenience in handling. When the small ring is used, it is set on the sand surrounding the die and its lower margin banked up with sand to prevent the escape of the molten metal while casting.

MELTING THE COUNTERDIE METAL

The fusing of the counterdie metal is accomplished in essentially the same manner as is employed for the die metal. It should be removed from the fire before the entire mass is melted and stirred to lower the temperature and collect the oxides and impurities present. These should be skimmed off and the stirring continued until the metal begins to assume a pasty condition.

The object in allowing the metal to cool somewhat and thicken slightly before casting, is to avoid danger of fusion of the die and its consequent union with the counterdie, a mis-

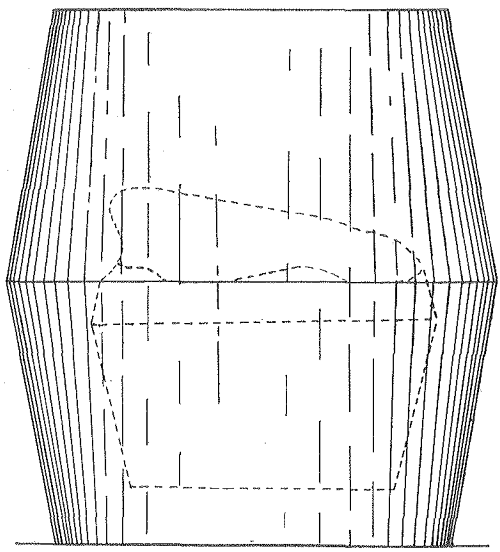


Fig. 66.— Sectional View of Rings and Imbedded Die Ready for Receiving Counterdie Metal

hap which frequently occurs when the latter metal is cast while overheated.

CASTING THE COUNTERDIE

When the metal begins to congeal around the ladle, it is quickly emptied into the ring and over the face of the die. Should the metal be in such a thickly plastic state that it fails to assume a level position in the ring when cast, it should be pressed down, while yet soft, with a square-end tamper, to give a flat base to the counterdie.

As a matter of fact, the counterdie metal can be cast while in a liquid condition if proper precautions are taken, viz.:

the die must be cold, its exposed surfaces coated with whiting, the metal allowed to cool to about the point of congealing, or so that it will not char soft wood, and in casting, directing the stream of metal on the sand surrounding the die, and not on the die face.

When poured in a liquid condition, the metal should be cast slowly. In this manner it rises gradually up over the surfaces of the die, and at the same time, from exposure to the air and through contact with the cold die, sand, and ring, the metal, if at or slightly above the point of fusion, is reduced in temperature so that union of the two will not occur.

CONSTRUCTION OF THE COUNTERDIE BY DIPPING

A method sometimes followed for securing a counterdie consists in pouring the metal into a ring of suitable size and immersing the face of the chilled die in it the necessary depth to cover the surfaces involved by the base plate. The die is held with the fingers or a pair of tongs until the counterdie metal has hardened sufficiently to sustain its weight.

THICKNESS OF THE COUNTERDIE

In the swaging process the die and plate are driven more or less deeply into the counterdie, the latter yielding under the hammer blows. To prevent the defacement of the prominent points on the die, the counterdie should have a depth of at least one-half inch in its shallowest part, or that portion between the high points of the die face and the base of the counterdie, which rests on the anvil. A good die may be readily distorted when the counterdie is too shallow and much stress is applied in swaging.

SEPARATION OF THE DIE AND COUNTERDIE

When the counterdie metal has solidified, the rings are tipped over and disengaged, the sand brushed off, and the die and counterdie chilled in cold water.

The two are loosened by placing on the swaging block and striking the die base sharply with the hammer, when they may readily be separated. If this procedure fails to break adhesion between the two, the die should be struck sideways in various directions. Should this effort prove futile, the source of adhesion will be the result of mechanical anchorage, due to undercut surfaces on the die into which the counterdie metal has flowed in casting, or to fusion of the two masses of metal at some point. If due to undercuts on the die, properly directed hammer blows against its sides will enlarge the counterdie sufficiently to release the die. Adhesion from this source is the result of carelessness, and will not occur if the undercut surfaces of the die are corrected with sand before casting the counterdie.

When adhesion is due to fusion and union of the two masses of metal, the die and counterdie are separated by hammering, prying, wedging or chiseling, as is found most convenient. Such means result in the defacement of both die and counterdie and usually necessitates the reconstruction of each.

Special care should be exercised in such cases where fusion of the two occurs, to entirely remove and cast aside that portion of the die and counterdie that have become united, before melting either one.

If the alloy thus formed is allowed to remain adherent to the die metal, the hardness and fusibility of the latter, when used again, will be reduced, and if with the counterdie, it will render that alloy harder and higher fusing.

PARTIAL COUNTERDIES

A method of using several counterdies of gradually increasing area has been in vogue for many years. The object in using these *progressive counterdies* is to insure the close and uniform adaptation of the base plate to the central vault portion first, before the labial and buccal surfaces have been lapped over and conformed to the border.

Such counterdies are very effective in those cases where the arch is narrow and the palatine vault is deep, as by their use the tearing of the plate is obviated.

Usually in this method, three counterdies are required; the first covering the palatine vault and terminating somewhat inside of the border crest; the second should cover the vault and extend somewhat outside of the border crest; the third consists of a counterdie of the regular form, made in the manner previously described.

CONSTRUCTION OF PARTIAL COUNTERDIES

To construct a partial counterdie, the die is set, base down, on the table, a large molding flask set evenly over it and sand packed around it and even with the top of the flask, leaving the central portion of the die exposed. With a suitable instrument the sand is cleared away so as to make a slightly flaring matrix in the sand, the floor of which consists of that portion of the die to be covered by the partial counterdie. The exposed face of the die is coated with whiting and the partial counterdie cast in the matrix in the ordinary manner.

Partial counterdies should be of sufficient depth or extend far enough above the die, when in position, to enable them to be grasped firmly with the fingers and thumb while swaging. The metal used for partial counterdies may be of lead, the regular counterdie metal of lead and tin, or composed of one of the triple alloys, such as Melottes metal.

Matrix Counterdies

Various substances, such as soap, clay, modeling compound, shot, etc., as previously mentioned, may be used instead of the ordinary cast counterdie, when the material is confined in a suitable receptacle, or matrix.

The Parker shot swager is one type of appliance used for such purpose. This device, however, is intended more particularly for securing the final adaptation of a base plate to the die or plaster model itself, if such step is deemed advisable.

The device in which the other materials mentioned are used consists of a heavy cast iron base, in the center of which is a deep recess corresponding peripherally with the inner walls of the small casting ring used for increasing the depth of the die. The soap or other material is placed in the recess and covered with a sheet of soft, pliable leather, to prevent adhesion of the swaging material to the plate.

When the adaptation of the plate has been fairly developed with the horn mallet, it is placed on the die and the latter introduced into the recess.

Since the periphery of the die coincides with and closely fits the opening in the ring, escape of the plastic material is prevented. Under hammer blows or screw power, the force thus delivered distributes the material and equalizes the pressure so as to drive the plate into all inequalities and against all surfaces of the die.

This device obviates the making of counterdies in many instances, since it is applicable to the swaging of base plates of almost any form when the dies are properly constructed.

The leather should be removed, the plastic material built high in the center, and the leather again returned to place, for each new case swaged. This step is necessary to insure palatine adaptation of the plate before the pressure is brought on the buccal surfaces.

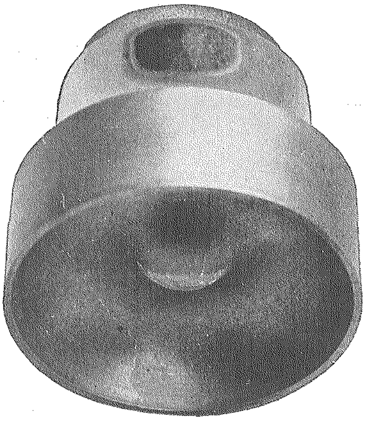


Fig. 67.— Top of Parker Shot Swager

The method here outlined is especially useful in the swaging of aluminum base plates. On account of its stiffness and elasticity, 18K gold cannot be readily adapted by this means. The device, however, as a time saver, is a valuable adjunct to the laboratory equipment.

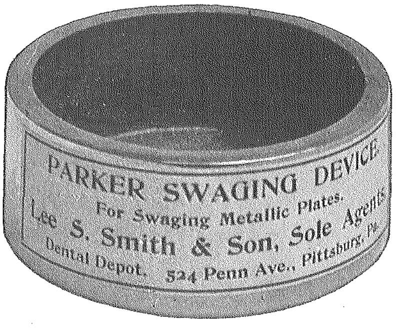


Fig. 68.— Base of Parker Shot Swager

Counterdies for Partial Cases

In constructing counterdies for partial dentures, the die is imbedded in the sand, so as to leave exposed the area to be covered by the baseplate, the surfaces of the teeth removed by cutting and possibly a slight amount of the labial and buccal surfaces of the die to guide and hold it in position in the counterdie while swaging.

Nothing is gained by having the die deeply depressed in

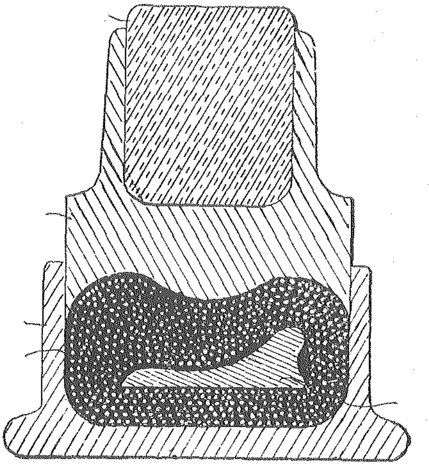


Fig. 69.— Diagrammatic View of Model in Position, Surrounded with Shot

the counterdie. In fact, such a condition is a disadvantage, rendering the removal of the plate more difficult, as from time to time it is taken out for inspection and trimming.

CHAPTER XII

CONSTRUCTION OF SWAGED DENTURE BASES OF GOLD

Securing Pattern for the Gold Plate

Suitable dies and counter dies having been constructed, the next step is to secure a pattern for cutting the gold plate. By the use of a pattern two important objects are attained, viz.:

First. Unnecessary loss of gold will be obviated. The trimmings and filings that accumulate in adapting a gold plate to a die are classed as "scrap," which must either be refined before using again, or be returned to the refiners at a loss of about 1-5 the original cost. When care is taken in keeping the scraps assorted and free from solder, filings and impurities, they can be remelted, rolled into plate, and used again without loss.

Second. A piece of gold, cut to the required outline of the denture, is more easily adapted to the die than an excessively large piece. The tendency of the plate to shift slightly in the preliminary steps of swaging necessitates a surplus of about 1-16 of an inch peripherally in the gold for full as well as partial cases.

Tin foil, sheet lead or paper may be used as a pattern. A sheet of No. 60 tin or lead foil is conformed to the die with finger pressure or a large pellet of compact cotton, and the excessive surplus trimmed off. It is again returned to the die, readapted and finally swaged in the counterdie. One or two light blows with the hammer, or the weight of the die itself, will secure close adaptation. When removed, the excess is trimmed away, allowing for the 1-16 inch surplus previously mentioned.

With the fingers the pattern is carefully bent and reduced to nearly a flat condition, care being taken not to strain or draw it more in one area than another. It is now laid on the flat palm of one hand and struck a sharp blow with the open palm of the other. This reduces the foil to flat sheet form slightly wrinkled in some places and possibly torn in others from the swaging, yet representing reasonably well the required peripheral outline of the denture.

The foil itself may be used as a pattern or its outline may be traced on a sheet of thin cardboard, which, when cut, facilitates the marking of the gold plate because of its greater thickness and stiffness. The tracing of the pattern on the gold is most easily accomplished with a round shank, sharp pointed instrument, held perpendicularly. If neither tin nor lead foil is at hand, ordinary tough writing paper, although not as satisfactory, will serve for the pattern.

When trimmed to proper outline, the pattern is laid on the sheet of gold plate, so that when the latter is cut the grain or lamina developed in rolling runs crosswise or from buccal to buccal, this being the line of direction of greatest stress on the baseplate, in swaging as well as in masticatory effort.

Carat of Gold Used for Denture Bases

Twenty carat gold is the standard fineness of plate used for denture bases. The advantages of this grade of gold are: excellent color, but little tendency to discolor in the mouth, no metallic taste, comparatively easy to adapt to dies, good resiliency when medium to thick gauges are used.

The only disadvantage noticeable is the tendency of the lighter gauges to become distorted under heavy stress. Obviated by using gauges of plate appropriate to the stress the denture will be subjected to in masticatory effort.

Eighteen carat gold is frequently employed for both full and partial denture bases. The only decided advantage it has over twenty carat gold is in having greater resiliency than the latter in plates of equal thickness, and, therefore, lighter gauges can be employed to advantage in some cases than when higher carats of plate are used.

The disadvantages of eighteen carat plate are: color not so good as the twenty carat, decided tendency to discolor in the mouth, and in some cases to exhibit a metallic taste.

Pure, twenty-two and coin gold are deficient in resiliency and are not adapted for denture bases unless combined with gold of lower carat. In difficult cases, where the maxillary surfaces are very rough and irregular, and the rugae are well defined, a thin sheet of 22 carat or 24 carat gold is sometimes adapted to the die and a second piece of 18 or 20 carat swaged over and attached to the maxillary plate with solder. The use of the finer and softer grade of gold next the die permits all of the irregularities to be accurately copied, while the second plate, being harder and more resilient, furnishes the necessary rigidity. This method of forming a double base is frequently followed in partial cases, but is seldom required in full dentures.

Gauges of Gold Used for Denture Bases

For full upper dentures, 28, 27, and 26 gauges of gold are used as conditions require. Twenty-eight-gauge, 20-carat plate is sufficiently rigid for narrow arches where the stress of mastication is light to medium heavy. Twenty-seven-gauge, 20-carat is indicated for arches of medium width, medium stress, and in narrow arches when stress is heavy. Twenty-six-gauge is indicated for wide arches when the denture will be subjected to heavy stress.

Full lower dentures seldom require heavier than 28-gauge plate, since the vulcanite which furnishes attachment for the teeth usually covers the entire base, and this, together with the peripheral wiring, supplies the needed rigidity. Frequently 29-gauge will prove satisfactory.

That one may form a just estimate of the relative thickness of the gauges mentioned, their value according to the Brown & Sharp micrometer scale is here given. This micrometer scale is given entire in the section on metallurgy.

26	gauge	equals	.01594	of an	inch								
27	"	"	.01419	"	"	Difference	between	26	and	27	gauge	equals	.00175
28	"	"	.01264	"	"	"	"	27	"	28	"	"	.00155
29	"	"	.01126	"	"	"	"	28	"	29	"	"	.00138
30	"	"	.01002	"	"	"	"	29	"	30	"	"	.00123

To gain rigidity within restricted areas, partial denture bases are frequently formed of two pieces of plate, swaged separately, then together, and finally soldered. Usually two pieces of 30-gauge or one of 30 and one of 29 gauge are combined in this manner. The two pieces of 30-gauge equal .0200, or approximately 24-gauge, which is .0201. The other combination equals .0212, or about 23½ gauge. Various other combinations of gauges can be utilized, as the conditions of individual cases demand, broad bases requiring thin, while narrow bases call for thicker gauges of plate.

ANNEALING THE PLATE

Gold plate, as usually furnished by the supply houses, is not in its softest possible condition, and therefore should be annealed before attempting to adapt it to the die, as well as at various times during the swaging process.

Hammering, rolling, bending, burnishing and polishing tend to stiffen and render the gold, as well as other metals, hard, more or less springy and elastic, and reduce their pliability.

Molecular tension is also developed by working the plate, a property which tends to bring the molecules back to the original relation they sustained to each other before the plate was subjected to working stress.

The hardness, tension and loss of pliability increase in proportion to the stress to which the molecules are subjected. Hardness and reduction of pliability render the securing of perfect adaptation of the base plate to the die difficult. Molecular tension tends to destroy adaptation by warping the plate when swaged to correct form, particularly when subjected to high temperatures, as in soldering on the peripheral wires and the attachments for the vulcanite.

Gold plate is annealed by laying it on a clean charcoal or asbestos soldering block and applying the soft brush flame of the blowpipe until the plate assumes a cherry red color, when it should be thrown quickly into clean, cold water or alcohol. Care should be taken not to overheat or fuse the gold at any point, or its toughness and cohesiveness will be impaired.

OILING THE DIE AND COUNTERDIES

Before beginning to adapt the plate, the surfaces of both die and counterdie should be coated with a thin film of thick, viscid oil, such as vaseline or heavy lubricating oil. This is done for two reasons: First, to prevent, as much as possible, the adhesion of the base metals to the gold under the heavy sliding friction induced by swaging the plate between the die and the counterdie. Second, the oil acts as a lubricant and permits the gold to slide over surfaces which, if not oiled, would result in tearing or shearing the plate. The oiling of the die and the counterdie is extremely important, and under no circumstances should it be neglected. Dies and counterdies composed of the triple alloys, such as are used in crown and bridge work, should receive the same treatment for similar reasons as stated.

The old method of interposing a thin sheet of rubber dam between the plate and counterdie to prevent contamination by the base metal is not to be commended, as the rubber acts as a cushion and reduces the positive action of the metal matrix against the gold.

CLEANSING THE PLATE — PICKLING

When gold plate becomes contaminated by any of the base metals such as are employed for die and counterdie purposes, and is subjected to the blow-pipe or Bunsen flame in the annealing process, an alloy is formed at the points affected, which is brittle and low fusing in character. When this occurs, the strength and fusibility of the plate is reduced. Subsequently, in soldering operations, the areas so contaminated are very liable to fuse and result in the formation of pits or holes, sometimes called "burning the plate." This is an incorrect term, as the alloy is merely fused and its tendency to spheroid causes it to draw back to the more infusible portions of the plate not so affected.

To remove the base metal that adheres to the plate as a result of hammering and friction between the die and counter-die, it should be boiled in dilute sulphuric acid from ten to fifty per cent strength. Even the action of the acid fails at times to remove all of the base metal, particularly the lead and tin, in reasonable time. Sulphuric acid, either full strength or diluted, does not act readily on these metals, as is apparent by the fact that it is often kept in lead containers for a long period without injury to the vessel. This, however, is partly due to the fact that after a time a film of lead sulphate is gradually formed, which limits further action of the acid on the unaffected lead.

A positive and final method of removing particles of base metal from the gold is by the application of pumice stone to the plate with a stiff brush wheel on the lathe. This should be resorted to after boiling in acid and rinsing in water.

Conforming the Plate to the Die

STEPS OF ADAPTING THE GOLD, IN FULL UPPER CASES

The gold plate having been cut according to pattern, is now evenly centered over the die, and with finger or thumb pressure forced down into the vault portions as closely as possible in this manner. The adaptation is carried further with a horn mallet, being careful not to mar the plate unnecessarily with the pointed end. Two or three forms of mallet, with ends of different shapes and sizes, should be at hand to meet the varying conditions which present. The small end of the average new horn mallet is usually too sharp and too pointed to be serviceable and should be cut off and somewhat rounded with a rasp.

From the very beginning, and until thoroughly close adaptation is secured, wrinkles or folds in the plate are very liable to develop. Such mishaps usually occur when an attempt is made to closely conform a considerable area of plate to an irregular or constantly varying surface of the die, as for instance a deep palatine vault, the labial surfaces of a prominent or V-shaped arch, or prominent tuberosities.

The physical conditions bearing upon the changing of a flat plate to the irregular form, assumed by a well-adapted base plate should be borne in mind. Certain areas must be raised, others depressed, and still others will require but little general modification. Molecular changes must be brought about uniformly. In some locations, the molecules will be stretched and pulled — occasionally to the point of destroying their cohesion, which will result in thinning and tearing the plate.

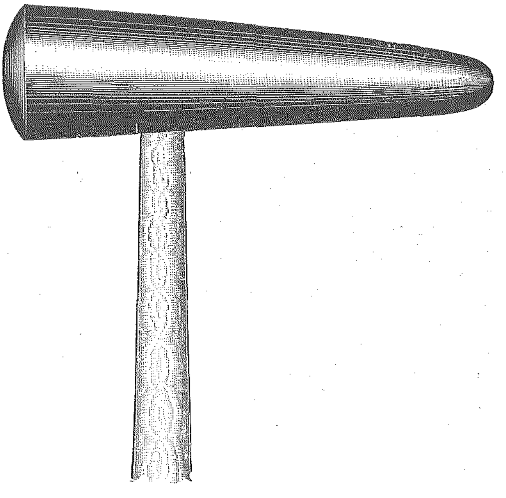


Fig. 70.— The Horn Mallet

In other areas, the molecules must be compressed upon themselves, the first noticeable effect of which is in the formation of wrinkles, with a slight tendency to thicken the plate. The folds and wrinkles must be obliterated as soon as they are formed and before they are jammed too closely together for correction. Flat and round-nosed pliers and the plate benders are used to advantage for this purpose. The judicious use of the horn mallet or a small riveting hammer will also correct the difficulty by striking the fold with a sliding blow peripherally, at the point on the adapted surface where it first appears.

The vault portion having been fairly well adapted, either by the aid of the partial counterdie or with the horn mallet alone, the next step is to conform the plate to and over the crest of the maxillary borders. The die can conveniently be held in the hand, the thumb pressing the plate and keeping it closely in contact with the vault portion, while adapting the metal to the border crest.

The large end of the horn mallet is applied here, using moderate blows to prevent thinning the plate unnecessarily — usually a few well-directed blows will accomplish the desired end.

USE OF PARTIAL COUNTERDIES

When partial counterdies have been constructed, the second or largest of the two partials is applied to advantage following the use of the horn mallet, for setting the plate against the maxillary border.

In difficult cases, where much irregularity of the border surface is present, a clamp may be used to advantage for holding the adapted vault portion of the plate firmly in contact with the die. A wad of compact, damp paper is placed against the vault portion of the plate to give bearing to the clamp screw, prevent the latter from marring the plate, and by its tendency to spread slightly under screw pressure, force and hold a considerable area of the adapted portion against the die. When partial counterdies have been constructed, the smallest of these can be used in lieu of the paper.

The die, with the plate in position, can be clamped to the bench, when necessary, to give the prosthetist the free use of both hands, but usually it will be found best to clamp the die and plate together so that they may be held in the hand and turned in any convenient position for the application of the mallet blows.

The plate is adapted to the labial and buccal surfaces of the die by striking a sliding blow from the border crest to the periphery. The adaptation should begin at the median line on the labial surface and be gradually developed distally, about equally on both sides. In other words, secure reasonably close adaptation from the median line to the cuspid eminence on one side, then direct the effort to the opposite side in like manner, continuing the adaptation similarly on the buccal surfaces and finishing at the tuberosities.

Another method in common practice is to slit the plate in the median line, on the labial surface, from the periphery to the crest of the border. The buccal surfaces are then adapted and the surplus plate worked forward, allowing it to lap at the median line. The excessive surplus of plate at the lap joint is removed with the shears and the joint soldered before the final swaging. The method first described is usually to be preferred, although at times, when the general form of the arch is narrow and the labial and buccal surfaces are deep from the border crest peripherally, slitting and soldering the plate as outlined will be convenient and satisfactory, and will enable the prosthetist to economize on time.

It is not expected that the adaptation of the base plate to the die with the horn mallet will be very close, but it should be reasonably well developed to prevent folds from forming in the final swaging in the counterdie.

The peripheral excess of the base plate is trimmed away to the required outline of the finished denture, the plate pickled in dilute acid, polished on the lathe with a stiff brush wheel and pumice stone, to remove any adherent particles of base metal which the acid does not remove, washed clean, and thoroughly annealed, before the final swaging.

SWAGING IN THE COUNTERDIE

The base plate being clean and soft from annealing, and the counterdie freshly oiled, the final adaptation is quickly secured. The base plate is placed on the die and settled evenly into the counterdie, as far as the latter will receive it. Place the counterdie on the swaging block, and with a four to six pound hammer, strike the base of the die squarely, one reasonably sharp blow, separate, remove the plate, and note whether any folds or wrinkles have developed, and if so, remove them. Return the plate and strike the die two or three heavy blows and again inspect, first for folds, and finally for adaptation. Repeat as often as may be necessary to secure perfect approximation of the plate to the die surfaces and especially around the periphery.

Finally, when the adaptation is satisfactory, pickle, polish, anneal and return to the counterdie and strike a final blow to correct the warpage occasioned by the last annealing, and which almost invariably occurs. A single well-delivered, heavy blow following this final annealing corrects warpage and does not develop any further appreciable molecular tension.

This latter step is very important, for if not carried out as described and the wiring of the base plate is undertaken while any molecular strain is present, warpage is most certain to occur.

The periphery of the base plate should be trimmed with shears and files, as accurately as possible, to the required outline of the finished denture before the final swaging, for if after trial in the mouth the shears are used, distortion of the base plate is liable to follow from the strain. Should this occur, correction must be made by reswaging.

Preliminary Steps in Securing Anchorage for Teeth to Baseplate

In full gold base denture cases, the teeth are usually attached to the gold base by means of vulcanite. This method of attachment obviates the many angles and spaces which result from backing plate teeth and joining them to the base with solder. Again, when more or less absorption of the border has occurred, and for esthetic reasons restoration of such loss is necessary, it can be most easily accomplished in vulcanite. Therefore, for hygienic and esthetic reasons, this method is resorted to in practically all full denture cases.

When rubber is molded and vulcanized against a smooth surface of gold plate, the two materials adhere quite firmly, but unless some positive mechanical anchorage is provided, the vulcanite will part from the baseplate sooner or later, under the constant vibratory stress of mastication.

VARIOUS MEANS EMPLOYED FOR VULCANITE ANCHORAGE

Several methods of anchorage can be utilized for increasing the bond of union between the gold and vulcanite, none of which alone will prove sufficient, but by combining usually three, a permanent and lasting attachment can be effected.

USE OF WIRE LOOPS

First, in full cases, from three to five loops of wire or narrow corrugated strips of plate should be soldered to the maxillary surface of the gold base, at various points along the border, in such manner as subsequently not to interfere with the arrangement of the teeth. In closing the packed flask, the rubber is molded around and under these anchor loops, where it hardens during vulcanization. This is the best and most positive form of mechanical anchorage possible to develop.

SPURRING THE BORDER SURFACES

Second, with a diamond point engraver, many opposing spurs should be raised over the entire area covered by the vulcanite. The spurs should extend to the extreme margins to prevent the thin edges of vulcanite from eventually warping and curling away from the baseplate.

APPLICATION OF RUBBER CEMENT

Third, by applying a thin film of chloro-rubber to the surface of gold involved, just before closing the packed flask, it will act as a cementing medium and aid the mechanical retention otherwise provided.

FORMING THE PERIPHERAL SHOULDER

In order that the line of junction of the vulcanite with the gold base may be symmetrical, and to further guard against the extreme margins of the vulcanite curling away from the

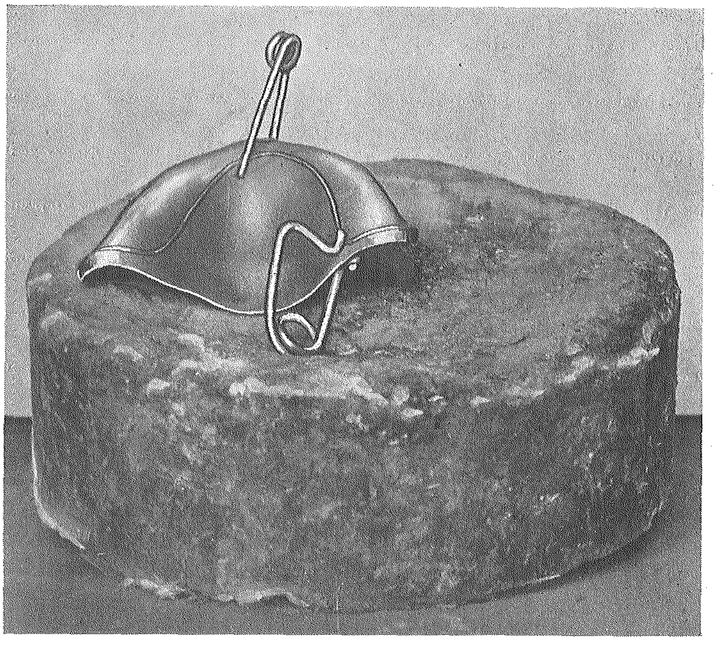


Fig. 71.— Soldering the Shoulder Wires to an Upper Base

base plate, a fine wire, usually 19 gauge, and 20 carat, is soldered to the labial and buccal surfaces and continued around the tuberosities along the lingual aspect of the border. The surface included within this wire loop represents the area to be covered by the vulcanite. When soldered, the inner periphery of the wire is squared out with small stones and burs so as to present a square shoulder against which the vulcanite finishes. In attaching the wire, care should be taken to avoid filling with solder the angle formed by the junction of the baseplate with the inner periphery of the wire. The application of an anti-flux will prevent the solder from filling angles and covering surfaces from which it should be excluded.

The outer side of the wire, or that surface presenting toward the periphery of the base and to the central vault portion, is filled in with solder and afterward ground to meet the baseplate, merging it into a symmetrical curve, thus obviating the formation of an angle into which food might find its way.

LOCATING THE POSITION OF THE WIRE ON THE BASEPLATE

The location of this wire which marks the boundaries of the vulcanite is determined by occluding and waxing the teeth to the base in the position they will occupy in the finished denture. On the lingual side the wax is contoured to represent the normal curvature of the palatine vault, terminating it as soon as possible without forming an angle at its junction

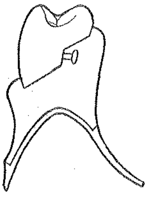


Fig. 72.— Sectional View of Base Showing Finished Shoulders with Vulcanite in Position

with the base or alveolar border. On the other hand, it should not be extended too far toward the center of the vault, or the contour of the finished case will be unnecessarily bulky.

The wire is attached to the labial and buccal surfaces of the baseplate about one-eighth of an inch from the peripheral margin. It is placed in from the margins to this extent so that after the denture is introduced, should peripheral trimming of the base become necessary, it may be accomplished without cutting into the vulcanite.

The exact position of the wire is determined by scratching a line on the gold base with a sharp instrument, just within the peripheral margin of the contoured wax rim. The position of the anchor loops can also be determined at this time by thrusting a sharp pointed instrument through the wax rim to the baseplate and scratching it in the lingual embrasures between the first and second molars, the first and second bicuspids, and as close in to the mesio-lingual angles of the central incisors as possible, so that this loop will not interfere with the proper lingual contour of the vulcanite, back of the incisor teeth.

The denture is now removed from the occluding frame on which it has previously been mounted, the teeth and wax rims are detached, and the baseplate thoroughly cleansed. A piece of wire about 9 inches long is required for forming the peripheral shoulder. One end of this is conformed and clamped to the wire line, beginning usually at one of the tuberosities, where it is fluxed and tacked with a small piece of solder. The baseplate is chilled, the wire is further conformed along the line for a distance of one-half to one inch and again clamped and soldered. This is repeated until the wire is attached to the entire peripheral outline on the base-

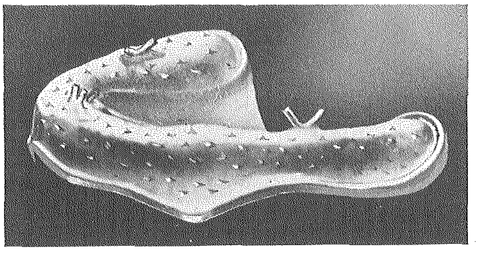


Fig. 73.— Finished Upper Base, Spurred, Wired, and with Loops Attached

plate marked. The application of an anti-flux to the inner margin of the wire, before each section is soldered, will prevent the filling in of the angle with solder.

ATTACHING THE WIRE LOOPS

A convenient method of applying the wire anchorage loops is as follows: Make a right angle bend near the end of a piece of 19 or 20 gauge wire and touch the angle with flux; place a small piece of solder on the baseplate at a point indicated for a loop; apply the blowpipe and when the solder is fused touch the bent wire to the solder, remove the flame holding wire until solder congeals; clip off the long end of the wire near the baseplate, leaving two short spurs projecting for anchorage. By using a wire 6 or 8 inches long it will serve as a handle for holding the loop while soldering. In arranging the teeth, if the ends of the wire interfere they may be bent out of the way. The teeth are now returned to the baseplate and their position and occlusion verified by trial in the mouth. The steps of flasking, packing, vulcanizing and finishing differ in no essential particulars from those employed in vulcanite work, to which the reader is referred.

Swaging Full Lower Baseplates of Gold

CUTTING THE PATTERN AND PLATE

The pattern for a full lower base is obtained in the same manner as for a full upper denture. Special care should be observed in flattening out the foil or tea lead not to distort it by undue stretching of either the labial or lingual surfaces. When the labial surface is stretched more than the lingual, the pattern will be too narrow around the curve of the arch, or from buccal to buccal, while if the lingual surface is distorted the reverse conditions prevail.

The lamina of the gold plate should run from buccal to buccal, as in full cases, to give strength in the median line to the finished denture.

CONFORMING THE PLATE TO THE DIE

It is somewhat more difficult, at the outset, to adapt the metal plate to a lower than to an upper die, because its narrow, curved form, as well as the peculiar shape of the die, renders it a difficult task to prevent the plate from sliding.

The base should be evenly centered over the oiled die, and with the fingers and thumb held as firmly as possible by its outer periphery. The lingual surfaces are bent downward and outward against the lingual surfaces of the die with light blows of the horn mallet.

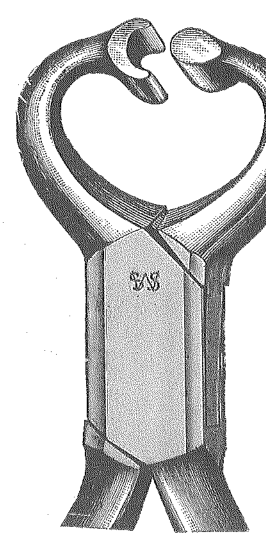


Fig. 74.— Plate Benders; Very Useful for Conforming a Baseplate Along the Border in Preliminary Swaging

No attempt need be made to secure close adaptation at the start; the lingual surfaces, however, should be conformed sufficiently to prevent the plate from sliding while bending the labio buccal flange downward in contact with the outer surfaces of the ridge. The plate benders are very convenient for starting the plate over the border. (See page 178.)

Usually far too much time is devoted to the use of the horn mallet in conforming the plate to the die.

The beating of the metal with the mallet develops undue molecular strain, thins the plate itself and reduces the high points on the die, all of which unfavorable features can be obviated, or at least greatly lessened, by the early use of the die and counterdie.

Except in cases of marked irregularity of the alveolar ridge, the swaging may begin as soon as the plate is conformed sufficiently to retain its position on the die.

SWAGING IN THE COUNTERDIE

A method applicable to all classes of cases for preliminary conformation of the plate to the die, with the minimum malleting, is as follows:

Place the partially conformed plate in the counterdie and set the die in position upon it. Place the palm of the hand over the die, the fingers and thumb grasping the periphery of the counterdie. Lift the die and counterdie, the plate being interposed, and strike the anvil once only with the base of the counterdie. The resulting impact will drive the die partially into the counterdie, the plate being carried with it. Remove the die and plate and examine the latter for folds or wrinkles. Should any have developed, correct with pliers or mallet and repeat the step until all tendency of the plate to buckle is overcome.

General adaptation of the plate to the die can be secured in this manner in a very short time. Final swaging is accomplished and close adaptation is developed with a heavy hammer on the swaging block, the same as in upper cases, previously described.

When extreme irregularity of the maxillary ridge and border surfaces in general exists, it is sometimes advisable, in order to insure close adaptation of the baseplate to the tissues, to swage two thin plates of 30 or 31 gauge separately, then together, pickle, polish and unite with solder. After soldering, reswage to correct warpage. This method of doubling the plate in difficult cases of any class is productive of excellent results.

SWAGING THE PLATE AGAINST UNDERCUT SURFACES

In case undercut surfaces are present on the die, and these areas have been filled with sand in the production of the counterdie, as previously described, the latter will be deficient opposite such filled-in areas of the die. To conform the plate to the die and against these surfaces, strips of lead of approximately the thickness of the depth of undercut are laid between the plate and deficient counterdie area, and the die and plate driven deeply into the counterdie.

It is usually useless, however, to force the baseplate into deep undercuts, because it must necessarily be distorted in removal from the die. The better plan is to allow the plate to enter the undercut to a slight extent only, so that in removal, although requiring to be sprung in passing over the bulge of the die, its inherent elasticity will return it to original form. The deficiency of the base, in such cases, can usually be corrected with the vulcanite by means of which the teeth are attached.

The same general steps of trimming to as nearly correct peripheral outline as possible, before trial in the mouth, pickling, polishing and annealing to relieve molecular strain, followed by the final blow to correct warpage, applies to lower as well as all classes of swaged base dentures which must subsequently be subjected to soldering operations.

Partial Baseplates of Gold

The construction of gold base partial dentures requires the exercise of as much, and in many instances more care, than is involved in the production of full gold bases.

The forms of dentures for partial cases vary widely, depending on the number of teeth to be replaced, the relation to each other of the spaces to be filled, the stress liable to be exerted in masticatory effort and the means of retention to be employed.

In a full-gold base denture the baseplate continues without a break, from the palatine vault, over the maxillary surfaces, to the labial and buccal areas, against which its peripheral margins terminate. The constantly varying, continuous surfaces of such a baseplate, when adaptation has been secured and molecular strain relieved, together with the attachment of the teeth to the base by means of vulcanite, tend to impart rigidity to the entire denture base.

In partial cases, however, the presence of some of the natural teeth, against the lingual surfaces of which the periphery of the baseplate must terminate, necessitates cutting or notching the outer margin of the denture to receive them. This step materially weakens the base wherever such notching occurs.

Reinforcing Partial Baseplates of Gold

To develop the required rigidity, so that under stress of mastication, or in handling, the denture may not become permanently distorted, one of the several methods in vogue for reinforcing baseplates may be adopted.

REINFORCING THE BASEPLATE BY DOUBLING

First: Develop the base from two pieces of comparatively thin gold plate, swage each piece separately, then together, and finally unite them with solder.

Advantages: Ease of adaptation, high degree of rigidity, uniform thickness of baseplate.

Objections: None, aside from the extra work of soldering.

REINFORCING THE BASELATE BY REFLECTION OF MARGINS AND WITH SOLDER

Second: Construct the base of a single sheet of gold plate, 27 or 28 gauge, reflect the margins against the lingual surfaces of the teeth involved and fill the resulting lingual angle with high-grade solder.

Advantages: Rigidity combined with comparatively thin base.

Objections: Possible tendency of the solder to discolor with use in the mouth.

REINFORCING WITH WIRE AND SOLDER

Third: Adapt plate or wire to the baseplate over the weak areas only, and attach with solder.

Advantages: Rigidity over weak areas, where specially needed, with use of minimum amount of material.

Objections: Unequal thickness of the baseplate because the reinforcement is not uniform.

SECURING NEEDED RIGIDITY BY USE OF THICK PLATE

Fourth: Use a single piece of thicker gauge than that mentioned in the second method, No. 25 or 26 gauge being usually employed.

Advantages: Rigidity.

Objections: Difficult to adapt.

DEVELOPING RIGIDITY BY USE OF SOLDER

Fifth: Flow solder alone over the weak areas of the baseplate.

Advantages: Rigidity.

Objections: Tendency of the solder to discolor; unequal thickening of the baseplate, due to solder filling the inequalities and seeking its level.

The first and second methods are most frequently followed and have proved most successful. In certain cases, however, some of the other methods mentioned may be used to advantage.

The first-mentioned method of doubling the baseplate is specially applicable to those cases where the teeth and spaces alternate with considerable regularity, where the rugæ are pronounced and well defined, and where the surface markings of the oral tissues in general are prominent. In such cases a baseplate consisting of a single piece, sufficiently rigid to withstand stress, cannot, because of its inherent rigidity, be driven into all of the irregularities of the die.

By substituting two thin pieces for the single, thicker plate, and conforming and uniting them as mentioned, the necessary rigidity and required adaptation are readily secured.

HOW TO ESTIMATE THE APPROXIMATE THICKNESS OF A DOUBLED BASEPLATE

Experience has shown that in partial dentures, where the baseplate is narrow, it should range in thickness from 27 to 22 gauge, depending on its width, in order that it may have the necessary rigidity to withstand stress.

The best method for determining the thickness of the component plates, where two are used, so that they may have approximately the same rigidity as the single, thicker plate, is by means of the table of gauges, shown on page 1099.

By reference to this table it will be seen that 24 gauge, for example, the probable required thickness of the base, is .0201 of an inch thick. Now by combining two thicknesses of plate of lighter gauge as follows, the doubled plate will be approximately equivalent to No. 24 gauge:

27 g. = .0149
34 g. = .0063

.0212

28 g. = .0126
31 g. = .0089

.0215

29 g. = .0112
30 g. = .0100

.0212

These three possible combinations range about midway between No. 24 and No. 23 gauge, any one of which can be used when deemed advisable. Other combinations, varying in thickness, are made in a similar manner, depending on the requirements of the case.

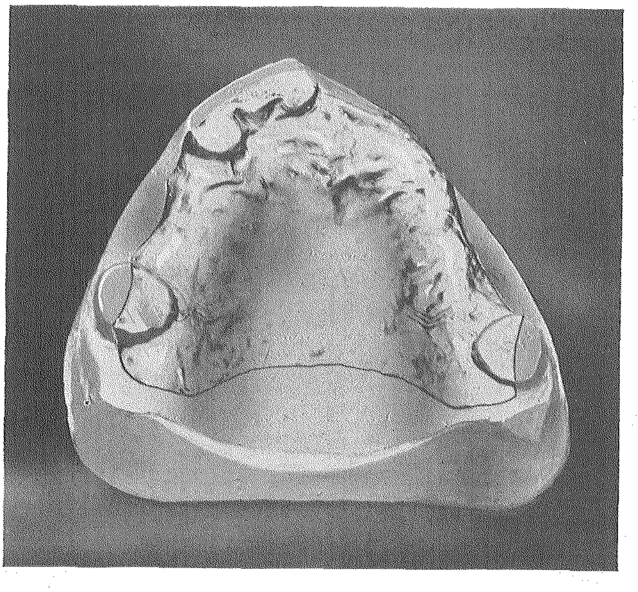


Fig. 75.— Outline of a Tinfoil Pattern for Partial Case

SWAGING PARTIAL GOLD BASES

When the base is to be of a single thickness of plate, reinforced by reflection of the margins and with solder as outlined in the second method, the construction steps are as follows:

Oil the die and counterdie; secure tin or lead foil patterns and trim to the desired form; cut the base from plate gold, 27 or 28 gauge, and 20 carat, according to pattern; anneal and adapt to the die, first with the fingers, then with horn mallet sufficiently to retain its position between the die and counter die in the initial stages of swaging; swage between die and counter die, using weight of die as previously suggested; with pliers correct any folds or wrinkles that form; return to counter die and strike one or two heavy, square blows with a hammer; correct wrinkles, trim off excess and again swage.

Fig. 76.— Application of the Chaser or Burnisher

To drive the gold into the linguo-gingival angles and embrasures, and reflect it against the lingual surfaces of the teeth, a small instrument, shaped somewhat like a cold chisel, is used. Although in general form its end is chisel-shaped, its edge is rounded to prevent cutting the gold.

This instrument is held firmly with the pen grasp, against the gold, opposite the depressions on the die into which it is to be carried. Under light, rapid mallet or light hammer blows, the chaser is gradually moved over the plate, along the linguo-gingival angles until finally the gold is forced into all of the depressions and inequalities of the die without the chaser perceptibly marring the plate or die.

From time to time the plate is pickled, polished and annealed, and the surplus trimmed away with the shears, plate nippers and files. The plate nippers are very useful for cutting out or notching the plate where the teeth pass through, or for cutting any short-curved margin, where the use of the shears would distort the plate. (See page 186.)

The reflected plate margin, which extends from the linguo-gingival angle, of tissues with teeth, occlusally or incisally, against the lingual surfaces of such teeth as are involved, should be about 1/16 of an inch wide. This margin serves two purposes, first, being bent at a decided angle to the baseplate proper, it imparts marked rigidity to the periphery of the denture in decidedly weak areas; second, the increased frictional bearing afforded by reflecting the plate against the teeth, adds stability to the denture. By flowing solder into the lingual angle of the plate and reflected portion the rigidity can be still further increased.

SWAGING DOUBLED UPPER BASES

To develop the required degree of rigidity, together with the closest possible adaptation of the denture to the oral tissues, and, by the simplest means, the baseplate should be swaged from two pieces of plate and united by soldering as previously suggested. The steps are as follows:

Cut two pieces of 20 carat gold plate, according to pattern, selecting from the gauge table two gauges of plate of suitable thickness, which when combined will afford the necessary strength. No. 29 and 31 gauge are commonly used.

Adapt and swage the thinnest piece to the die. Trim it peripherally to the required outline of the baseplate, reflecting it against the lingual surfaces of the teeth as previously described. By using care in trimming to the exact outline at this time, the loss, both of material and time, will be avoided. When swaged, trimmed, annealed and finally reswaged to the die to correct warpage it is laid aside.

Now swage the second or thicker piece of plate. The adaptation of this piece of gold will not be quite so sharp as that of the first piece, first, because the plate is thicker, and second, because some loss of detail of the die must naturally occur during the swaging of the first plate.

When much loss of detail occurs to the die, a new one should be run up, but not necessarily a new counter die, as one or two hammer blows will force the old counter die surfaces into all the inequalities of the new die.

The two plates are now swaged together, the first, or thinnest, being placed next the die, since being sharpest, and showing the finest details, it should lie next the tissues.

The peripheral surplus of the second base swaged is usually allowed to extend beyond the margins of the first base, to afford a shoulder on which to lay the solder while uniting them.

In some cases, however, it is advisable to reduce the second base periphery until it lies entirely within that of the first base. This method obviates the use of an excessive amount of gold, but is not always so convenient in soldering.

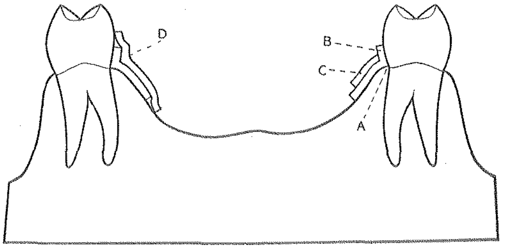


Fig. 77.— Showing Two Methods of Applying the Doubler

SOLDERING THE DOUBLED BASE

After swaging, the bases are pickled, polished and washed in clean water. A film of clean borax paste is spread on their contact surfaces and three or four small steel soldering clamps are applied to hold them in contact. The clamped bases are now laid on the solder block, and small pieces of solder placed peripherally on the marginal shelf, and in close contact with the edge of the first plate.

The brush flame of the blowpipe, properly applied, will fuse and draw the solder between the two plates until the space is perfectly filled and the two are united. Merely uniting the two bases at the peripheral margins will not be sufficient nor will the needed strength be developed; the solder must be drawn through from one margin to the other, and the baseplates united into one solid mass. A good plan to insure complete union between the two plates is to set the clamped piece on the block so that the shelf on which the solder is placed is higher than the opposite margin on which no solder

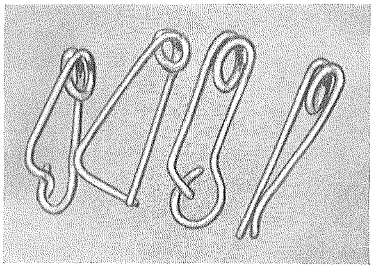


Fig. 78.— Various Forms of Wire Soldering Clamps

is laid. Heating the piece uniformly, until the solder fuses, will result in its being drawn down until it shows continuously along the lower margin of the now united base. A break in the line of solder on either margin indicates that some of the area between the plates is not filled.

The peripheral surplus is now removed with shears, plate nippers, files and stones, and the plate reswaged to correct

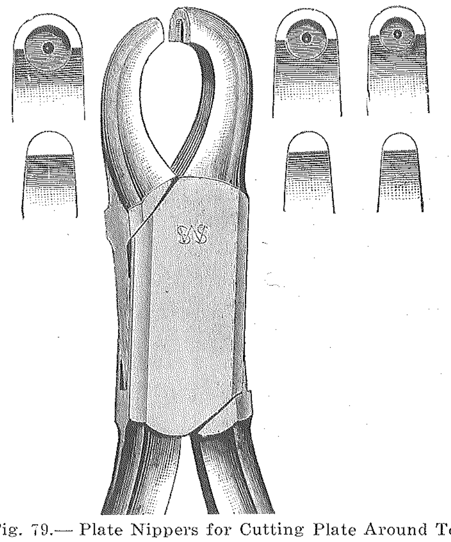


Fig. 79.— Plate Nippers for Cutting Plate Around Teeth

warpage due to soldering and from cutting. It is again pickled, polished, washed and is ready for trial in the mouth.

DOUBLING PARTIAL LOWER BASES

Frequently a lower partial denture of single thickness may be rendered sufficiently rigid by burnishing or swaging and soldering to it a piece of plate but little larger than the weak areas.

Lower partial dentures, involving the replacement of the posterior teeth only, are frequently reinforced anteriorly by a second piece of plate overlaying the first, the ends of which pass backward and terminate about three-eighths of an inch back of the last natural teeth, or so as to extend well onto the saddle portion of the base and outward to or beyond the crest of the border.

In dentures of this type the baseplate should extend well up over the cingula of all the anterior teeth present, to afford support to the denture in this region; prevent it settling down when subjected to stress, and thus avoid injury to the soft tissues underlying it.

DEVELOPING RIGIDITY BY USE OF WIRE AND SOLDER

When teeth are to be attached to the gold baseplate by means of a plastic base, the wire which is soldered on to form a shoulder against which to finish the vulcanite can frequently be placed in such position or extended onto weak areas so that when soldered the required rigidity is developed without the necessity of doubling the entire baseplate, the wire and the solder used for the shoulder thus fulfilling two purposes.

One of the most important considerations in the planning and construction of partial dentures is to determine the means of retention that will render the appliance most efficient. At the time of planning the denture retention means must be decided upon, as these, to a certain extent, determine the form of the baseplate.

Application of Frictional Appliances

When specialized frictional appliances, as the Roach or Gilmore attachments, are to be used, the crowns or inlays to which the stationary parts of the appliances are fixed are usually constructed before the impression is secured, from which in sequence the die will eventually be formed. In case crowns are used for the attachment of retention appliances, these are set in position on their respective roots, afterward reproduced in the die, wholly or in part, and the baseplate swaged to conform to them just as to the natural teeth. The application of the attachments under consideration will be given in another section.

When any of the ordinary forms of clasps are to be employed the order of procedure is as follows:

The clasps and baseplate having been constructed, the clasps are placed in position on the teeth they are to embrace. The baseplate is introduced, the points of interference with the clasps noted and filed away until it can be firmly and evenly seated on the tissues, without displacing the clasps or itself becoming dislodged by them.

An impression in plaster is now taken of the clasps, teeth and baseplate; when removed the clasps are returned to position in the impression, wedged apart, luted to place and a cast secured, by means of which the clasps and baseplate are held in correct relation; they are then attached to the baseplate by soldering in such manner as to interfere the least possible extent with the resiliency of the clasp.

Taking the Bite

In partial cases, when a number of natural teeth are present and in normal occlusion, a *mash* bite, sufficiently bulky to receive and hold firmly the bite stem of the face bow in front of the anterior teeth and without interference with occlusion, will usually fulfil all requirements for occluding the teeth, after the casts have been secured and mounted on the occluding frame by means of the face bow.

When any complications are present, or when a considerable number of teeth are being replaced, the best plan is to occlude the teeth, attach them to the baseplate with sticky wax and try the model denture in the mouth. This method proves the occlusion, the degree of esthetic success attained as to form, color and arrangement of the teeth, the position for the lingual shoulder wire against which the vulcanite will finish, when such means of attachment of teeth to base is employed, and enables the prosthetist to judge the value of his work at a time when corrections can readily be made, should occasion require.

Attaching Teeth to Baseplate by Soldering

When but little absorption of the process has occurred, in spaces occasioned by loss of the natural teeth, the best means of attaching the porcelain substitutes to the gold base is usually by backing a plate tooth with gold, in the usual manner, grinding it to position on the cast, attaching it to the base with sticky wax, investing the case in some good investment material, and finally flowing solder over the entire backing and against the baseplate at its junction with the latter.

Frequently, in order to render the repairing of the case simple, in case of accident, some of the replaceable types of crowns or facings in common use, as the Steele, Goslee, Davis, etc., can be used to advantage.

When the bite is extremely close, so close, in fact, that porcelain cannot stand the stress of mastication without fracturing, a wax tooth of the dimensions required may be formed and cast, or a cusp may be swaged, filled in solidly and attached to the base with solder.

CHAPTER XIII

ALUMINUM BASE DENTURES

Aluminum is used to a considerable extent, in both cast and swaged form, as a base for dentures. The good qualities of this metal may be summed up as follows: It is malleable, tough, comparatively rigid, good color, shows but little tendency to discolor, odorless, tasteless, and a good conductor of thermal changes.

Some of the objections and disadvantages of the metal, in general, in its application to denture construction are as follows: It is extremely difficult to solder, and when soldered the joints, under the influence of oral secretions, discolor badly; in some cases the solder itself is rapidly dissolved away, particularly when mercury is one of its constituents.

Since soldering operations are difficult, the ordinary means for forming finishing shoulders, attaching loop anchorages, and, in partial cases, uniting one or more isolated teeth to the base, as carried out in gold base denture construction, are not practicable. Other means, therefore, must be resorted to for developing the attachment of the vulcanite to the denture base, and while these means are more or less efficient, they require more care and involve greater effort than when accomplished by soldering.

Aluminum is susceptible to the action of dilute hydrochloric acid, the alkalis, and salt solutions in general. Since food, and consequently the oral secretions at times, contain these substances more or less diluted, of course, aluminum bases frequently show a decided tendency to disintegration in the mouth. These facts are in accordance with observations made by Figuier in his Year Book for 1858. One of the early editions of Richardson quotes him as follows: "Caustic alkalis, potash and soda, and even ammonia, dissolve aluminum sensibly." He also states that common salt and acetic acid (vinegar), especially when mixed, attack and dissolve aluminum. He adds that the mixture of salt and vinegar for seasoning a salad, made in a spoon of aluminum, feebly but inevitably attacks it.

The same edition further says: "Calvert states that when aluminum is immersed in water for any considerable length of time, oxidation takes place slowly." It is therefore plainly apparent why the surfaces of dentures of this type, both cast and swaged, become etched and roughened with use, and in time so reduced in thickness as to be useless.

Pure aluminum is more resistant to the action of the solvents mentioned than the more or less impure commercial varieties, and, therefore, in both cast and swaged work, only the purest products obtainable should be employed.

Aside from the general disadvantages just cited of the use of aluminum for denture bases, there are certain deleterious properties which arise in casting the material and which will need special mention.

Cast Bases of Aluminum

The principal advantage of a cast aluminum base lies in the fact that the vulcanite anchorage can be more readily developed on a cast than on a swaged base. Loops and spurs of wax, in addition to the usual peripheral rims, can be arranged on the model, and all reproduced at the time of casting. Peripheral rims are of decided advantage, as when properly formed they will effectually prevent the thin margins of vulcanite from curling away from the base, a defect which is specially noticeable in both cast and swaged aluminum bases.

Another decided advantage of a cast over a swaged base, from an esthetic point of view, is that in case absorption of the border has progressed irregularly, the greater portion of the required restoration can be accomplished in metal instead of vulcanite, as is necessary with swaged bases. The distribution of the vulcanite can therefore be made symmetrical in cast bases, while in swaged bases it can seldom be accomplished, the finished case often presenting a very unsightly and unbalanced appearance after the necessary contour has been developed.

Cast aluminum base dentures, although promising much from an esthetic standpoint, usually fall very much short of perfection from the practical point of view. Two very serious drawbacks are manifest in dentures of this type; first, the tendency of castings to warp in the making, thus impairing, if not entirely inhibiting, successful adaptation and retention of the denture; second, imperfect density of the casting when produced.

WARPAGE OF CAST BASES

Warpage of a cast base is due to two causes; first, the inherent tendency of most metals to contract in passing from a fused to a solid state is very marked in aluminum; second, the heat necessary to volatilize the wax and prepare the matrix to receive the molten metal causes contraction and warpage in the investment itself, so that when cast the fused metal is forced against a distorted form. In addition to this, warpage in the metal, due to contraction, also occurs to further complicate the difficulty. Warpage is a most serious fault, and because of the resulting misfits it occasions has retarded the use of the cast base more than all other causes combined. The method for correcting warpage will be detailed later.

IMPERFECT DENSITY OF CAST ALUMINUM BASES

Imperfect density in a casting is due to contraction of the metal toward many centers as it assumes a crystalline, or rather granular, form in cooling, each granule or crystal becoming a center toward which the cooling metal contracts. As a result of this contractile tendency, many spaces necessarily result throughout the substance of the casting. Very often they are invisible to the eye, and in a newly finished case, the metal appears dense and homogeneous, but with use in the mouth the porosity becomes apparent. A low power magnifying glass discloses many open spaces on the surface of any aluminum casting. If broken, the spaces will be found more or less generally disseminated throughout the fractured sections.

ACTION OF ORAL FLUIDS ON ALUMINUM

Fluids of the mouth find their way into these pits and open spaces, and in those mouths where solution of the metal does occur the action is much more rapid than when the metal is free from such imperfections.

The oral fluids contain during and for some time after each meal attenuated particles of food; these find their way into the pits, are retained, and after a time decompose, often giving rise to very disagreeable odors. Bicarbonate of soda solution and sometimes, in extreme cases, dilute caustic soda are used for cleansing and removing odors from vulcanite and gold base dentures. These solutions should not be used for cleansing aluminum base dentures because of their solvent action on the metal. Dilute nitric or sulphuric acids, neither of which have any perceptible action on aluminum, may be used instead of the alkalis for removing odors. The acid should be neutralized with weak aqua ammonia and the denture washed thoroughly in water to remove all traces of the latter.

GRANULAR STRUCTURE OF CAST ALUMINUM

As before stated, in passing from a fused to solid condition aluminum assumes a granular form. The metal contracts toward the granular centers and thus produces the open spaces referred to. In addition to this change there is a molecular rearrangement distinctly noticeable by the slight crackling sound on removal of the casting from the flask, apparently regardless of the length of time it remains in the flask. This is no doubt due to the release of tension on the already contracted and warped base, by the removal of the investment cast and matrix, the presence of which, at the time of solidifying of the metal, partially restricted full contractile movement.

For these and various other reasons not here detailed the casting of dense, well fitting baseplates of aluminum is practically an impossible task. Summarized, the advantages and objectionable features of cast aluminum bases may be stated as follows:

Advantages: Convenience in developing required vulcanite anchorage; great esthetic possibilities.

Disadvantages: Warpage of the base during and after casting; imperfect density of the casting when produced; susceptibility of cast bases to solution by the oral fluids.

There are many methods of technic in vogue, also many kinds of casting devices in use at the present time for the production of cast bases of aluminum. Lack of time and space as well will preclude more than an outline of the essential steps common to most systems of casting. Two general methods will be described, known as the *indirect* and *direct* methods. Dr. Hart J. Goslee has recently described in detail an *indirect* system of casting he has formulated, and which promises to correct some of the disadvantages of the cast base (Dental Review, August, 1914). The following is a brief outline of the indirect methods referred to.

CASTING BASES BY THE INDIRECT METHOD

The advantages of the indirect over the direct method of casting depends upon the preservation of the original cast (model) of the mouth until after the base has been produced, and of the correction by swaging of this usually warped base on the original cast of the mouth. The technic of the system is as follows:

TECHNIC OF FORMING THE WAX MODEL

An accurate impression of the arch is secured in the impression material most strongly indicated.

This impression is filled with either a hard cast plaster, or, better still, a mixture of oxy-chloride of magnesia, because of its much greater hardness.

The cast, of whatever material composed, should have a flat base, and be of good depth, to prevent fracture under the stress of subsequent swaging.

To this cast of the mouth a sheet of pink wax slightly thicker than the base is to be, is conformed, and trimmed to correct outline of the baseplate.

Small rolls of wax, about one-eighth of an inch in diameter, are adjusted peripherally, and burnished smoothly to the required form to afford finishing shoulders for the vulcanite.

Anchorage loops for the vulcanite are attached at several points, in such manner as not to interfere with the correct arrangement of the teeth.

Three rolls of wax, also an eighth of an inch in diameter or slightly larger, are attached, one to the most distal point of each tuberosity and the other to the extreme median, labial, surface of the baseplate. These are brought into a common point opposite the center of the palate and there united with a slightly larger roll standing at right angles, which serves as a sprue former. This arrangement of the wax rolls which form the smaller sprues is applicable to cases when invested in the open end ring flask. This type of flask is usually shallow. In such case the three sprue formers should be placed nearly horizontal and as close to the baseplate as possible, to conserve perpendicular space and make room for ample depth to the crucible in the top of the flask.

When the deep box flask is used, the rolls of wax are attached to the baseplate in the same location as above described, but are all brought back of the distal margin of the cast and there united to a slightly larger sprue former, or they may be attached separately but close to each other to the crucible former. The flasked case in this instance will then present three separate openings leading from the base of the crucible to the matrix, while in the former instance there is only one exit, the divergence of the small sprues occurring in the investment.

In both cases, regardless of whether the molten metal leaves the crucible by one or three exits, it enters the matrix at three widely divergent points. The three streams of metal which issue from the several entrances must spread out, fill the entire matrix, meet, and coalesce without forming seams. The pressure exerted on the molten metal must be sufficient to force the contained air within the matrix into the investment,

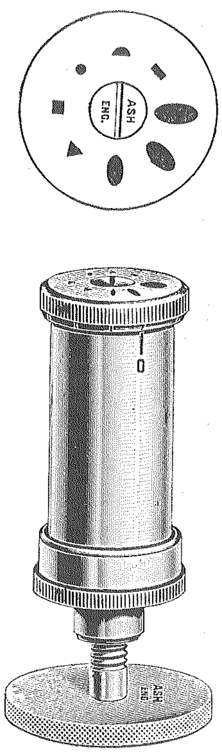


Fig. 80.—Wax Former for Making Sprue Rods

or out through sprue vents, otherwise it will be caught and confined somewhere between the margins of the inflowing portions and result in holes.

Still another method of attaching the wax sprue formers, applicable when the case is to be cast by centrifugal force, is as follows: A roll of wax three-sixteenths of an inch in diameter is attached to the extreme labial surface of the baseplate and extends up to the crucible to form the feed sprue.

Two smaller vent sprue formers extend from the highest point of each tuberosity to the outer margin of the crucible, above the level of the contained metal when fused. In casting, the metal enters the matrix from the crucible at the lowest point, and on the principle that a liquid will seek its level it rises upward in the matrix, the air escaping through the vent sprues. Since the exits of these sprues are higher than the level of the metal in the crucible the latter will rise nearly to the top of the openings of the vent sprues, but cannot escape.

INVESTMENT OF THE WAX MODEL

The baseplate having been given its required form, and the anchorage lugs attached, it is ready for flasking.

A fine grained, slightly porous investment material, which is hard when set, should be selected for flasking the wax model. A small amount of this is mixed moderately thin, and with a brush is spread carefully and evenly over the entire surface of the baseplate to eliminate all air bubbles. With a spatula more is now added, care being taken to work it under and around the sprue formers so as to entirely enclose them; the labial and buccal surfaces should also be fully covered with a layer sufficiently thick to withstand handling when the cast is removed. Altogether the investment should cover the baseplate from one-fourth to three-eighths of an inch thick.

When hardened, the half invested wax baseplate is carefully removed from the cast of the mouth on which it has been formed, another mix of investment made, and with a brush the entire interior of the baseplate is covered with it, care being taken here as before to eliminate all air bubbles. More investment is added to this, to take the place of the original cast, extending it labially, distally, and buccally, to overlap and unite firmly with that on the reverse side.

The wax model and most of the sprue formers are now encased in a comparatively rigid shell of hardened investment, which should be trimmed so as to enter the flask without encroaching on the sides at any point. Completion of the investment in a ring flask is carried out as follows:

Sufficient investment material to surround the case and fill the ring is mixed somewhat thicker than that used in first covering the wax model. This is filled in the ring, the hardened core containing the wax model is soaked in water for a moment to exclude the air and insure perfect union between it and the freshly mixed mass, and is then pressed well down to the bottom of the ring to give ample space for the crucible in the upper end. A slight vibratory movement of the spatula in the plastic mass will cause it to settle around and over the core and permit the air to escape.

The investment is smoothed up level with the top of the flask and around the wax sprue former which should occupy a central position in the upper surface and extend above the upper margin of the flask.

When hardened, the investment is trimmed out to form a crucible for containing the metal while fusing and preparatory to casting. This should be deep and wide enough to hold considerably more metal than the matrix will contain. In some forms of flasks the wax sprue formers before the case is invested are united with a crucible former, which, by means of guides, is carried to correct position in the flask and the investment is molded around it, thus obviating the necessity of cutting the crucible.

PREPARING THE CASE FOR CASTING THE METAL

The flask should be placed above a low flame and gradually heated to dissipate the wax. The heat may be increased from time to time to accelerate the volatilizing of the wax, but at no time should it exceed 370 degrees F., as that is the temperature at which plaster is readily and quickly disintegrated. By heating the case for a long time at low temperature the wax can be removed, the matrix cleared of residue, and the integrity of the investment maintained far better than with the rapid application of intense heat.

As in inlay work, smoother castings will result if, after clearing the matrix, the invested case is allowed to cool somewhat before introducing the molten metal. The temperature should not be allowed to drop too low or the metal, which even when well fused is slightly sluggish, will lose some of its heat by radiation and contact with cooler media, become chilled, and clog in the matrix, or in some cases in the sprues and result in an imperfect casting.

CASTING THE FUSED METAL

Aluminum may be cast by various means, compressed gas or air, by partial vacuum, by a combination of the two means just mentioned, by steam, centrifugal force, and by actual mechanical pressure.

In any case and by whatever means the casting is accomplished, the object in utilizing one or more of the forces mentioned is to rid the matrix of the contained air, either at the instant of casting, as in the case of the vacuum appliance, or force the molten metal into the matrix with sufficient pressure to drive the air into the porous investment or through vent sprues, and fill the entire space with fused metal under compression.

Although more difficult to cast sharply than some of its alloys, pure aluminum should be used because of its greater resistance to chemical action.

A thin, slightly tough film of oxide quickly forms on the surface of molten aluminum, which limits further oxidation. Because of the lightness of the metal and the slight tenaciousness of the surrounding film of oxide the molten metal does not fall into or fill even a large sprue, as would be the case with any of the metals of greater specific gravity, but requires vibration or some applied force to drive it into the matrix.

When first fused, aluminum, although plastic, is sluggish, and if cast in this condition will not copy fine lines sharply. The blowpipe flame should, therefore, be continued on the molten mass a sufficient time to bring it to a thinly liquid condition, yet without overfusing, before forcing it into the matrix.

A new, clean ingot (not scraps nor previously used pieces) containing nearly twice as much metal as the case requires is placed in the crucible and the blowpipe flame applied. The flame should be large and the heat forced as rapidly as possible, to melt the metal before any great degree of heat is transmitted to the matrix, and thereby cause unnecessary dimensional changes in its walls.

When brought to a thoroughly liquid condition, the film of oxide is cleared away, the casting force, of whatever character employed, is applied and the metal is driven into the matrix.

Since metals having much greater specific gravity than aluminum require pressure of 7 pounds or more to cast densely, it naturally follows that to produce sharp, well defined and dense castings of this much lighter metal more force should be applied in injecting it into the matrix. From 8 to 12 pounds direct pressure, or 14.7 pounds, full vacuum pressure, which, however, even though the gauge records it is never realized, is none too much. Pressure should be maintained until the metal congeals, the idea being to condense upon themselves the granules or crystals as long as the hardening mass will yield under the applied pressure.

When cast, the case should be allowed to cool down gradually; sudden chilling will induce more warpage and greater molecular change in the casting than will occur when the temperature is gradually lowered.

FINISHING AND SWAGING

On removal of the casting from the flask the waste gates are removed with a saw, the surfaces and margins smoothed

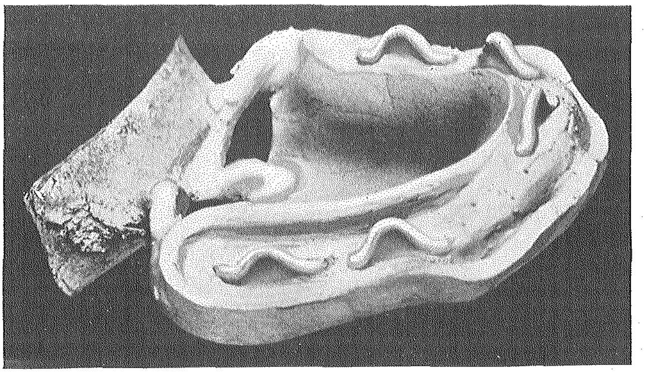


Fig. 81.— Rough Casting. Loops too Large, Except in Case of Excessive Border Absorption

up with files, stones, and fine emery cloth on the lathe mandrel. All nodules and irregular areas are removed from the palatine and border surfaces. The baseplate should, in fact, be practically finished, except the freshening of the margins of the vulcanite shoulder, which on account of danger of marring should be deferred until after the final swaging.

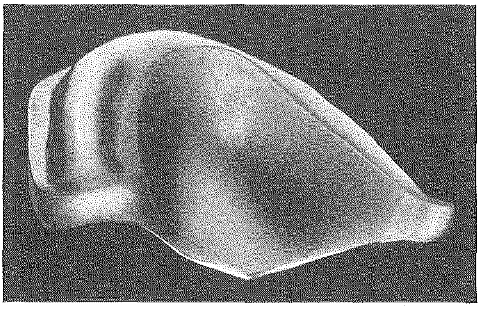


Fig. 82.— Partially Finished Casting, Not Spurred

The baseplate is now set on the original cast of the mouth, placed in the swaging device, and subjected to screw or hydraulic pressure sufficiently heavy to adapt it to all parts of the cast face. The final finishing is now given the shoulder against which the vulcanite is to abut, with square edge stones.

Any other areas that may need attention are smoothed, and the baseplate is ready for the application of the wax rims. The constructive steps from this point on are the same as in vulcanite work.

ATTACHING THE TEETH TO BASE WITH VULCANITE

In addition to the anchorage loops usually provided in the waxing of the case before flasking, a graver is used to raise heavy spurs in various directions around and under which the vulcanite will be molded. A film of chloro-rubber painted on the surfaces to be covered by the vulcanite acts as a cementing medium and increases the efficiency and permanency of the joint between the latter and the metal base.

DIRECT METHOD OF PRODUCING A CAST BASE OF ALUMINUM

The direct method of producing a cast base of aluminum is identical to that followed in indirect casting, up to the point of removal of the wax model from the cast, previous to investing the case. In this method, the wax model baseplate remains with the cast, the two are invested together, the cast becomes a part of the matrix, and is destroyed in the production of the casting. To correct a misfit due to warpage by this method a new impression and another cast must be produced, on which the warped casting can be readapted by swaging or the entire case must be reconstructed, beginning with the impression.

Since the average cast baseplate, made by the direct method, lacks that positive adhesion to the tissues so desirable, and, in fact, essential to usefulness and comfort, and since a casting of this type can be readily corrected by swaging on an accurate cast of the mouth, it is obvious that the so-called indirect method is literally the most direct, because one impression and one cast of the mouth fulfills all requirements while the direct method usually requires two, since to secure the desired adaptation it must be reswaged.

Until the dimensional changes in both investment materials and aluminum due to thermal variations is overcome to a greater extent than is possible by present methods, the adaptation and general usefulness of cast aluminum bases can be greatly improved by swaging.

CENTRIFUGAL CASTING OF ALUMINUM

Another method of casting aluminum bases with centrifugal force by the Dr. W. W. Wood's appliances will now be briefly described. These appliances consist of a special flask, an adjustable cover, a crucible former, a base for attaching the wax model to the sprue former, a high-geared centrifugal machine for forcing the molten metal into the matrix, double-burner stove for heating the invested case and for melting the aluminum, a small iron crucible for holding the metal while heating, and from which it is poured into the crucible of the flask, and, finally, two sheet-iron hoods for confining the heat around both flask and crucible in the preliminary steps.

TECHNIC

The crucible former has three openings in its apex, and in these, three rods of wax about one inch long are luted.

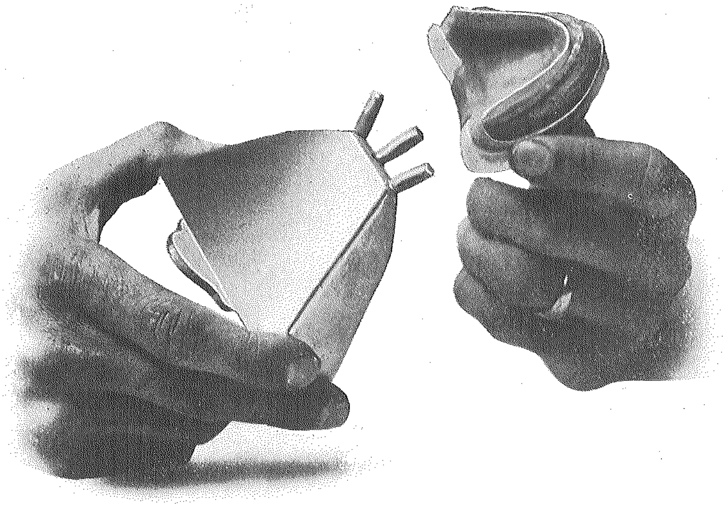


Fig. 83.— Crucible Former and Wax Model Ready for Attachment

The crucible former is adjusted to the cast-iron base. The wax rods bent to unite with the baseplate at each tuberosity and in the central vault portion.

The cast should not extend beyond the round end of the base, otherwise, in forcing the crucible to place the wax sprues are liable to be disconnected.

MIXING AND APPLYING THE INVESTMENT TO THE WAX MODEL BASE AND CAST

A mix of some good quality of investment is applied to the wax base with a brush, painting it against all surfaces so as to eliminate the air. A mix of coarser investment can

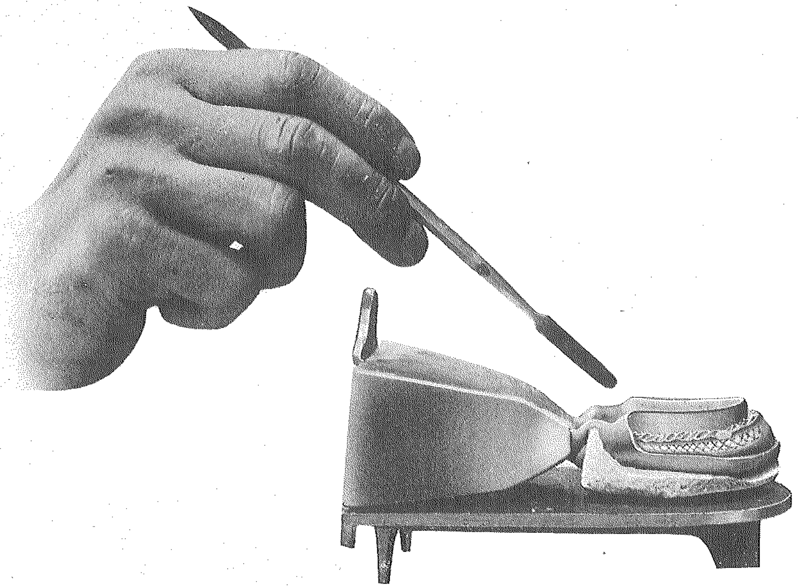


Fig. 84.— Attaching Wax Model to Crucible Former on Iron Adjustment Base

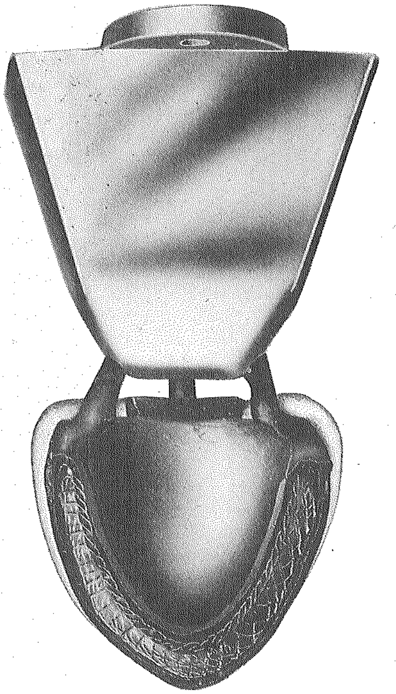


Fig. 85.— Wax Model Attached to Crucible Former, Ready for Investment

be made and extended not only over the wax, but carried up around the exposed sides of the crucible former in a layer sufficiently thick, when hardened, to rigidly unite the cast, wax base and crucible former.

When hardened, the attached cast and crucible former are removed from the cast-iron base and investment applied to the opposite side in a similar manner as described.

INVESTING THE CASE IN THE FLASK

The flask is now filled about two-thirds full of coarse investment mixed moderately thin.

Fig. 86.—Introducing the Partially Invested Wax Model in Flask

The invested wax model and crucible former are dipped in water and introduced in the partially-filled flask, with a churning motion to eliminate air and cause the investment to settle closely around that already hardened. The crucible former should rest upon the margins of the flask.

When set, the flask is inverted over the flame to slightly warm the wax sprues and crucible former when the latter, by tapping slightly, will readily come away. By oiling the crucible former before applying the investment it will part easily from the flask.

DRYING OUT THE CASE

The flask is placed on its side over a low flame until the wax has melted and partially flowed out through the sprues.

It is now inverted over the flame, the size of which is increased, the sheet-iron hood adjusted, and heat maintained until the investment is thoroughly dry.

While the invested case is drying out, which requires usually about an hour, the aluminum should be placed in the

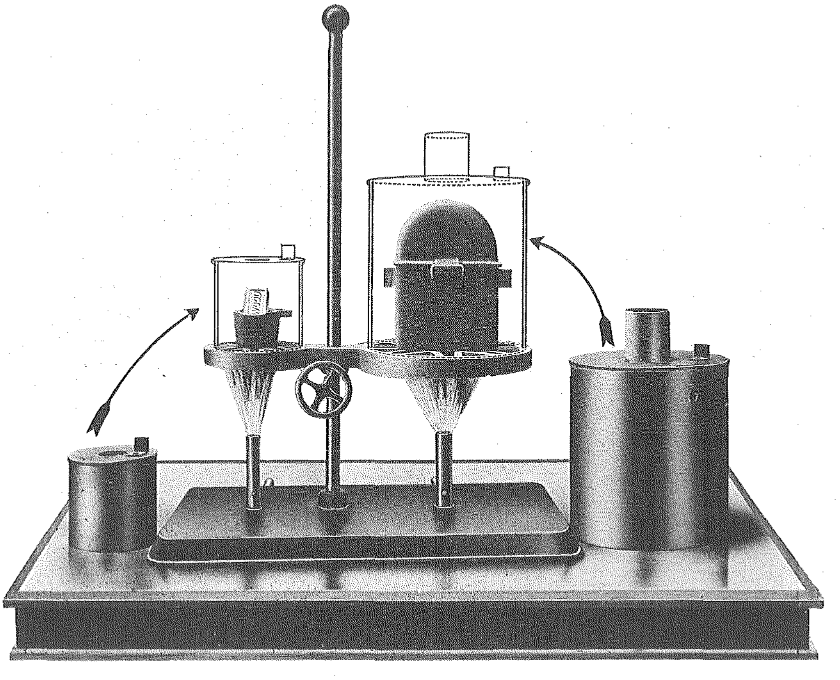


Fig. 87.— Heating the Case and Aluminum

iron crucible, set over the smaller burner and the hood adjusted.

Since aluminum requires a higher temperature to fuse than that developed by the burner, the blow pipe flame should be applied, and the metal brought to a well-fused liquid condition.

CASTING

When the moisture has been driven from the investment, and the latter has attained practically a low, red heat (900° F.), the flask is adjusted to the arm of the casting machine, the cover set in position and firmly clamped.

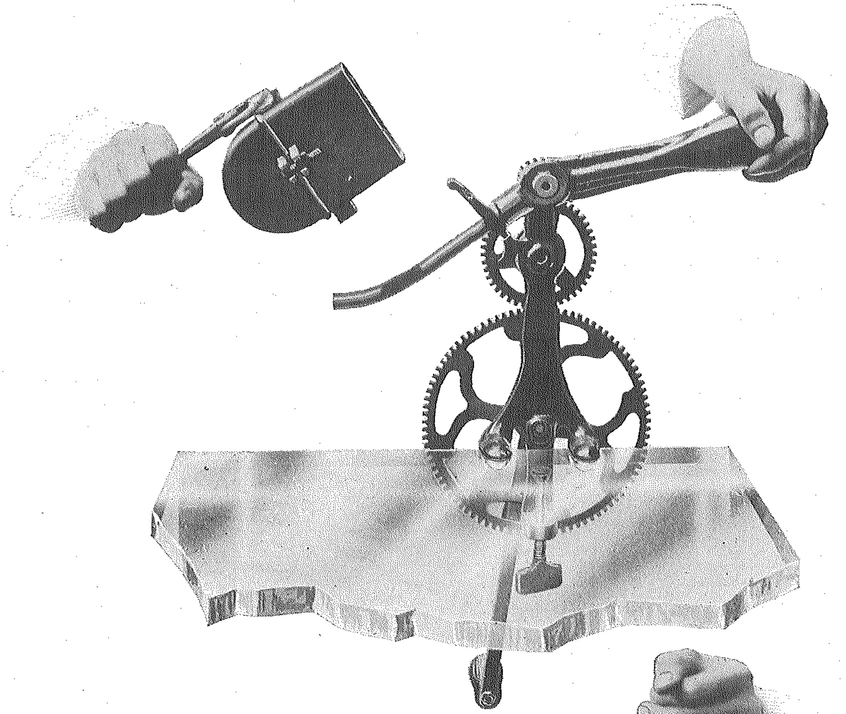


Fig. 88.— Adjusting Heated Flask to Casting Machine

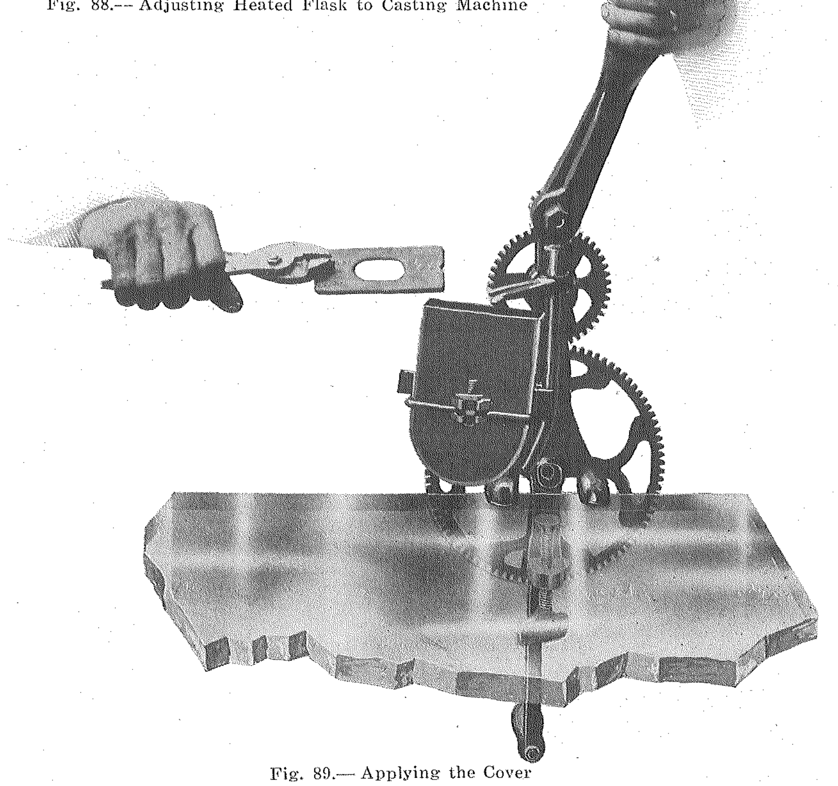


Fig. 89.— Applying the Cover

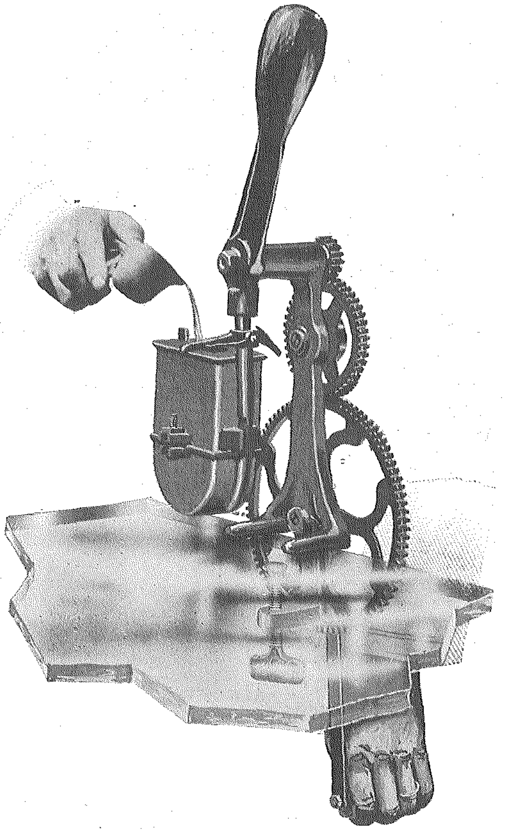


Fig. 90.— Pouring the Molten Aluminum

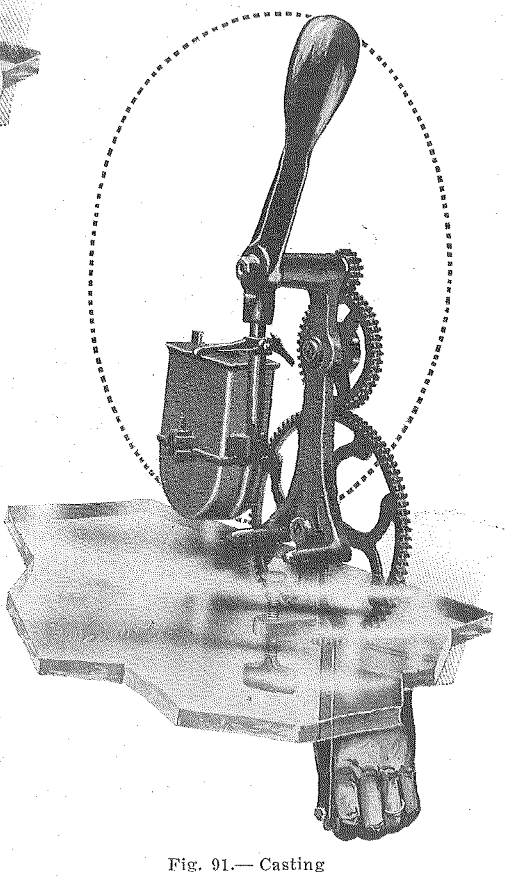


Fig. 91.— Casting

The melted metal is now quickly poured into the crucible, through the small opening in the cover, and the machine set in motion as rapidly as possible.

To thoroughly condense the metal the centrifugal force should be continued for at least three minutes or until the aluminum has solidified.

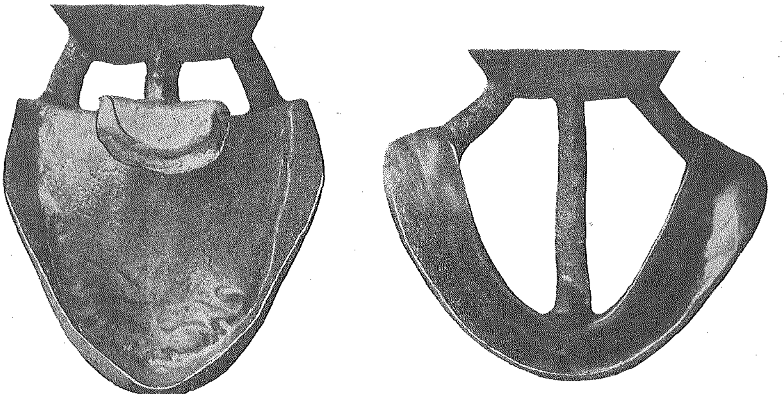


Fig. 92.— Appearance of an Upper and Lower Base as They Come from Flask

The methods here outlined vary somewhat from those previously described, principally in the manner and amount of heat applied. The results, however, in both density of castings and low shrinkage produced, justify the writer in

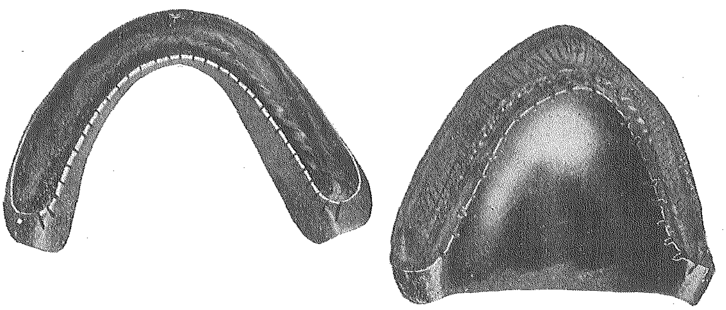


Fig. 93.— Dr. Wood's Method of Preparing the Vulcanite Attachment

strongly recommending the centrifugal method and processes similar to those just described.

Important Properties of Aluminum in Reference to Casting

Schnabel gives the following data in reference to aluminum. These facts are more appropriately placed here than in the section on metallurgy.

"The fracture of cast aluminum shows a coarse fiber and irregular grain, while it is sinewy or fine grained, and shows a high silky lustre after being hammered and rolled."

According to Deville, aluminum crystallizes in regular octahedra, if cooled slowly. According to Rose, the crystals do not belong to the regular system.

The specific gravity of aluminum at 22° C. is 2.64 for cast, and 2.70 for drawn metal. Its specific heat is 0.202.

It melts at red heat, 658.7 C. At a higher temperature it volatilizes, but the exact boiling point has not yet been determined.

As its specific heat is high, it needs much heat and some time to fuse; and as its latent heat is also great, it takes a long time to cool and solidify.

According to Deville, when it is cast into small bars it is several hours before these can be held in the hand.

There is a diminution of volume during solidifying, the shrinkage being 1.8 per cent of the original volume.

Swaged Bases of Aluminum

Because of the difficulty in the past, and even at the present time, attending the production of successful cast base aluminum dentures, yet recognizing the need of a metallic base less expensive than gold, many prosthetists have turned to the swaged aluminum base, hoping to find in that the much desired substitute.

Swaged aluminum bases have been employed for years, with varying degrees of success, or what is more literally true, of disappointment, for in the larger percentage of cases they have not fulfilled the hopes of the prosthetist nor the practical needs of the patient.

The principal and valid objections to swaged bases of aluminum, as ordinarily constructed, are as follows:

First, general deterioration of the metal in the mouth. The solvent action of the oral fluids and foodstuffs on aluminum is manifested in several ways, first, by destroying the polish of the base, followed by deeper etching of the exposed surfaces; this in turn results in gradual thinning and eventual weakening of the base plate, distortion under stress, formation of holes, and finally loss of adhesion.

Second, difficulty in securing effective and permanent anchorage between the metal and vulcanite, and of preventing the lingual margins of vulcanite from curling away from the baseplate, a fault which often occurs even though the general anchorage may be satisfactory.

COMPARATIVE DURABILITY OF CAST AND SWAGED BASES OF ALUMINUM

The statement is frequently made that the cast is more generally satisfactory and permanent than the swaged aluminum base. This is undoubtedly true of the average swaged base as made today, but is not in accordance with fact with reference to bases of heavy gauge, constructed by the more improved methods of technic.

Let us, for a moment, consider the difference in thickness, and bulk of metal in general, between the *average cast,* and the *average* swaged base.

The wax which forms the model baseplate determines the thickness of the cast base, since the investment matrix is formed against and around it. Those familiar with the casting of aluminum know that it cannot with certainty and at all times be cast into constricted spaces. Therefore, to be certain of producing a reasonably perfect casting, and, further, to insure its having the required inherent strength, the wax of which the model baseplate is formed must be of sufficient thickness to meet the above requirements in the formation of the matrix.

Usually the base of the wax model is formed by applying a sheet of pink baseplate wax over the face of the cast. This is further strengthened by the addition of the wax rolls which form the vulcanite finishing shoulders. In nearly every case a slight additional film of wax will be added to the palatine area, the prosthetist feeling that such an addition will make certain a perfect casting, while if too thick, the baseplate can be reduced without injury.

Now the thickness of the average pink baseplate wax is 16 gauge, or 0.050 of an inch thick. The completed wax model, and consequently the casting, on account of the addition of wax noted, usually measures 14 or 13 gauge, or 0.064 or 0.072 thousandths. It is true, some of this thickness may be lost in the final finishing of the denture, but in the many practical cases observed and gauged by the writer of work done by the best prosthetists, all exceeded 17 gauge or 0.045 of an inch in thickness, while a number ranged between 15 and 14 gauge.

Most of the swaged base dentures at the present time are constructed of 26 gauge, 0.016. It will be observed that 26 gauge is approximately only one-third the thickness of 17 gauge, therefore the cast base, being three times thicker than the plate ordinarily used in swaged work, besides being thickened and thereby greatly strengthened by the peripheral rims, should outlast the swaged base a proportionate length of time under conditions most favorable to the swaged base, while under adverse conditions to be mentioned later the time efficiency of the latter becomes greatly reduced.

The first well-written description within the writer's knowledge of the swaged aluminum base appeared in the American System of Dentistry, 1888. In that article, 26 gauge plate was recommended as being most suitable and practical and, unfortunately, many still adhere to the use of that and even lighter gauges.

The anchorage for the vulcanite was obtained by raising opposing spurs on the labial, buccal and lingual border surfaces. Practically, this method of anchorage proved insufficient. Later someone suggested drilling a number of holes, one-sixteenth of an inch or larger, through the baseplate, at various points along the border surfaces, countersinking the border or palatine ends of the holes, filling the holes with wax in flasking to exclude the plaster so that the vulcanite would fill both holes and countersunk portions and become riveted, as it were, at several points, to the baseplate. Another method of anchorage consists in developing loops in the border surface of the base itself by means of a special plier-like device. In a general way these methods solved the question of anchorage and obviated the frequent mishap of the body of vulcanite in which the teeth were mounted from being dislodged from the baseplate.

In this system of technic as first outlined, no provision was made for a finishing shoulder for the vulcanite, consequently it was found that after being in use a short time the thin, sharp margins of vulcanite where they joined the base, particularly on the lingual side, would curl up, break off or draw away from the metal, leaving an unsightly joint, annoying to the tongue, into which food would find its way. To overcome this very objectionable feature, a groove in the baseplate was cut at the line of termination of the vulcanite with the base, in order to thicken and strengthen the margin of the vulcanite.

This method of forming the finishing shoulder on 26 gauge and even somewhat thicker bases is not successful, because if the groove is cut deeply enough to give the needed strength to the vulcanite margin, the baseplate is so weakened that fracture often occurs under stress in a short time.

When 26 or even heavier gauges of aluminum are swaged in the ordinary manner, the plate being first adapted to the die with the horn mallet, the injudicious application of mallet force, particularly on high points and in deep depressions, as the central portion of a high vault, will result in thinning the base over such areas. These same high points and depressed areas are subject to special stress in swaging between the die and counter die. They are very liable to, and usually do, become contaminated with die and counter die metal. Unless the base metal is removed by thoroughly polishing before annealing, an alloy is formed which apparently is more readily acted upon by the oral fluids than is the uncontaminated plate. The result of such action is seen in the formation of holes in the affected areas. The thinning of the plate from careless malleting undoubtedly aids in the early formation of these openings, probably through the disturbance of normal molecular cohesion, thus reducing the resistance of the aluminum to chemical action.

SUMMARY OF THE CAUSES OF DETERIORATION OF SWAGED BASES OF ALUMINUM

Briefly summed up, the real causes of the rapid deterioration and general failure of the 26-gauge swaged aluminum base appears to be due to the following:

First, contamination of the aluminum by the die and counter die metal, with possible formation of an alloy, easily disintegrated chemically.

Second, excessive thinning by mechanical working, of a plate, which is conceded to be the lightest of the series of gauges used, suitable for denture bases of this type.

Third, molecular disturbance of the metal in certain areas, which reduces its integrity as sheet metal and lowers its resistance to chemical action.

Fourth, reduction of the inherent strength of the baseplate by the cutting of a lingual groove.

Fifth, failure to develop thoroughly, the several means of anchorage possible, as previously outlined.

It is the opinion of the writer, based on a number of years practical and clinical experience, that, compared bulk for bulk, the base swaged from sheet aluminum will outlast the cast base.

Construction of Swaged Aluminum Bases

As has been previously intimated, only the heavier gauges of aluminum should be employed in the construction of swaged bases for dentures, in order that the baseplate, when weakened as it must be by grooving, to form the vulcanite shoulder, may still have sufficient inherent strength to resist masticatory stress.

For a number of years past no lighter than 18, and frequently 16, gauge has been recommended and used in practice by the writer, in most instances with very gratifying results. Aluminum plate of these gauges and even heavier can, with proper technic, be conformed to a die with comparative ease. The plate should not be annealed before beginning nor at any time during or after the swaging operation. Any base metal from die or counterdie can be removed with polishing wheels and thus the formation of the low fusing alloy, due to annealing, either of which apparently renders the base more susceptible to oral fluids and food chemicals, can be avoided.

TECHNIC OF SWAGING

The actual constructive steps are as follows:

A die and counter die are secured in the usual manner. Both are oiled with a film of heavy, viscid oil. Vaseline will answer if a thicker oil is not obtainable. The oil will, to a great extent, prevent contamination of the aluminum by the die and counter die and lubricate the surfaces, thus obviating the tearing of the base.

Several large sheets of an ordinary newspaper are saturated with water and the excess expressed under heavy pressure, as one would squeeze the water out of a wadded up towel. The ball of condensed paper should be about three inches in diameter. This is placed directly over the opening of and on the counter die, and flattened slightly by pressure. On the paper a sheet of suitable size of 18 or 16 gauge aluminum, as the case requires, is placed, the die set in position on the plate and held firmly with the fingers, and its base struck two or three heavy blows with the swaging hammer. The first effect of the swaging will be to drive the plate into the palatine vault of the die, to a greater or less extent, without bending it over the outer sides of the border, the sheet sliding over the inclined surfaces of the oiled die without tearing or becoming thinned to any appreciable degree. The plate is

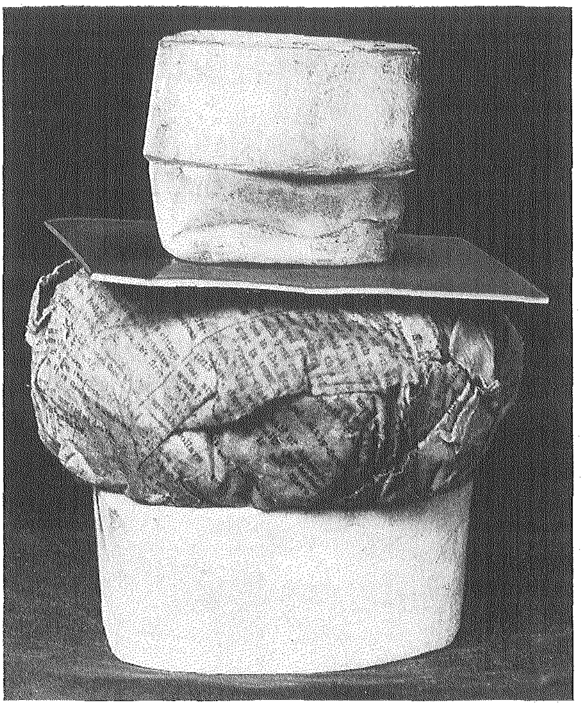


Fig. 94.— Roll of Damp Paper Adjusted to Counterdie

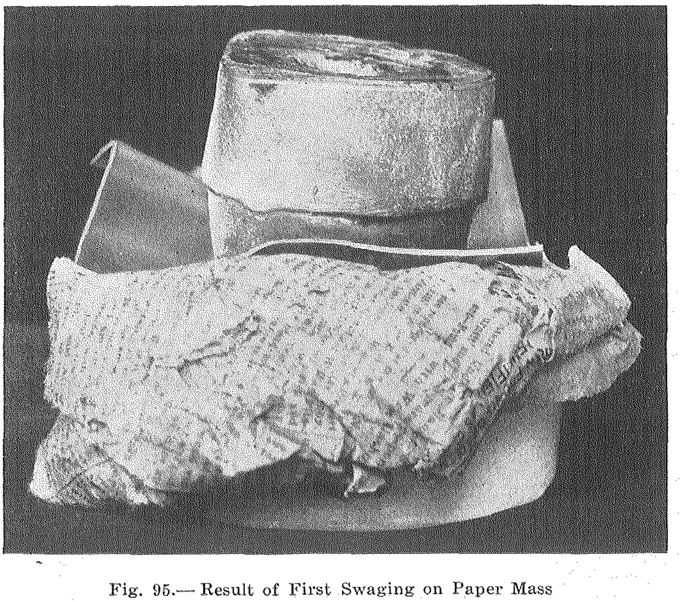


Fig. 95.— Result of First Swaging on Paper Mass

now examined, and wrinkles corrected if any have formed. This preliminary swaging does not drive the plate or die into the counter die, but into the ball of paper which should now be reformed and the plate swaged again as before. Two or three swagings are usually sufficient to secure fair palatine and partial border adaptation. In case the palatine arch is deep and it is difficult to drive the plate into the deepest portion of it, the die may be set, base down, on the swaging block, a ball of paper large enough to fill the vault space is adjusted, and a piece of hardwood about an inch in diameter and long enough to serve as a handle, the end of which is rounded, is set against the paper, and with the hammer adaptation is quickly secured. The paper is now removed from the counter die and re-formed into a layer about one-fourth inch thick.

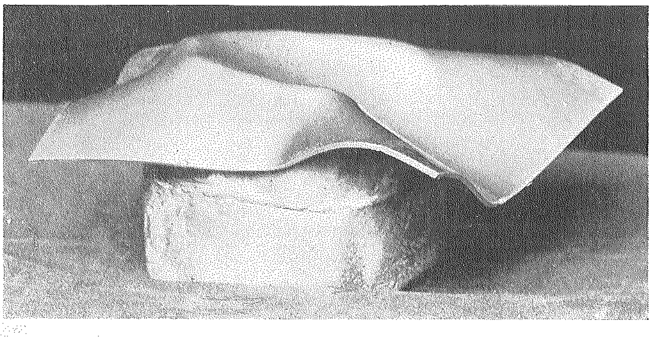


Fig. 96.— Result of First Swaging on Plate

This is spread over the counterdie and into its depression, the plate set in position, and with the die it is driven partially to place, with two or three light blows of the hammer. Remove, correct wrinkles, trim off excessive surplus, and repeat the swaging until adaptation is secured, always keeping a considerable layer of paper between the counterdie and plate.

The time required for swaging a base of heavy plate by this method is usually less than ten minutes, after the die and counterdie have been secured and the paper ball prepared. The lingual surface of the base does not show an indentation or scratch, if reasonable care is observed. The baseplate is not perceptibly thinned at any point, and an adaptation to the die, equal to that secured in the usual way with thinner plate, can readily be developed. The paper acts as a cushion, and obviates tearing, stretching, and excessive thinning of the plate. With a thick die, heavy smashing blows can be delivered with a heavy hammer, and the plate quickly brought into shape, the cushion-like action of the paper obviating to a great extent the marring of the die face.

Care should be taken to keep the anterior margin of die back of the corresponding opening in the counter die while swaging in the paper ball, otherwise there is danger of shearing the plate anteriorly as the die is driven into the flattening mass of paper.

Practically the same results can be secured with the Ash Rubber Cushion Swager, or with any good hydraulic press in which a yielding or plastic material can be interposed between the plate and counterdie or which, by confining properly, will answer for the counterdie.

DEVELOPING THE VULCANITE SHOULDERS AND ANCHORAGES

In all cases, whenever possible, the location of the finishing shoulder for the vulcanite should be determined after having occluded the teeth, waxed up the case and tried the denture in the mouth. This plan enables the prosthetist to develop the correct lingual contour of the denture in wax, so that enunciation may be normal, and lay the shoulder line at the margin of the wax as determined by this final test. The groove is cut and the shoulder developed in the aluminum base after the case is flasked and separated. Or this may be the order of procedure:

The line may be located and the groove cut, after having occluded the teeth, before trial in the mouth. This plan will give approximately accurate results, but occasionally it will be found necessary to restrict or extend the area as first outlined. In case extension is necessary this can be easily accomplished, but when the area must be restricted, the shoulder having already been formed too far to the lingual, an unsightly marring of the baseplate results which is difficult, if at all possible, to eliminate. Finally this method may be adopted.

It is common practice, but decidedly a wrong method, to locate the position of and form the shoulder by guesswork before trial in the mouth or even arranging the teeth, because in nearly every instance some modification will be found necessary when the teeth have been occluded.

TECHNIC OF FORMING THE SHOULDER

The shoulder is formed by first cutting a groove with a small wheel bur in the engine, following the line scratched on the plate which marks the line of junction of the wax with the baseplate. This groove usually extends from slightly inside the center of the tuberosity on one side, lingually, around to the corresponding point on the opposite side. The outer or buccal margin of the groove is chiseled or ground away, cutting the plate freely and broadly, to give the necessary depth to the vulcanite margin which will later occupy the angle and adjacent area. The shoulder is not extended around the labial and buccal surfaces in these cases as it is in cast

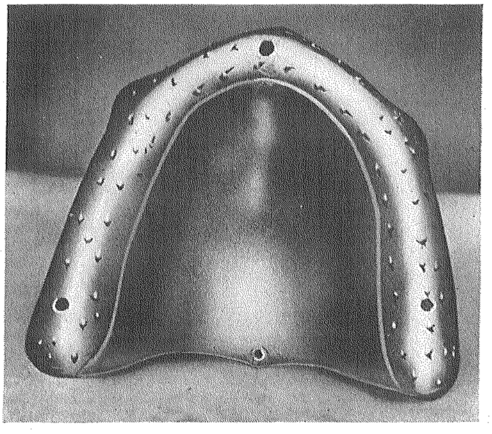


Fig. 97.— Baseplate Showing Anchorage Means Developed

bases, or in gold base dentures, since, if properly anchored, the vulcanite will not curl or warp away from the base plate.

SPURRING THE BASE

The general anchorage for the vulcanite is developed by raising many heavy opposed spurs on the area to be covered by it. These spurs can be made heavier and longer, and are therefore much more effective than it is possible to develop on lighter gauges of plate.

ANCHORAGE BY PERFORATING THE BASE

In addition to the spurs, five or more holes, one-sixteenth of an inch in diameter or slightly larger, are drilled through the base, one on each tuberosity, one opposite each cuspid eminence, on the labial surface, and one on the border crest opposite or between the central incisors. It is essential that holes be placed in these locations for obvious reasons; there is no objection to increasing the number, when by so doing the efficiency of the anchorage can be improved. The palatine ends of the holes are countersunk, and later the entire hole should be filled with wax, to exclude the plaster in flasking, thus insuring the rubber becoming firmly anchored to the base at several divergent points. The loop forming plier may be used to raise anchorage loops instead of forming the holes as described.

In these cases, as in all other classes of dentures where vulcanite and metal join, chloro-rubber or ordinary rubber

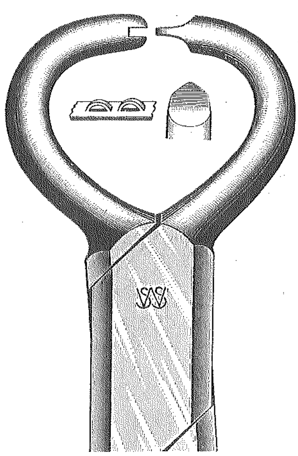


Fig. 98.— Punch for Forming Anchorage Loops on Aluminum Bases

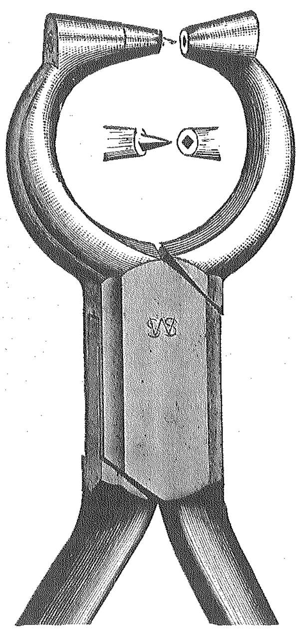


Fig. 99.— Perforating Punch Used for Vulcanite Anchorage Purposes

cement should be painted on the metal parts just before closing the packed matrix, to insure a permanent and watertight joint.

Formation of the Vulcanite Shoulder by Means of a Doubler

A method recently introduced for forming the lingual shoulder without grooving the baseplate is accomplished by swaging a partial base, covering the palatine portion of the base proper, its margins laid in correct position to form the lingual finishing shoulder. The doubler is attached to the base by three or more aluminum rivets, which are invisible if the holes on both sides of the plate are slightly countersunk and the wire which serves as rivets fills the holes accurately. Since there is no actual union between the two pieces of plate other than being held in contact with the rivets, fluids of the mouth must sooner or later find their way between, and a disagreeable odor develop. With a successful solder for uniting the two plates the doubler would prove of great advantage in many cases, particularly in badly absorbed cases. In such instances the margin of the doubler in the absorbed area could be lifted away from the base and raised to a level with the plate at the corresponding point on the opposite side. This

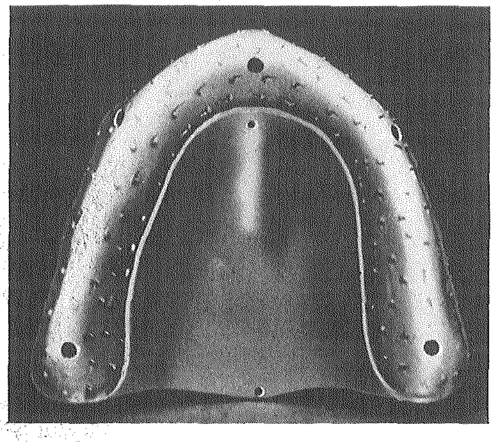


Fig. 100.— Application of a Doubler Held by Riveting

will permit the proper palatine contour to be developed without showing an unsymmetrical area of vulcanite at any point.

Some Facts on the History of Aluminum Casting

The first efforts within the writer's knowledge of attempts at casting aluminum were made by Dr. J. B. Bean, of Baltimore, who, in 1867, had granted to him Patent No. 68548, for a device for casting aluminum, a description of which may be found in the patent records of that year.

The essential points of the apparatus consisted of a box-like flask, in which the matrix was formed in an investment of plaster and pumice stone. There were three openings communicating with the interior of the flask, one for the introduction and another for the exit of hydrogen gas, which was forced into and filled the matrix at the instant of casting, thereby excluding the atmosphere and preventing oxidation of the metal.

The third opening had fitted to it a long, tapering, detachable conduit of soapstone, which served also as a reservoir for sustaining a standing column of considerable height, of excess molten aluminum. The specific claim made for the conduit was that it afforded means for "supplying fluid metal to compensate for contraction of the metal in the mold, as well as to secure a denser casting by means of the detachable reservoir, D, heated previous to the pouring of the metal as described."

Dr. Bean's demise occurred in 1870, and as no one at that time seemed to have succeeded in mastering the technic of his process, but little progress was made in aluminum casting until the latter part of the eighties.

In the June, 1888, Dental Register, Dr. C. C. Carroll, presented a method of casting aluminum under pressure, together with a description of his apparatus for carrying out the steps as detailed. While interesting, time and space are too limited to present his method in full, and since it has no direct bearing on present day technic, for fuller details than those which follow the reader is referred to the article in the journal mentioned or to Harris' edition of 1892.

The essential features of the Carrol apparatus consisted of a flask in which the matrix was formed of a mixture of three parts plaster and one of fine sand or marble dust.

The crucible was detachable, and served as a receptacle for the metal while fusing. After adjusting the metal to the flask, the fused metal was cast directly into the matrix through a central sprue, which subdivided within the investment into three, one leading to each tuberosity, the other to the distal vault portion. At the time of casting, the top of the crucible was closed with a tightly fitting plug. To this a rubber hand bulb was connected, which on compressing forced the molten metal into the matrix.

In the hands of careful prosthetists, the Carroll apparatus was capable of producing a fairly dense casting, with probably no more warpage than occurs in the castings of today. The apparatus was easily thrown out of adjustment, while the melting of the metal was difficult to accomplish. These objections coupled with the frequent failures, due to various causes, lead to its final abandonment.

Between 1892 and 1895, the Fenner and the Zeller appliances were introduced. These were similar in this respect, that each consisted of a two-piece flask in which the wax model was invested, and to one of the halves of the flask was fixed a crucible in which the aluminum was fused.

In the Fenner appliance, the top of the crucible was turned true and a close fitting cap adjusted to it. A tube was set in the cap, through which was transmitted the compressed air, by means of which the metal was forced into the matrix.

In the Zeller appliance a partial vacuum was created in the matrix and the metal was drawn in by suction.

Later on Dr. R. C. Brophy demonstrated that by having reasonably large sprues, the aluminum when sufficiently fluid, could be made to fill the matrix by tapping the flask. An alloy of 90 per cent of aluminum and to which some other metals were added to increase the specific gravity, cast better by this method than the pure aluminum.

CHAPTER XIV

WEIGHTED LOWER DENTURES

Weighted lower dentures are indicated in those cases in which the alveolar border is badly absorbed, and where a denture of ordinary weight is liable to be more or less disturbed by the action of the tongue and cheek muscles. Because of their greater specific gravity, dentures of this type retain their position better under masticatory stress and in speaking than do those composed of vulcanite alone. The weight for dentures of this class is provided for in three ways:

First, by using weighted, instead of ordinary rubber for the base.

Second, by inclosing a bar of metal within the body of a vulcanite case.

Third, by casting a base of metal, to which the teeth are attached, usually with vulcanite.

Dentures of Weighted Vulcanite

Weighted rubber consists of ordinary dental rubber, having uniformly incorporated within it coarse filings of tin or some metal that does not readily oxidize. In the construction of weighted dentures, this rubber is substituted for the ordinary basic material, the incorporated metal furnishing the additional weight required. The technic of construction differs in no respect from that of an ordinary vulcanite case.

Vulcanite Dentures Weighted by Means of a Metallic Core

Additional weight may be given a vulcanite denture during the constructive steps as follows: Shape a bar of tin or one of its alloys, so that it will fit within the matrix walls of the flasked case without interfering with those walls, the border crest of the cast, or the ridge laps of the enclosed porcelain teeth. The outer wall or gum portion of the matrix is packed with pink rubber first; the lingual portion is lined with basic material, packing it carefully under the pins of the teeth; the bar of metal, previously conformed, and tested, is laid in the partially filled matrix, the remainder of the rubber is added, and the flask closed and vulcanized in the usual manner.

This simple method of imparting varying degrees of weight to a denture, as the conditions of the case require, is oftentimes very effective.

Cast Metal Bases

When a denture of considerable weight is indicated, a base is cast in metal for supplying the required weight, and to this the teeth are attached by various means, the most convenient being vulcanite. Since the metal which forms the base is cast, the entire matrix into which it is cast must be composed of some refractory material that will not change form perceptibly under the heat to which it will be subjected in preparing it to receive the molten metal. Plaster is unsuited for this purpose because of its tendency to crack under heat. A number of good investment compounds are procurable, those ordinarily used for crown and bridge purposes being applicable to the casting of this type of denture bases.

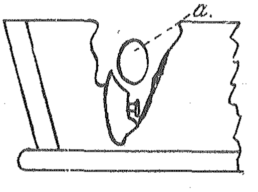


Fig. 101.— Sectional View of Lower Case, Flasked with Metal Core in Position

TECHNIC OF A WEIGHTED CAST BASE

The details of construction of a cast lower base is as follows:

From a suitable impression of the lower arch, develop a cast in investment material.

Soften a sheet of pink baseplate wax, and apply to the face of the cast.

Trim it to the approximate outline of the denture base.

Adapt rolls of wax to the labio-buccal and lingual peripheries of the base, burnishing them so as to form a continuous shoulder against which the vulcanite will rest. The outer surfaces of these strips, which in reality form the outer and inner walls of the denture base, should be squared up practically parallel with each other, so that the metal base and the vulcanite may form a continuous surface from the margins of the denture base to the gingivæ of the teeth. These surfaces may be, and usually are, more or less curved, but the line of junction of the vulcanite with the base should be free from angles. Or stated differently, both buccal and lingual surfaces of the metal base should meet the corresponding surfaces of the vulcanite so as to form continuous surfaces without forming angles.

Usually one thickness of baseplate wax over the general surface of the cast, increased by the rims around its margin, will prove sufficiently bulky, when reproduced in metal, to give the necessary weight to the denture for retention purposes.

Excessive weight in lower base dentures should be avoided, as they tire the masticatory muscles, frequently to such an extent that the patient cannot wear a denture of this type with comfort, or continuously, but must lay it aside from time

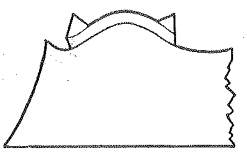


Fig. 102.—Sectional View of Lower Wax Model Base, Showing Flat Shoulder Surfaces

to time, to give the muscles and oral tissues a rest. Irritable areas frequently develop under the denture base at various points, apparently without cause, but which are in reality directly traceable to the heavy, shifting load to which the mucous tissues overlying the hard, bony points are constantly subjected. Such cases are relieved by reducing the weight of the denture, and by scraping the base over the irritated areas.

FLASKING THE WAX MODEL BASEPLATE

When the wax model is formed and anchorage loops for the vulcanite are properly placed, the case is invested in a Watt's flask. Or an ordinary vulcanite flask will answer the same purpose, by making two half round openings in each side of the flask, opposite the tuberosities, through which the metal may be poured.

The cast of the mouth on which the wax model has been formed is now trimmed peripherally, and reduced in depth, so that when set in the lower half of the flask, the peripheral or border margin of wax is level with the line of separation between the two halves of the flask. The cast, when properly trimmed, is removed, a mix of investment is made and spread over the bottom and against the sides of the lower half flask. The cast is dipped in water, so that it will not absorb the moisture in the freshly mixed investment, and thus interfere with its proper setting, pressed into the investment, and the latter smoothed evenly from the inner margin of the flask to the periphery of the wax base. That portion of the flask in which the casting gates are formed should also be filled level at this time. When set, the exposed surfaces of the investment are treated with soapstone, rubbing it in thoroughly, to prevent adhesion of the investment in the upper half of the flask, when added. Slight grooves, leading from the distal

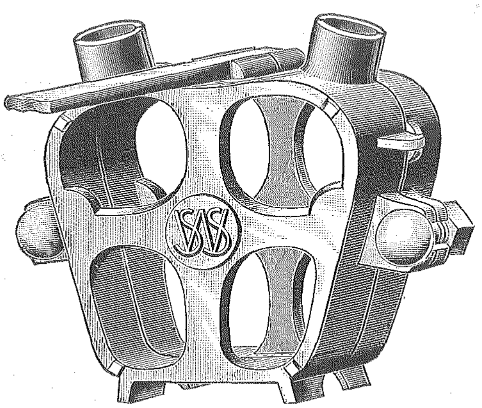


Fig. 103.— Watt's Flask for Fusible Alloy Casting

ends of the baseplate to the outer ends of the gate projections, should be drawn on the upper surface of the investment of the half flasked case, to indicate the width and direction of the sprues to be cut, through which to pour the molten metal. These grooves on the lower produce ridges on the upper investment, which coincide in location and direction with the opposite grooves. When half round grooves are scraped between these lines, the latter of which should diverge from within outward to give a funnel form to the feed sprue, and the two halves of the flask are placed together, a full, free, open gate is formed, leading from without inward to each distal end of the matrix.

The second mix of investment is now made, and the top half of the flask entirely filled with it. Before adjusting the two halves of the flask together, some of the freshly mixed investment, of which there should be a surplus, is applied to the exposed surface of the wax base, care being taken to work it into all of the irregular surfaces and angles. By piling the investment somewhat higher in the middle of the case than at the edges, adjusting the upper half of the flask, and closing under pressure, the excess is forced out around the margins and through the openings on the top and bottom of the flask, thus eliminating air spaces.

When the investment has set, the flask is separated, the wax removed, the half gates cut on each side of the flask, all delicate margins are removed, the matrix freed from all debris, and its entire interior, together with the cast face, are brushed thoroughly with No. 1 graphite to aid in the production of smooth surfaces to the casting. The flask is closed and clamped, and the joint between the two halves luted with a paste of equal parts soapstone and plaster, which should be carefully forced into every crevice, to prevent the escape of the molten metal when poured.

The flask is now set over a low flame to expel the moisture from the investment. The heat should not be so intense as to disintegrate the plaster binder of the investment. Tests for moisture should be made, from time to time, by holding a piece of polished cold steel or glass over the gate openings; when no steam condenses, the case is ready for casting.

CASTING THE BASE

For weighted dentures any of the several alloys prepared and sold for this purpose may be used, or an alloy which will serve equally as well can be compounded in the dental laboratory. Kingsley's alloy is composed of tin, 16 parts, and bismuth, 1 part. Another which serves equally as well is tin, 16 parts, cadmium, 1 part. Tin alone will not cast sharply, nor is it as hard as an alloy of this type should be for the purpose intended, therefore one or the other of the metals mentioned is added to correct the fault.

The flask is now set upright, an ingot of alloy is fused in a small ladle and poured in one of the openings. If the case is sufficiently hot, perfectly free from moisture, and no cracks have developed in drying out, the metal will fill the matrix and rise in the opposite gate, thus indicating that the space is filled. Should crevices develop in the investment while preparing the case for casting, the flask should be entirely surrounded with molding sand, well packed around the sides, leaving only the sprues exposed, otherwise the metal will escape through some of the openings, and the matrix be imperfectly filled.

When the metal has crystallized, the flask is chilled in cold water, and the casting removed and cleansed. The excess metal is removed with saw and files, and those surfaces of the base not to be covered by the vulcanite are smoothly finished.

With a graver retention is secured by raising heavy, opposing spurs on the area to be covered by the vulcanite. These spurs are developed in addition to the loops which are formed in casting.

When properly trimmed and polished, a roll of wax can

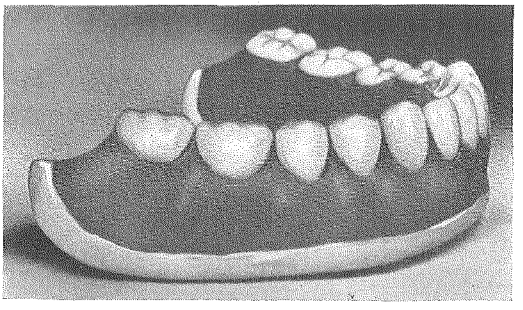


Fig. 104.— Cast Base with Teeth Waxed in Position

be mounted on the cast base and a wax contour model developed in the usual manner.

Modification of the Foregoing Method

Since the recent improvements in the technic of casting and in investments, and waxes, it is found that these weighted base dentures can be handled much the same as aluminum, that is, making a single investment and dissipating the wax by heat.

The specific gravity of the alloy is sufficient to insure a dense and usually perfect casting without the application of pressure, as required in aluminum casting.

In flasking a weighted base denture, preparatory to packing and vulcanization, the line of separation of the flask should occur at the line of junction of the vulcanite with the metal, thus leaving the base in the lower half, while the matrix containing the teeth is in the upper half of the flask.

The surface of the metal to be covered by the vulcanite should be painted with a film of chloro-rubber, or rubber cement, just before the final closure of the flask.

HISTORY

In 1856, Dr. A. A. Blandy introduced a system of casting denture bases, similar to the method just outlined, and which he designated the *Cheoplastic Process,* signifying "the making of *plates* by *pouring* a metal made *plastic* by heat" (Harris).

The production of a denture in those days, by forming it in a matrix, of a plastic material which hardened, was an innovation. Vulcanite and celluloid were not yet introduced, and, therefore, this was the first plastic process of denture construction.

The exact composition of Blandy's alloy is not known, but the metals consisted of silver, bismuth and antimony.

The introduction of vulcanite as well as celluloid following shortly after lessened the interest in cast metallic bases in general, but because of the advantages of the weighted base for lowers, more or less use has been made of it where indicated.

Weston, Wood, Watt, Rose, Kingsley and others have formulated alloys for denture bases, which are mentioned elsewhere.

Vulcanite Baseplates

In cases where it is apparent that good adaptation of a denture to the oral tissues may be difficult to secure, because of peculiarities in form of the border or some unusual condition of the oral tissues, a preliminary baseplate of vulcanite can oftentimes be constructed to good advantage. This vulcanite form, molded over an accurate cast of the mouth, affords a reliable test as to adaptation and stability of the baseplate, before the bulk of technical details have been carried out and if successful becomes the permanent base. If unsuccessful, another one can be constructed, or a different plan of procedure adopted, early in the constructive stages, and without further loss of time.

TECHNIC OF CONSTRUCTION

Over an accurate cast of the mouth sheet wax is adapted in the usual manner, and trimmed to correct peripheral outline. The wax baseplate should be slightly thicker than the permanent base is to be, so as to allow for loss of material in finishing. A roll of wax about one-eighth inch in diameter is laid, in a symmetrical curve, around the lingual surface of the border, beginning a little to the buccal of one tuberosity, passing lingually and terminating at a corresponding point on the opposite side. The margin of wax presenting toward the border crest should be finished squarely and without

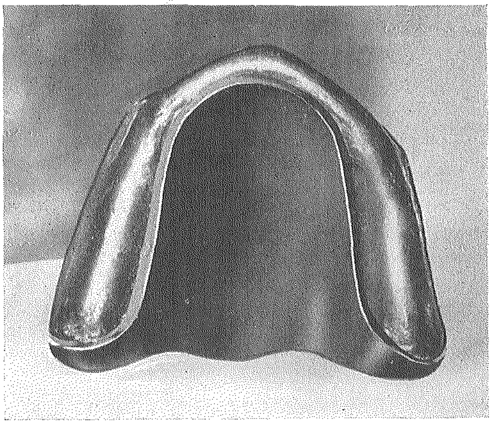


Fig. 105.— Vulcanite Base Ready to Receive Wax Occlusion Rims

undercuts, for it is against this shoulder of the vulcanite that the rubber which encloses the teeth is molded. The shoulder should be carried well up toward the crest of the border, but must be broadened lingually to furnish an ample base for the

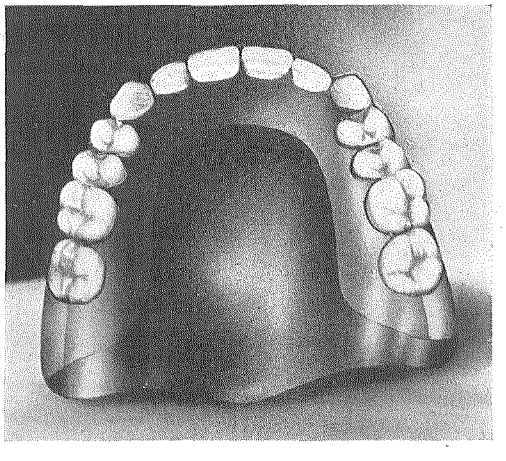


Fig. 106.— Lingual View of a Finished Denture Composed of Three Colors of Vulcanite

bicuspids and molars. If broader than necessary, it is easily reduced in the final finishing of the denture.

It is not necessary to extend the strip around the labial and buccal periphery of the baseplate, as the pink vulcanite will present a better appearance than a rim of basic material in this location. That margin of the strip presenting toward the central vault portion of the baseplate should be burnished down smoothly so as to form a symmetrical curve with the general palatal arch.

Having been given its proper form and being smoothly finished, the wax baseplate, on its cast, is flasked in the usual

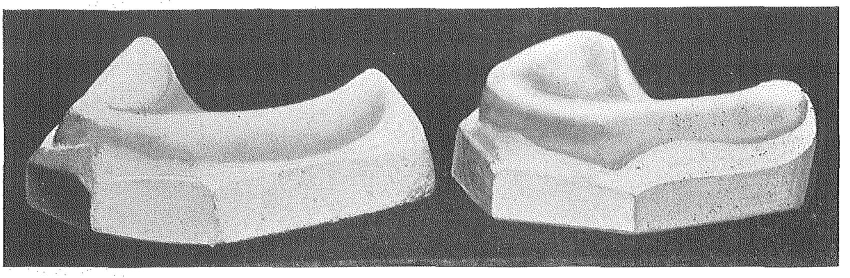


Fig. 107.— Plaster Casts Ready for Application of Baseplates

manner, the flask packed, and vulcanized. The baseplate is now only roughly finished on the lingual, but thoroughly polished on the palatine surface. In this condition it is ready to receive the wax rim, the formation and application of which will be described later.

It is common practice to form the baseplate of dark or jet black rubber, and attach the teeth to it in the second vulcanization with maroon or some of the lighter shades of red

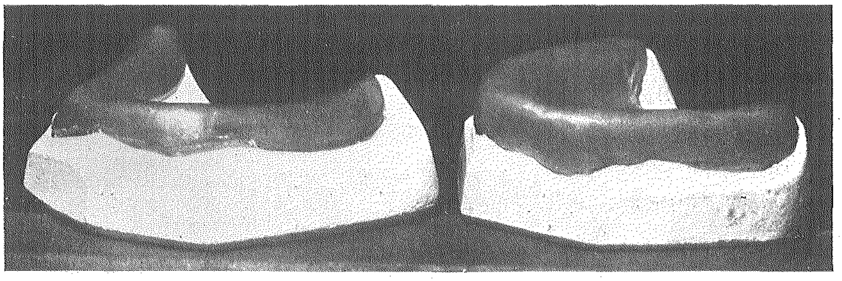


Fig. 108.— Baseplates Applied to Casts

rubber. When this plan is carefully executed most beautiful and artistic substitutes can be produced. Such a denture, finished, will present palatine and border surfaces entirely black, a similar lingual surface extending well out to the lingual surfaces of the teeth, a narrow, symmetrical band of maroon or red vulcanite between the black vault portion and the teeth, with full gum restoration of granular pink on the labio-buccal surface.

Construction of Temporary Baseplates

using "Ideal Baseplate, Special"

The following directions should be observed in the construction of temporary baseplates:

Place cast on bench, face up. Center a sheet of rigid baseplate material (preferably Ideal, Special) over it. Apply the soft brush flame of the blowpipe, moving it quickly so as not

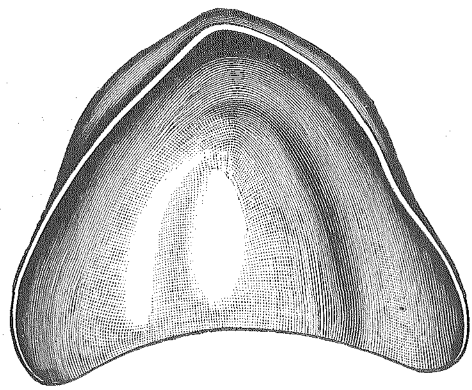


Fig. 109.— Ideal Baseplate Removed from Cast

to overheat any particular area and cause adhesion to the cast, but rather to soften the whole sheet uniformly. As soon as it begins to settle, remove the flame, and with the fingers apply light pressure to adapt it to all surfaces of the cast. Avoid undue pressure which thins and weakens the material unnecessarily. Apply the blowpipe to the labio-buccal por-

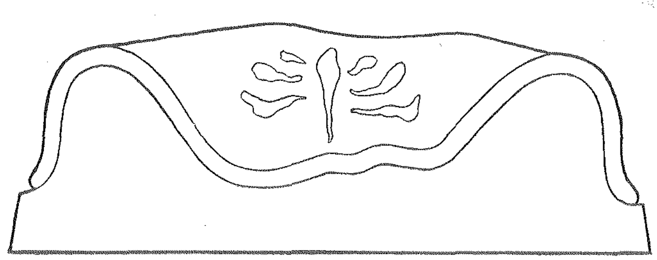


Fig. 110.— Sectional View of Cast and Baseplate Uniformly Adapted

tions to soften somewhat, remove the partially adapted baseplate, and with shears cut the base to approximately its correct peripheral outline. Return to the cast, correct the distortion that has occurred from the use of the shears, complete the adaptation, chill and use the vulcanite file for the final finish of the peripheral margins. The file should be applied diagonally or somewhat along the line of direction of the margin rather than crosswise, to obviate fracturing the baseplate. A thin blade spatula, heated quite hot, may be used instead of the shears for cutting the baseplate to correct peripheral outline, passing it along the peripheral line while the baseplate is on the cast.

The baseplate may be reinforced in several ways, one of the most common methods being to *melt* some of the surplus material against the areas it is desired to strengthen, and smooth the addition down with a very hot spatula. Another method is to bend a piece of 11 or 12 gauge brass, German silver, or iron wire to the form of the arch, but slightly smaller, attach it by warming and with melted wax to the baseplate just inside the border crest, so as neither to interfere with the proper arrangement of the teeth nor with the development of correct lingual contour in the final waxing of the denture.

When trimmed to correct peripheral outline, strengthened in the weak areas, and final close adaptation has been secured, the baseplate is ready for the application and preliminary contouring of the wax rims.

TEMPORARY BASEPLATES OF METAL

Sheet tin or lead, 14 to 16 gauge, when properly adapted to the cast makes a most excellent base for wax contour models. The simplest method of developing a base of this class is as follows: A cast of the mouth having been secured and its base made flat, it is placed on the rubber cushion of the Ash Swaging Machine, a sheet of metal of suitable size is laid over its face, the other rubber cushion laid on the sheet and pressure applied to force the metal partially to place. The surplus is trimmed off with shears, the wrinkles corrected, and final swaging completed on returning to the press. If care is observed in these steps, no injury will occur to the cast, and it can be used subsequently for the completion of the case. In work of this class, the use of oxy-chloride of magnesia for casts is most strongly indicated, as, in fact, it is in all vulcanite denture construction.

Another method, whereby a metal baseplate similar to the one just described can be formed without subjecting the permanent or final casts to the pressure of swaging, is carried out as follows:

A reasonably good impression of the arch, involving all of the areas to be covered by the finished denture, is secured in modeling compound, omitting the reheating steps previously mentioned. From this impression a cast is secured and a tin base swaged as described. This base is trimmed to correct peripheral outline and tested by trial in the mouth. A thin layer of softened modeling compound not more than one-sixteenth of an inch thick is laid evenly over the interior of the baseplate, which now is to serve also as an improvised impression tray. An impression, worked out by reheating and the various corrective steps previously mentioned, is secured, and all excess carefully removed. This now constitutes an *impression-baseplate,* on which rims of wax can be built to form the wax contour model. When transferred from the mouth to the occluding frame by means of the face bow, instead of dropping the original casts on which the metal bases were formed into the wax contour model, freshly mixed plaster or the magnesio compound is filled in and built against the bows of the occluding frame. If oiled before forming the cast and no undercuts are present, the wax model denture will readily separate, when removed for final trial in the mouth. The advantage of this method consists almost solely in the increased stability of the wax model dentures during trial in the mouth, over temporary baseplates, of any type, adapted to casts in the ordinary manner.

CHAPTER XV

RETENTION OF PARTIAL DENTURES

A partial denture, to be successful, must fulfill certain requirements:

First: It should restore as fully as possible the function of mastication so far as the latter may have been impaired by the loss of the natural teeth.

Second: It should restore the esthetic features of the dental arch by supplying substitutes which harmonize in form and color with the remaining natural organs.

Third: It should be so adapted to the remaining teeth and tissues as to maintain its position with certainty and comfort when the masticatory apparatus is in an active, as well as a passive, state without causing immediate or gradual decay or injury to the natural teeth present.

Of the several requirements mentioned, that of retention is usually the most difficult of accomplishment. Various means, both physical and mechanical, are employed to attain this end, the most important of which are *atmospheric pressure, adhesion, friction* and *specialized frictional appliances.*

Atmospheric Pressure and Adhesion

The principles of retention by means of atmospheric pressure, and adhesion also, have previously been explained. For various reasons these forces, although of value, are not as effective in the retention of partial as of full dentures.

The degree of force exerted by the atmosphere and adhesion upon objects from between the contact surface of which the air has been exhausted and close adaptation secured, is directly proportional to the square of the area involved. Therefore the more limited the area of oral tissues covered by the baseplate, the less can these forces be relied upon for retention purposes.

In partial cases the presence of natural teeth necessarily restricts the size of the base plate, since the periphery of the latter must fall within, or terminate against, the lingual surfaces of the teeth involved. This reduction in size of the baseplate therefore reduces the effectiveness of adhesive force. Again, the line of junction of the denture with the natural teeth is a peculiarly vulnerable point for the ingress of air, since the mucous tissues of the cheeks, lips and palate cannot be utilized for sealing up and protecting the margins against the return of air when once withdrawn from between baseplate and tissues, as is the case in full dentures, and this also is a further cause for reducing the force of adhesion.

Frictional Retention of Partial Dentures

The simplest form of frictional retention available for partial dentures consists in abutting the sides of the latter against the lingual surfaces of, and in the embrasures between, teeth situated on opposite sides of the arch, or sufficiently far apart to present opposing surfaces, which, when the denture is in position, tend to resist displacement. The alignment of the teeth must be favorable for such retention,

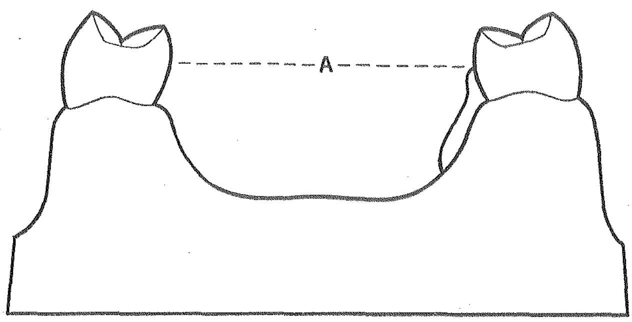


Fig. 111.— Cut Showing Inclination Toward Each Other of Teeth on Opposite Sides of the Arch

viz., the distance between the cervices of the teeth opposite each other in the same arch must be greater than at the points of greatest lingual convexities, or points of their nearest approach.

A denture moulded over the cast of a mouth with teeth bearing the relation to each other as stated, will spring as it passes over the points of nearest approach of the teeth involved, and resume its normal width without undue lateral pressure when firmly seated on the oral tissues. Such an appliance is called a *spring plate* or *denture,* and yet it does not exert lateral pressure against the teeth except on introduction and removal.

When the lingual surfaces of the teeth diverge from gingival to occlusal this means of retention cannot usually be utilized, as the constantly diverging surfaces are mechanically opposed to such retention. Frequently, however, by allowing the denture margins to extend into the embrasures, when the latter are well defined, frictional retention may be developed even in those cases where the general alignment of the teeth presents more or less parallel relation of surfaces.

In such cases, and especially when the crowns of the teeth are too short for clasping, the writer has inserted inlays with projecting lugs in two suitably situated opposing teeth in such manner that the lugs will engage with, and offer frictional resistance to, the displacement of the denture. Sometimes, too, *How* anchor screws inserted in the lingual surfaces of the teeth will fulfill the requirements of the case. The use of the inlays and wire lugs, as suggested, have proven very useful in many difficult cases, while no serious results have followed this method of practice.

In case either the anchor wires or the lug inlays are used, the projections should be rounded so as to permit the denture

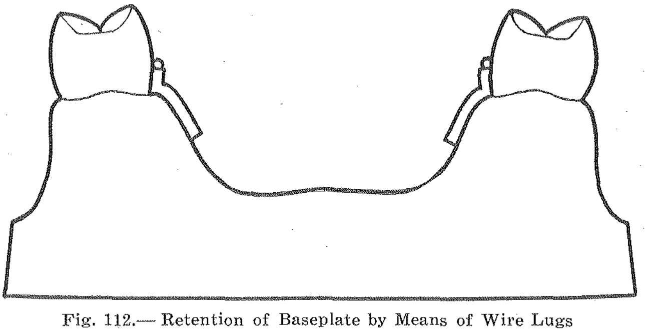


Fig. 112.— Retention of Baseplate by Means of Wire Lugs

to spring in and out of position without catching on the lug margins or straining the teeth to an undue extent.

Specialized Frictional Appliances

Various forms of specialized frictional appliances are in common use for retaining partial dentures in position in the mouth. These usually are attached to and become a part of the denture itself. In other cases the attachment consists of two parts, one of which is attached to the denture, the other to a natural tooth, to an inlay, to a crown set upon a natural tooth or root, or to a wire or bar permanently fixed to crown or inlay.

Among the appliances in general use may be mentioned clasps of various forms, double bars or stays, and special attachment, such as the Roach, Gilmore, Morgan, etc.

Clasps

Clasps are partial band-like appliances adapted to the natural teeth for retaining in the mouth the partial denture of which they form a part. They are usually constructed of flat plate or half round wire of gold clasp metal, composed of pure gold, platinum, silver and copper. This alloy possesses well defined elastic properties. The proportions of silver and copper may be varied, however, or the silver omitted altogether, as its presence imparts but little resiliency.

Considerable difference of opinion exists as to the ultimate value and utility of clasps, the argument of those opposed to their use being that the injury to the natural teeth far outweighs the good derived from their use. Those who favor the application of these appliances are equally as positive in their conviction of the benefits of such attachments. A statement of the objections and advantages of clasps will be in order.

OBJECTIONS TO THE USE OF CLASPS

The principal objections urged against the use of clasps are as follows:

First — The accumulation, retention and fermentation of food in the space between clasp and tooth will invite, and in many cases does, induce caries.

Second — Frictional action of the clasp against the enamel will abrade the latter, induce hypersensitiveness in the tooth structure, set up gingival, and in some cases, peridental irritation. As consequence the patient suffers more or less discomfort, and in time the crown or the entire tooth may be lost.

The deleterious conditions here cited are frequently observed and therefore these objections have an apparently good foundation. They can, however, in almost every instance be traced to one or more of several causes, most of which may be averted, as for instance, injudicious application of clasps to teeth unsuited for the extra stress they must sustain; imperfect technic in the construction of the appliances; or to lack of habitual care of the natural teeth and denture on the part of the patient.

ADVANTAGES DERIVED FROM THE USE OF CLASPS

First — Stability of the denture at all times, in speaking, laughing, and in masticatory effort is practicaly insured.

Second — By their use the baseplate which carries the replaced teeth need cover but a very small area of the oral tissues, since adhesion and atmospheric pressure as a means of retention are unimportant factors when clasps are used.

When judiciously applied, properly constructed, and the mouth is given reasonable care and attention by the patient, clasps are of the greatest convenience and comfort, and will cause but little injury to the teeth or tissues. In the experience of the writer, the advantages gained from the use of clasps, where indicated, are infinitely greater and far outweigh any harm that may result from their presence.

Should sensitiveness be induced, or caries eventually develop, the tooth can be devitalized and crowned when occasion requires, and be made to render still further service, by carrying a newly adapted clasp. It is seldom advisable to crown a tooth to be clasped in anticipation of subsequent caries, as such procedure may never be required.

Requisites of a Clasp

A clasp, as its name implies, is an appliance which *grasps* or *clings* to the tooth to which it is adapted. To be effective it should embrace more than one-half, usually about two-thirds, of the periphery of the tooth. A clasp should be so constructed that when in position firm, frictional contact is established between both its gingival and occlusal peripheries and the axial walls of the tooth to which it is adapted. In fact, the efficiency of a clasp depends on *closeness of adaptation* to the tooth, *resiliency,* and *inherent strength.*

ADAPTATION

Closeness of adaptation insures stability by lessening the tendency of the clasp to rotate, cant or slide when in position on the tooth, all of which movements tend to unbalance the denture when subjected to masticatory stress. The nearly parallel relationship of the axial walls of most teeth suitable for clasping renders the attainment of this requisite difficult, in clasps of the ordinary partial band type. Stability may be secured, when good adaptation has been developed, by the addition of a small but rigid lug extending from the occlusal margin of the clasp, up to and over the mesial or distal marginal ridge of the tooth clasped. The lug should be located as centrally as possible between the two extremities of the clasp. Such an addition converts an ordinary partial band clasp into a *stop clasp.*

Without doubt this form of clasp, or some modification of it, in which the stop principle is embodied, is the most satisfactory and serviceable of any of the common types of partial band clasps. By the addition of the stop, frictional wear of the enamel is practically overcome, undue pressure on the alveolar process covered by the denture and on the gingiva surrounding the tooth clasped is obviated, and a feeling of security and comfort to the wearer of the denture results, not possible to be realized from the use of the ordinary type of clasp. The credit of having evolved, demonstrated and described the practical applicability of the stop clasp should be ascribed to Dr. Bonwill.

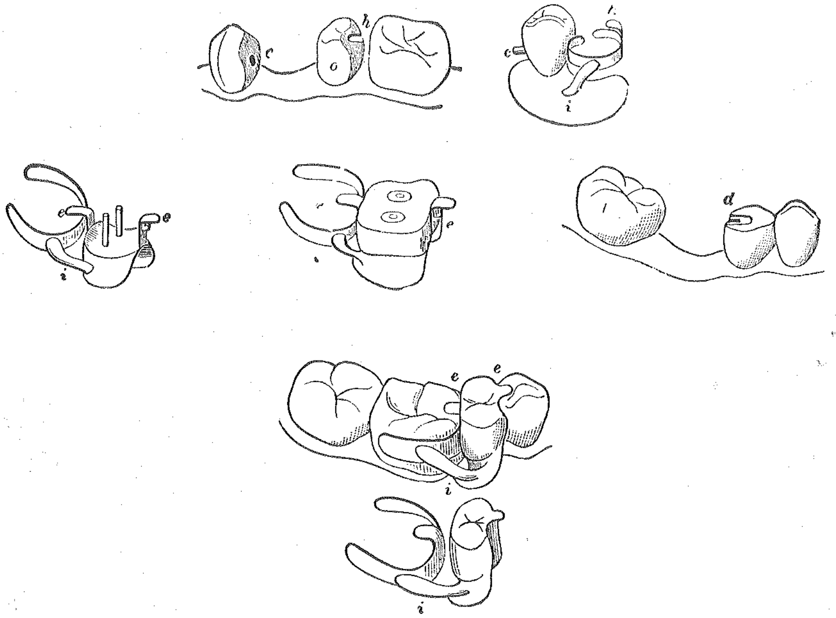


Fig. 113.— Three Cases by Bonwill, Showing His Application of the Stop Clasp, and Wire Attachment of Clasp to Baseplate

The degree of perfection of adaptation of the clasp to the tooth depends on the skill displayed by the prosthetist, the technical steps employed, and to a certain extent on the character and thickness of the metal used in its construction.

RESILIENCY OF THE CLASP

Resiliency in a clasp is that property which permits it to spring over the enlarged portion of the tooth it embraces in introducing and removing the denture, without becoming permanently distorted when subjected to such stress. This quality depends on the character of the metal of which the clasp is composed, as well as on the width and gauge of the clasp itself. The gold alloy known as *clasp metal,* previously mentioned, is used almost exclusively for clasp construction because of its hardness and well defined elastic property. The elasticity noticeable in a clasp when subjected to stress would be classified in physics under the term of *elasticity of flexure,* in which the molecules of the clasp metal on the inner periphery are elongated when subjected to stress, while those on the outer side are compressed. Permanent distortion occurs when the stress applied carries the metal beyond the *modulus limit,* in which condition it is said to be *strained,* as when stress is removed, the piece, of whatever shape, does not return to its original form.

THE INHERENT STRENGTH OF CLASPS

A clasp may be well adapted to a tooth, possess sufficient resiliency to be carried to, and removed from, position in the mouth without becoming distorted under ordinary stress, and yet prove unsatisfactory with use.

Undue stress exerted on clasps in polishing on the lathe, in introducing and removing the denture, careless handling in cleansing, letting the denture fall, as well as other accidental causes, frequently distort and oftentimes destroy the effectiveness of these appliances. Many clasps otherwise suitable fail because of lack of inherent strength, and consequently the very object for which they are designed is defeated.

The remedy lies in correctly estimating the proper width and thickness of the clasp in proportion to its length, and developing the appliance accordingly. These two factors are determined by the length of tooth to be clasped. Short teeth require narrow, but rather thick, clasps, the thicker gauge compensating for the weakness resulting from restricted width.

A thick, narrow clasp, however, is not as resilient as a thinner, wider appliance of equal length containing an equal amount of metal as the former. The truth of this proposition is plainly apparent by noting the difference in resiliency of steel springs of varying widths and gauges. A spring should be so proportioned as to carry the extreme load to which it may be subjected without the occurrence of permanent distortion. In fact, it should possess a considerable range of elasticity between the extreme load limit to which it will be subjected and the modulus limit, or point where permanent distortion occurs.

Inherent strength with bulk to carry extreme loads, while a high degree of resiliency is retained, is imparted to springs in the mechanical field by dividing the necessary bulk of metal into comparatively thin layers called *leaves*. In other words, the spring is made up of several members consisting of the principal spring reinforced by a series of leaves of gradually decreasing length, but of approximately the same thickness, rigidly fixed to the main spring, usually at the point where stress is applied. The leaves throughout the greater portion of their length are free to slide or move freely against each other as the load or stress varies, and thus the resilient power of each member of the spring is utilized in reducing shock and avoiding strain.

This principle of reinforcement of clasps for dental purposes cannot well be applied for obvious reasons, although

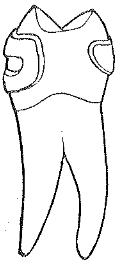


Fig. 114.— Clasp from Which Central Section Is Removed to Increase Resiliency

at times it is necessary to vary the flexibility of a clasp at different points throughout its length. For instance, when a clasp must of necessity be narrow, thick and almost devoid of resiliency where it passes through the interproximate space, the buccal and lingual flanges may be increased in width and decreased in thickness to develop greater elasticity. In such cases extra thick plate is used for the clasp to give strength in its narrowest part, and the necessary reduction in thickness on the broad areas is made by filing, grinding and polishing. In a number of cases the writer has secured excellent results by cutting a section from the central portion of the broad areas of a clasp after adaptation has been developed, without reducing the thickness of the appliance.

Various modifications of the ordinary flat band clasp, specially of the broad type, are employed to decrease rigidity and increase resiliency. In addition to removing a central section from the flange as detailed, it may be divided throughout a portion of its length, as suggested by Dr. G. H. Cushing, or the central area may be removed, and the gingival portion severed.

While a clasp must possess inherent strength sufficient to withstand unusual stress, it should not be too unyielding. When deficient in elasticity because of its bulk, and at the same time possessing excessive inherent strength, the tooth

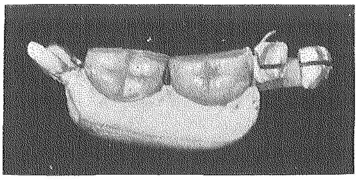


Fig. 115.— A Case Constructed by Dr. G. H. Cushing in 1869

which it embraces will be subjected to unnecessary strain in removal of the denture if the adaptation of the clasp to the tooth is reasonably close.

Gauges of Clasp Metal Commonly Employed

Many clasps fail under stress of usage, as before stated, because of lack of inherent strength. This is usually the result of using too thin a gauge of clasp metal, or so reducing their width as to render them weak.

As a rule, 26-gauge clasp metal is as thin as should be used.

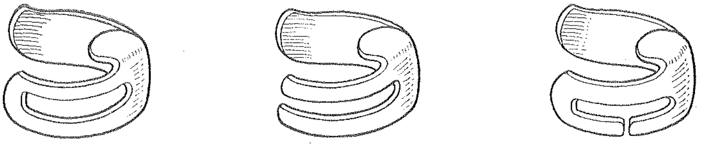


Fig. 116.— Various Methods of Increasing Resiliency in Clasps, Buccal View

When 28-gauge is employed, unless very wide, it should be stiffened by flowing 18K solder on the outer periphery. While this method imparts rigidity, it reduces resiliency, and therefore should seldom be adopted.

Usually three gauges of clasp metal will answer for all ordinary cases that may present: 26 gauge for long, 24 gauge for medium and 22, or in extreme cases 20 gauge may be required, for short teeth. Clasps of equal length may vary in width, thickness and resiliency, and yet contain essentially the same amount in bulk of material. For example, a clasp one-eighth inch wide, composed of 20-gauge plate, which equals .03196 of an inch thick, will contain essentially the same amount of metal as one of equal length and twice as wide of 26 gauge, which equals .01594 inch thick. Its resilient index, however, will be noticeably less than that of the 26-gauge clasp.

Types of Clasps Most Commonly Used

Clasps vary in form according to the requirements of the case for which they are constructed. These requirements include the class and forms of teeth to which they are adapted, the part they are to fulfill in the retention of the denture, and the load they are required to carry.

The ordinary forms of clasps may be tabulated as follows:

1. Partial flat band clasp.
2. Half-round wire clasp.
3. Double wire or bow clasp.
4. Stop, wire or band clasp.
5. Double-stay clasp.
6. Stay clasp.

The Partial Flat Band Clasp

This form of clasp, as its name indicates, consists of a partial flat band, usually of clasp metal of suitable gauge and width, which embraces about two-thirds of the tooth periphery. The gingival and occlusal margins of the clasp should be practically parallel to insure as nearly equal resiliency throughout its entire length. This, however, does not imply that these margins should be straight, but curved somewhat similar to, but usually less pronounced than, the gingival gum curvature.

Band clasps should be reasonably broad, the average width varying from two to five millimeters. The broader the clasp, the more stability will be afforded the denture.

On the other hand, a clasp of this type should not be so broad as to encroach upon the gum tissue and thereby induce irritation; neither should it interfere with occlusion of the opposite teeth. The buccal and lingual flanges can usually be so formed as to avoid impingement on the soft tissues. When the tooth clasped proximates with two others, and the gum septum in the embrasures through which the appliance passes is normal, or nearly so, it is sometimes difficult to entirely avoid impingement on the tissues in such locations.

While it is advisable in most instances to avoid the use of clasps where tissues fill the embrasures, it becomes necessary to apply them in other cases, especially where there are no other teeth of suitable form, or in proper location, to be utilized.

When a clasp is applied in such cases, extreme care should be taken to conform it closely to the mesial or distal axial wall of the tooth clasped, to reduce it to the minimum width consistent with strength, and to smoothly round off all angles presenting toward the gingiva. The tissues, although subject to compression for a time, will usually adjust themselves to the clasp without permanent injury resulting.

The Half-Round Wire Clasp

ADVANTAGES

Various gauges of half-round clasp metal wire are frequently used in clasp construction. The advantages of half-round wire for this purpose are as follows:

First — The clasp is of uniform thickness and resiliency throughout its entire length, except where attached to the plate, at which point it is rendered more rigid because of the solder.

Second — It can be adapted to teeth with comparative ease.

Third — Less tooth surface need be covered by the clasp, and consequently there is less *liability for food to accumulate.*

Objections

First — Wider space is required between proximating teeth for the accommodation of the clasp.

Second — Limited stability afforded the denture because it does not grasp the axial walls of the tooth as firmly as a broader clasp.

The Double Wire Clasp

This type of clasp consists of a wire of 18 or 19 gauge clasp metal looped on itself and the ends soldered so as to form an elongated, more or less parallel sided, endless band. The distance between the gingival and occlusal wires varies from one to four m.m., depending on the length and form of the tooth clasped. To retain a firm grasp on the tooth, the gingival wire should lie to the gingival and the other wire to the occlusal of the greatest diameter of the tooth, thus tending to resist displacement either gingivally or occlusally.

The double-wire clasp may be converted into a stop clasp by the addition of a strip of heavy clasp metal of 19 or 20 gauge, or square wire 18 gauge, bent so as to form an occlusal lug, and extending so as to connect the two wires and further furnish attachment of the clasp to the gold base or vulcanite, as the case requires.

Another modification of this clasp, suggested by Dr. F. E. Roach, and by him designated the "double-bow clasp," consists in adapting the gingival wire closely to the proximate surface of the tooth, and leaving it unattached to the lug bar. More flexible adjustment is claimed for the clasp constructed in this manner, particularly in those cases where the substitute is designed to correct a space between two natural teeth, and where they lean slightly toward each other. (Dental Review, October, 1913.)

While lacking the strength of some of the other forms of clasps described, when well planned and properly constructed the double-wire clasp clings to a tooth with wonderful tenacity, and will sustain a denture with firmness and comfort to the wearer.

The principal advantages of the double-wire clasp may be summed up as follows:

First — The large extent of linear contact existing between the clasp peripherally and the tooth surfaces, with the minimum amount of surfaces actually covered.

Second — Great resiliency and ready adaptability of the clasp to the tooth surfaces.

Third — Comparatively simple to construct.

The principal disadvantage lies in possible lack of inherent strength, particularly in those cases where the tooth is large, requiring a long clasp peripherally, and where the denture will be subjected to heavy stress or careless handling.

The Stop Clasp

The stop clasp has been previously mentioned under "Requisites of a Clasp." Clinical experience with this type of clasp has been so satisfactory as to lead to its adoption in practically every case.

Any of the forms of clasps described may be converted into a stop clasp by the addition of an occlusal lug. In case of the flat-band clasp the lug may be formed of the same piece of plate as the clasp by allowing for the extra width in cutting the clasp metal, or it may be soldered on after the appliance is constructed.

The lug should be so placed that, when the clasp is in position, it rests on, or hooks over, the mesial or distal marginal ridge of the tooth clasped. If the ridge is excessively prominent, it may be reduced by grinding and polishing so that the lug may not interfere with the occlusion of the tooth

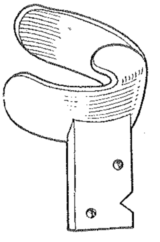


Fig. 117.— Ordinary Band Clasp with Stop, Lingual View

in the opposite arch, or the tip of the occluding cusp may be ground and polished until clearance space is gained. In case the tooth clasped is carious and suitable for the reception of an inlay, it may be restored in this manner and a depression made in the occlusal surface of the inlay, so as to permit the occlusal surface of the lug to rest flush with that of the restored part. It is essential that the lug should be slightly hook-shaped and the surface on which it rests correspondingly curved, to prevent the tendency of the clasp to slide away from the tooth when the denture is subjected to stress.

The Double Stay

A method much in vogue in Europe, but infrequently applied in this country, consists in attaching two rather thin pieces of clasp metal of 28 or 29 gauge to the baseplate. The strips should be in close apposition to each other, so as to pass through the interproximate space between two suitably located proximating teeth. The ends of the stays which terminate in the buccal embrasure are bent away from each other so as to lie in close apposition to the teeth they proximate.

Retention by means of this "Doppel Klammern" (double clasp), as the Germans term it, is very effective in favorable cases. The retention does not depend on mesial and distal frictional contact, but on the action of the reflected ends of the two flanges tending to draw the two teeth inward toward the baseplate. The stops themselves should not exert spring pressure on the proximating surfaces of the teeth, or in time gradual and permanent separation of the latter will occur.

The Stay

This appliance is commonly called a *stay clasp,* but the term is incorrect since it embraces less than one-half of the

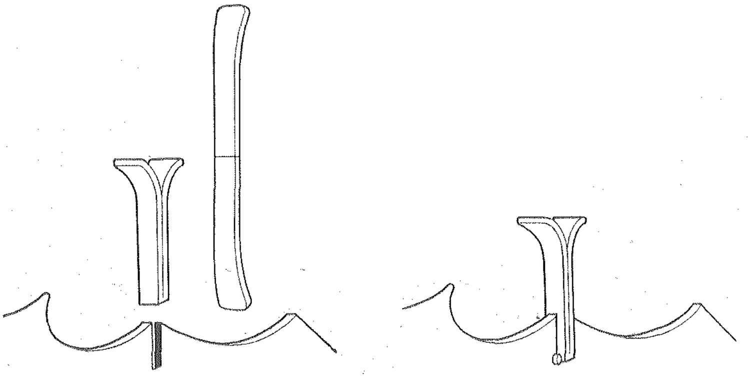


Fig. 118.— The Double Stay, Showing Elemental Construction Details

periphery of the tooth to which applied, and therefore does not perform the function nor fulfill the purpose of a clasp.

Appliances of this type are seldom indicated, being usually applied in those cases where ordinary frictional retention of the denture is uncertain because of the parallel, or slightly diverging, relation of the lingual surfaces of the teeth on opposite sides of the arch, and when for any reason clasps are contra-indicated. Two well adapted, opposed stays, the

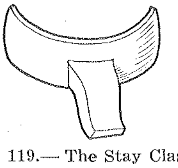


Fig. 119.— The Stay Clasp

ends of which pass well into the lingual embrasures, will frequently give the required stability.

Indications and Contra-Indications Governing the Application of Clasps

For the retention of partial dentures, clasps may generally be used to advantage in all cases when the mouth is in a comparatively healthy condition and the teeth are so situated that when the clasp denture is introduced it will balance and not become displaced.

Unless the teeth clasped are suitably located, displacement of the denture by gravity, muscular strain, or the two forces combined, will sooner or later occur, regardless of the presence of the clasps. For example, in an upper case where all of the teeth, except the third molars, are missing and retention of the denture depends solely on clasping these two teeth, gravity and the action of the lip and cheek muscles will overcome the resiliency of the clasps and result in partial, if not complete displacement. Or if the clasps are heavy enough to resist these displacing forces, the teeth themselves will be gradually and permanently tipped backward, thus permitting the denture to become unseated and the clasps will then be a detriment instead of an advantage.

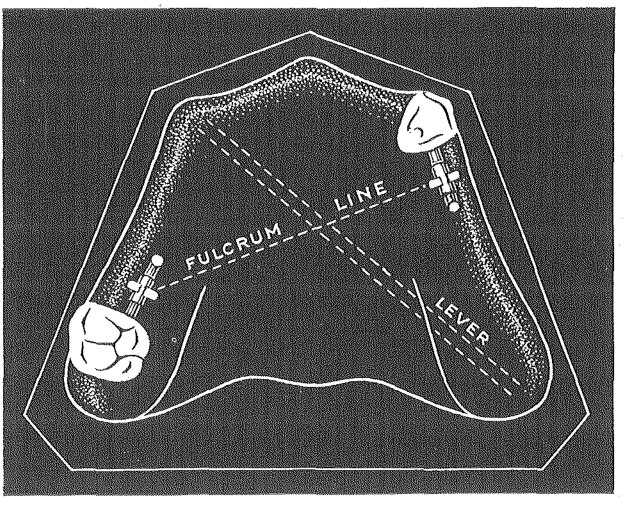


Fig. 120.— Diagrammatic View of Case Showing "Denture Balance"

The location for clasps best suited to insure stability is at a point midway between the anterior and posterior terminals of the denture on either side. The tendency to tip anteriorly is thus instantly counteracted by pressure of the distal end of the denture against the tissues, and vice versa. Such *balancing* requirement really limits the number of teeth that may be clasped to advantage to the second bicuspid and first molar on either side, although at times the first bicuspid and second molar, if present and on opposite sides of the arch, may be utilized for such purpose. Although neither clasp would be situated midway between the mesial and distal terminal, yet a straight line drawn from one clasp to the other would disclose a diagonal balance quite as effective as when the more centrally located teeth are clasped.

There is oftentimes a temptation to utilize the diagonal balance by clasping the cuspid on one side — all of the posterior teeth on that side having been lost — and the second or third molars on the opposite side. Usually such attempts result in failure because the conical form of the cuspid tooth precludes the application of a stable, partial-band clasp, except in those cases where tissue absorption has progressed to such an extent as to expose the constricted portion of the tooth, thus allowing the clasp to extend well up over the cingulum.

When but little absorption of tissue has occurred, a modified form of band clasp is sometimes constructed for cuspids, involving considerable effort in construction, but resulting in marked stability. A cavity is formed on the lingual surface

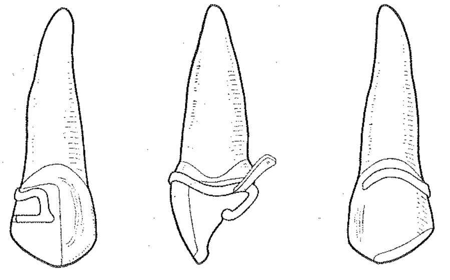


Fig. 121.— Lingual, Distal and Labial View of Cuspid with Lingual Lug Clasp

of the cuspid extending about two-thirds of the distance from distal to mesial, and from near the gingiva to the incisal third. In this cavity an inlay is placed, in which is formed a round-bottomed groove extending from its disto-lingual angle to near its mesial margin. This groove should be near the gingival margin of the inlay. The distance between the bottom of the groove and the labio-gingival surface of the tooth should be less than between that point and the diameter of the tooth immediately to the incisal of it. A clasp is now adapted to the gingival portion of the tooth as closely as possible, and embracing more than one-half of the periphery. A piece of iridio-platinum or clasp metal wire is fitted in the groove and connected to the clasp by interposing a piece of plate or wire, and soldering.

Usually some other form of specialized frictional appliance which involved no display of metal labially can be used to better advantage than the form of clasp just described.

Sometimes the ingenuity of the prosthetist will be taxed to the utmost to devise adequate means of retention in partial cases. Frequently, although several teeth are present, they may not be suitable in form to carry clasps, or be in correct position to insure denture balance should clasps be adapted to them. In such cases specialized frictional appliances can usually be applied in some manner so as to develop the required stability.

Specialized Frictional Appliances

Many forms of specialized frictional retention appliances have been devised in an effort to overcome the disadvantages and weak points of the various types of clasps commonly used. Specifically the main objects sought in devising and using these special appliances are, to avoid danger of caries, as well as other injuries to the natural teeth; to secure greater stability to the denture than can be derived from the use of clasps; to produce esthetic restorations of the highest type; and finally, to develop a means of retention applicable in cases where clasps for any reason are contra-indicated.

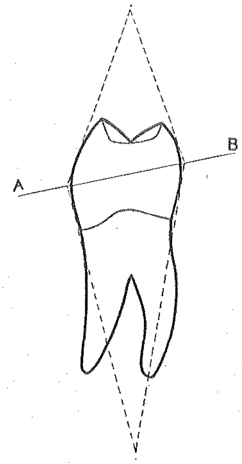
Most of these appliances consist of two parts, and require for their application the crowning of, or placing inlays in, one or more of the natural teeth. One of the parts is attached either directly or indirectly to the crown or inlay, the other to the denture.

CHAPTER XVI

TECHNIC OF CLASP CONSTRUCTION

Axial Contour Forms of Bicuspids and Molars

The form of the crown of a bicuspid or molar tooth usually represents sections of two more or less regular cones reversed, the bases of which meet in a common plane passing through the greatest bucco-lingual diameter of the tooth, Cut I. The gingival cone is quite regular, since the buccal, lingual, mesial and distal axial surfaces converge from the intersecting mid-plane gingivally. The occlusal cone is less typical in form, the buccal and lingual axial surfaces converging more or less regularly from the mid-plane (A, B) occlusally, while the mesial and distal surfaces are to a greater or less extent parallel or divergent.



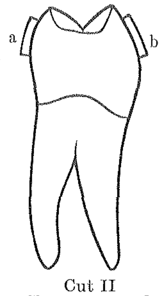
Cut I
Fig. 122.— Proximal View of Bicuspid Showing the Occlusal and Gingival Cones

An elemental factor of great importance, relative to the stability of clasps, should here be mentioned.

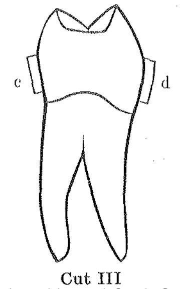
In Cut II let *a* represent the buccal and *b* the lingual flange of a clasp in sectional area. It will readily be seen that a clasp, so adjusted to the occlusal cone, when possessing any appreciable grasping properties, will tend to lift or unseat the denture from the border.

Again, a clasp without a stop, adjusted to the gingival cone as represented by *c, d,* Cut III, would offer no resistance to masticatory stress, and if capable of grasping the tooth, would constantly cause undue pressure of the denture against the border. As a result elongation of the tooth or absorption of the border must eventually occur.

Third, let *e, f,* or *g, h,* Cuts IV and V, represent a clasp, one flange of which embraces the occlusal and the other the gingival cone of a tooth. In this case, while passive stability



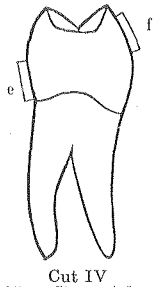
Cut II
Fig. 123.— Clasp Adapted to Occlusal Cone of Tooth



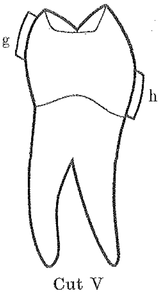
Cut III
Fig. 124.— Clasp Adapted to Gingival Cone of Tooth

may be developed, little or no resistance to movement, either gingivally or occlusally, will result.

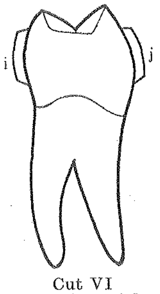
It is therefore apparent, that in order to develop maximum stability under all conditions, a clasp should embrace a portion of each cone base, *i, j,* Cut VI, on both buccal and lingual surfaces of the tooth. While it is not always possible to secure this ideal relationship between clasp and tooth, the



Cut IV
Fig. 125.— Clasp Adapted to Bucco-Occlusal and Linguo-Gingival Cone of Tooth



Cut V
Fig. 126.— Clasp Adapted to Bucco-Gingival and Linguo-Occlusal Cone of Tooth



Cut VI
Fig. 127.— Clasp Adapted to Embrace Both Occlusal and Gingival Cones

principle should be kept in mind, and an effort made to utilize it as fully as conditions permit.

Outline of the Various Steps

To encourage precise technic in the construction of clasps, and in the application of these appliances to denture retention, the various steps which have proven satisfactory will now be given in sequence, with more or less detail.

Assuming that the plan of the denture has been determined, and that suitable teeth for clasping are present and in proper position to insure denture balance, the outline of procedures is as follows.

First — Securing an impression of each tooth to be clasped.

Second — Rebuilding the impression for receiving and retaining the die metal.

Third — Melting the die metal and casting the die.

Fourth — Cutting the clasp metal to suitable dimensions.

Fifth — Consideration of the axial contour forms of bicuspids and molars.

Sixth — Preliminary concaving of the strip to aid in surface adaptation.

Seventh — Securing peripheral adaptation of the strip to the die with pliers.

Eighth — Securing surface adaptation with hammer.

Ninth — Developing final surface and peripheral adaptation with pliers.

Tenth — Soldering stops and anchorage lugs.

Eleventh — Finishing with files and polishing.

Twelfth — Securing the correct relation between the clasps, the teeth they embrace, and the baseplate.

Thirteenth — Uniting the several factors of the denture.

Securing an Impression of the Tooth to Be Clasped

An impression of the tooth to be clasped, as well as those teeth which proximate it, if any are present, should be taken in plaster. The impression should include not only the tooth crowns but extend well onto the buccal and lingual alveolar borders as well.

By using a small sectional or hinged tray, jointed mesiodistally along its occlusal floor, the plaster may be fractured and removed in two principal sections. This manner of removal obviates the breaking of the plaster which surrounds the crevices of, and fills the embrasures between, the teeth. An improvised cardboard tray, when properly shaped, will fulfill the same purpose as a divided metal tray. An ordinary metal tray may be used, but should first be oiled before introducing the plaster, to permit its ready removal from the impression before the removal of the latter from the teeth. The impression may then be divided and removed, and returned to the tray, or the parts may be adjusted and the impression rebuilt, as subsequently described. In such case, the impression should be grooved along its occlusal surface, when by pressure outward on the buccal, and inward on the lingual parts, it can be easily fractured and removed.

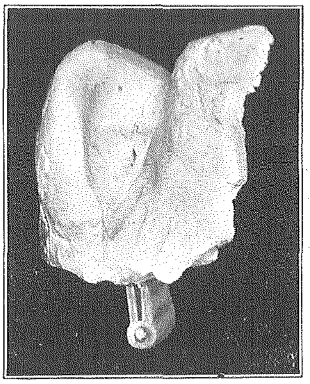


Fig. 128.— Hinged Tray, with Fractured Impression Closed

To facilitate the ready fracture of the impression for removal, on introduction, it should be carried occlusally until the floor of the tray touches the cusps, thus reducing the

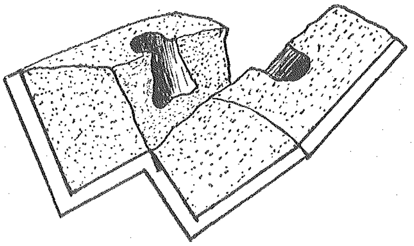


Fig. 129.— Impression, Taken with Cardboard Tray

depth of plaster in this area so that on pressure it will readily break.

Modeling compound is not a suitable material for impres-

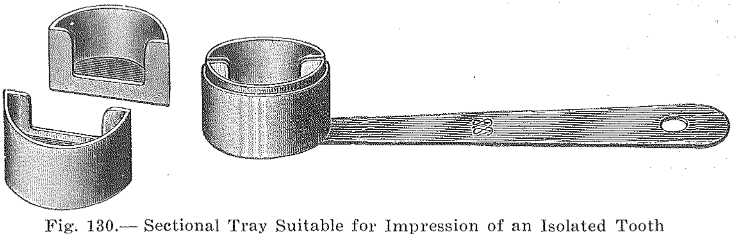


Fig. 130.— Sectional Tray Suitable for Impression of an Isolated Tooth

sions in clasp work for two reasons; first, because it usually distorts in removal, and second, because fusible metal will not cast sharply in such an impression. It may, however, be employed by the sectional method, when the models are to be run in cement or modelite.

Rebuilding the Impression for Receiving and Retaining the Die Metal, When Cast

An impression of one or more teeth intended for die construction in clasp work must be *rebuilt,* or prepared for the reception of the die metal. The steps are as follows:

The impression having been removed from the mouth, the fractured surfaces are freed from debris, the broken parts replaced in proper relation to each other and luted with sticky wax sufficiently to hold them together. No wax should occupy any portion of the matrix, as its presence, on pouring the molten metal, would generate gas and result in an imperfect

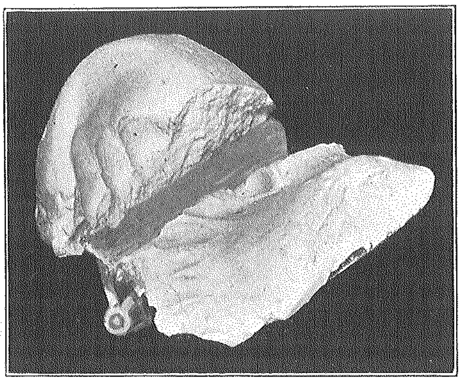


Fig. 131.—Impression of Tooth to Be Clasped, Taken with Hinged Tray

casting. By exercising care in handling the assembled impression the use of wax can frequently be dispensed with.

To strengthen the assembled impression and hold it firmly together a mix of plaster is made and spread on a piece of paper on the bench. Into this plastic mass, the impression, and tray, if the latter has been used for holding the fractured pieces together, should be sunk deeply, and the surplus built around the sides and into the ends of the impression to form walls for confining the metal in casting. It is frequently necessary to make additions to the buccal and lingual margins of the impression so as to bring them up to uniform height, and give good depth to the die.

For convenience in clasp construction, the die should be from ¾ to 1 inch in diameter across its base and about 1 inch in depth. These dimensions insure ease of handling, and afford sufficient weight to the die to render hammer blows effective when directed against the clasp. A die of these dimensions will require about 1½ to 2 ingots of Melotte's metal. The use of too light and small a die is responsible for much of the difficulty encountered in clasp construction.

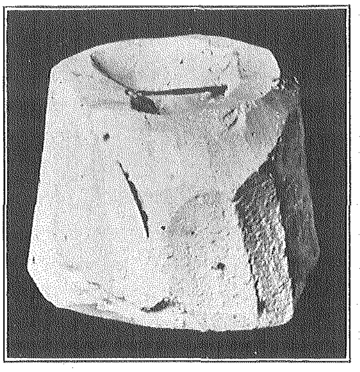


Fig. 132.— A Rebuilt Impression. Tray and Impression Enclosed in Surrounding Plaster

Since the matrix gives form to the die, with these dimensions in mind, its formation, by imbedding the impression in

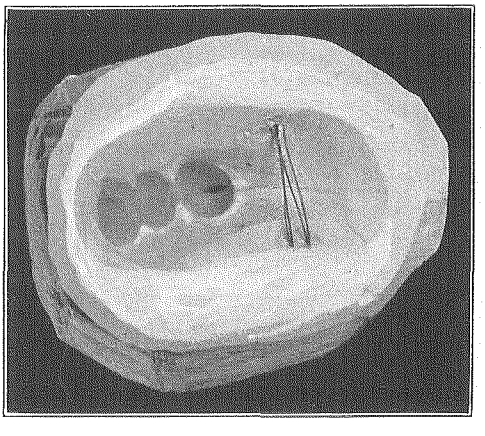


Fig. 133.— Top View of Rebuilt Impression, Showing Binding Wires Still in Position

plaster as described and by proper trimming, is readily accomplished. The usual method of forming the matrix by the addition of mouldine is more tedious and less accurate than when plaster is employed. Unless firmly luted, the broken parts are very liable to become distorted and wedged apart in applying the clay.

When teeth proximate mesially and distally with the tooth to be clasped, the impression of the tooth adjacent to the interproximate space through which the clasp is to pass should be filled in with plaster or mouldine, to exclude the molten metal in casting. The presence of a tooth in such location on the die seriously interferes with clasp construction. The other proximating tooth should be developed in the casting, as it serves as a guide in finishing the terminal ends of the clasp. Any unnecessary irregularities such as high points or depressions, present within the matrix, should be corrected by trimming or additions as required. The general form of the die should be cone shaped, from its base occlusally.

The impression having been converted into a matrix as described it should be closely inspected to see that all essential parts are in place, that no loose particles of debris are

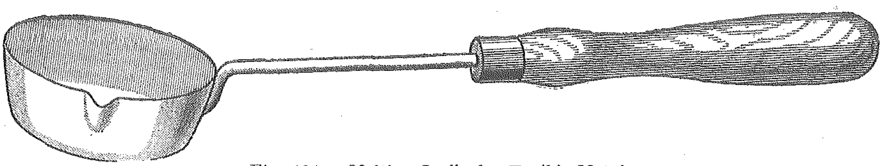


Fig. 134.— Melting Ladle for Fusible Metal

present, and that no openings exist at any point through which the molten metal can escape when cast.

Drying the plaster matrix before casting the die is not essential, since the fused metal, when poured at a low temperature, generates but little steam, while that which does form finds ready exit outwardly through the matrix walls. On the other hand, overheated metal cast into a damp or even partially dried matrix will cause such rapid generation of steam that it cannot all escape before the metal solidifies. Casting under such conditions usually results in impaired density or deficient sharpness of the die.

Casting the Die

Two ingots of Melotte's metal are placed in a small melting ladle and held over the Bunsen flame until a little more than half of the mass is fused. The ladle is then removed and the half-melted metal stirred with a small instrument or flat wooden spatula, to disseminate the accumulated heat throughout the mass until all is fused. Stirring also prevents *liquation* of the component metals, which, on account of their different specific gravities, gradually occurs. The film of oxide which forms on the surface should be skimmed off before pouring.

By watching the surface of the fused metal at its margins, it will be seen that the spherical appearance noticeable in most metals when fused gradually disappears, and as the temperature is reduced the alloy will settle squarely against the ladle wall. This appearance denotes that the metal, although somewhat reduced in temperature, is in its most fluid condition, and when cast will adapt itself to the most irregular surfaces.

Usually in this class of work the casting is deferred until the metal begins to lose its fluidity, or is on the point of congealing, in which condition little or no steam will be generated, and a dense, sharp casting may be obtained.

As soon as the die has hardened it can be quickly chilled in cold water, although it will be less brittle if allowed to cool slowly.

When freed from the impression and cooled, the die should be inspected for defects. These usually appear as excrescences, due to openings or spaces in the impression, caused by loss of broken particles in assembling the impression and into which the metal is cast. These defects are filed or chiseled away so as to restore the tooth to correct form. The embrasures, when filled in, should be burred or chiseled out and the die is ready for use.

Cutting the Clasp Metal to Suitable Dimensions

A strip of No. 60 tinfoil, adapted to the tooth with the fingers, and by burnishing if necessary, is cut to suitable length, and slightly wider than the required clasp, to serve as a pattern for cutting the strip of clasp metal. This pattern is laid on a piece of clasp plate of the required thickness, lengthwise of the lamina developed in rolling the ingot into sheet form, and its outline marked with a sharp instrument. Failure to parallel the clasp with the lamina of the plate usually results in fracture of the clasp during construction or under slight stress when in use. It also insures greater resiliency in the clasp.

When a stop is to be formed from the same piece of plate it should be so indicated on the pattern and the strip cut wider at this point.

Before beginning to conform the strip of clasp metal to the die it should be carefully and uniformly annealed at a low, red heat. This reduces its stiffness but does not deprive it of all of its resiliency. The full degree of elasticity may be restored in the final polishing by subjecting the completed clasp, after the final soldering, to the action of a stiff brush wheel, on a high speed lathe, and by burnishing.

PRELIMINARY CONCAVING OF THE STRIP OF CLASP METAL

When the clasp strip has been cut as described, the first preliminary step in adaptation is to concave it from end to end with the hawkbill pliers, on that side to be applied to the

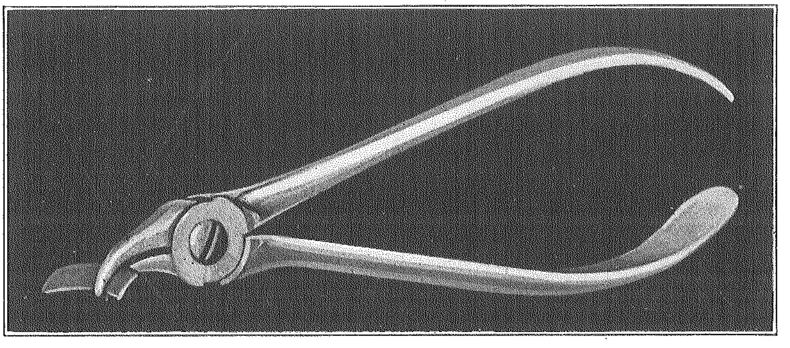


Fig. 135.— Hawkbill Pliers as Applied in Concaving the Strip of Clasp Metal

tooth. This concave depression embraces the cone bases or greatest diameter of the tooth, and permits the occlusal and gingival margins of the clasp to rest in contact with the more or less convex axial walls of the tooth as peripheral adaptation is carried on, step by step.

The terminal end of the strip, which rests in the embrasure and where adaptation is to begin, should be rounded on

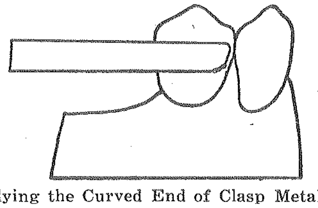


Fig. 136.— Applying the Curved End of Clasp Metal Strip to Tooth

the gingival edge, curving it so as to parallel the gum margin as it rises in the embrasure, where this end of the clasp will rest.

Frequently the convexity of the strip produced by the hawkbill pliers is greater than that of the axial walls of the tooth. The central portion of the clasp will then stand away from, while the occlusal and gingival margins will lie in con-

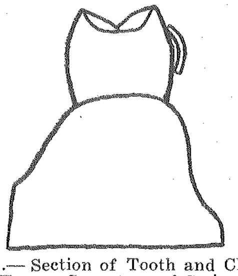


Fig. 137.— Section of Tooth and Clasp, Showing Excess Curvature of Strip

tact with the axial walls. This is an advantage rather than a detriment, as light hammer blows, in subsequent steps, will reduce the excess curvature and develop surface adaptation.

Securing Peripheral Adaptation of the Strip to the Die With Pliers

The peripheral adaptation of a clasp to a die should be developed by steps rather than by converting the strip at the outset into a partial band of general form by means of the clasp benders. The latter method, although most commonly followed, is less accurate at the start and in the end will result in requiring greater care in securing adaptation than where the former method is employed. The following procedure is practical, accurate and rapid, when once the technic is understood, and the required skill for carrying it out is developed.

The concaved strip, its angle rounded as described, is carried into the embrasure where it is eventually to rest, and laid closely against the axial surface of the tooth. By viewing it occlusally, the areas not in contact are readily noted. The strip is then removed, held firmly with the fingers near the end being adapted and with the hawkbill pliers applied to an area not in contact, a positive bend is made in a direction to secure the desired adaptation. It should again be returned to the die and the change wrought by bending noted. One or two additional bends and trials may be required to effect reasonably close adaptation of the strip against an area representing about one-sixth of the tooth periphery. In the same manner the strip is grasped somewhat further in from the end already conformed, while other bends are similarly made until the areas of the clasp not touching the die are brought into reasonably close contact.

When a torsional bend in the clasp is required, as in turning the angles of a bell-crowned tooth, it can be accomplished by substituting a pair of pliers for the fingers for holding the unadapted strip, the hawkbills being applied to the adapted portion, while round or flat beak or another pair of hawkbill pliers can be used on the unadapted portion, as the contour of the surfaces requires.

To illustrate the steps as outlined, the adaptation of a clasp to an upper first bicuspid will be described. The two ends of the clasp will terminate mesially.

The strip of concaved clasp metal is applied to the mesio-buccal angle of the axial surface of the tooth and the areas not in contact noted. These are corrected to the crest of the

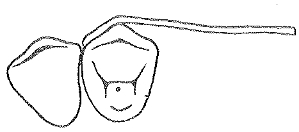


Fig. 138.— Clasp Adapted to the First One-Sixth of Tooth Periphery

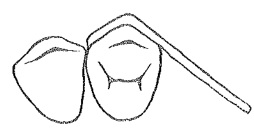


Fig. 139.— Clasp Adapted to the Buccal Surface of the Tooth

buccal ridge, usually representing a linear distance of about three-sixteenths of an inch. Adaptation should then be secured between the buccal ridge and the disto-buccal angle in like manner. Then the turn is made around this angle and adaptation secured across the distal surface, to the disto-

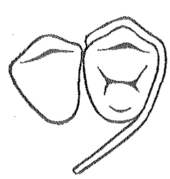


Fig. 140.— Clasp Adapted to Buccal and Distal Surfaces of Tooth

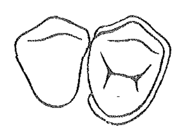


Fig. 141.— Peripheral Adaptation of Clasp Completed

lingual angle. From this point the strip is bent against the lingual surface to the center of this side. The final step consists in turning the mesio-lingual end of the strip into place. Thus the process of peripheral adaptation of a clasp consists of five, or, in certain cases, seven distinct steps where the terminal ends of the clasp require special adaptation in the embrasures.

Securing Surface Adaptation of the Clasp to Die With Hammer

Peripheral adaptation refers to the bending of the strip into partial band form, so that it embraces the periphery of the tooth closely throughout its entire length. Peripheral contact, however, does not imply that the entire inner surface of the strip is in close adaptation to the die at all points or throughout its entire occluso-gingival width.

Surface adaptation involves not only good peripheral contact, but close approximation, occluso-gingivally of the partial band to the axial walls of the tooth or die as well. Peripheral contact is comparatively easy to develop with suitable pliers, but of itself does not afford the required stability in the completed clasp. Surface adaptation is essential to stability, but is much more difficult to secure, especially in the thicker gauges of clasp metal. The preliminary concaving

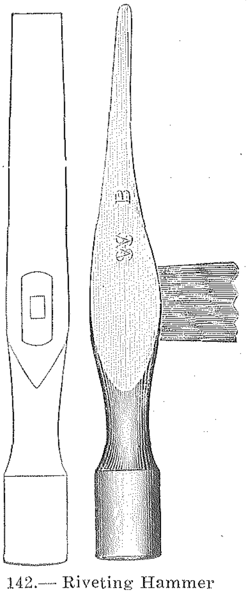


Fig. 142.— Riveting Hammer

of the strip with the hawkbill pliers aids greatly in securing surface adaptation.

Since the concavity of the clasp is more or less uniform in curvature from end to end and the axial walls of the tooth constantly vary in curvature, it becomes necessary to decrease over some and increase over other areas the concavity of the clasp. This is most easily accomplished with the small riveting hammer.

The die, when of the dimensions previously mentioned, serves the same purpose as an anvil and affords ample resistance to hammer blows, so that heavy gauges of clasp metal are readily conformed to its surfaces under such stress, properly applied.

To develop surface adaptation, the same order of procedure as was followed with the pliers is carried out with the hammer, the blows being first directed against the mesiobuccal section of the clasp and continued around to the opposite terminal. The application of the hammer and the horn pene mallet causes the clasp to open, so that from time to

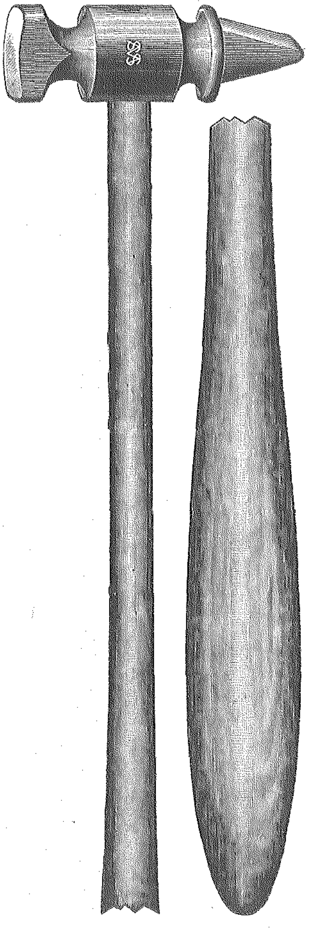


Fig. 143.—Melotte's Horn Pene Hammer

time it will be necessary to remove it from the die and reduce its diameter with pliers and by finger pressure, until it again grasps the metal pattern firmly.

Final Adaptation of the Clasp to the Die

When general surface adaptation between clasp and die has been secured with the hammer, the final finishing touches are given with the pliers. The clasp should grasp the die tooth so firmly as to require considerable force to dislodge it. Usually a clasp, when transferred from the die to the natural tooth in the mouth, will fail to grasp it closely, even though it may fit the die perfectly. This is due to the fact that the die metal in cooling expands slightly, and therefore the die is in reality a trifle larger than the tooth. Correction is easily made in adjusting the clasp to the natural tooth in the mouth by bending the two flanges slightly toward one another.

Soldering the Stops and Anchorage Lugs to the Clasp

When the clasp is constructed without a stop, and it is deemed advisable to attach one, the steps are as follows: Cut a piece of 22 gauge clasp metal about 1-16 of an inch wide and of suitable length to form the hook over the marginal ridge, extend gingivally to the ridge and furnish attachment to the metal or vulcanite baseplate. The clasp is placed in position on the die and with a pair of pliers the strip of metal is conformed as closely as may be to the clasp and die, the final adaptation being secured with the hammer.

The clasp and stop are waxed together in proper relation to each other on the die, removed, invested and soldered. Final adjustment of the clasp to the die is now made, and the position of both the occlusal and gingival ends of the stop bar corrected if necessary. That portion of the bar which forms the anchorage lug should lie close to the crest of the border, somewhat to the lingual so as not to interfere with the placing of the artificial teeth. It is frequently necessary to reinforce this portion of the bar so as to render it rigid and unyielding, and thus obviate distortion of the relation between the clasp and denture when subjected to stress. Many clasps, otherwise well planned and serviceable, fail because the anchorage lugs are weak, lack rigidity and bend under stress.

FINISHING THE CLASP

The ends and outer margins of the clasp should be rounded and beveled with files and engine discs, and finally polished with felt wheels and polishing powders. When properly finished, the tendency of the clasp margins to irritate the soft tissues of the cheeks and tongue is obviated, and the liability of food to accumulate around the appliance is reduced to the minimum.

Holding the finished clasp for a short time against a stiff brush wheel running at high speed will restore the elasticity in the metal, which has become reduced as a result of soldering operations. Rubbing vigorously with a burnisher will also have a similar effect.

Various Methods of Clasp Construction

Other methods of clasp construction than those previously described are frequently employed to good advantage, some of which will here be briefly outlined.

COMBINATION CLASP OF PURE GOLD WITH CLASP METAL

Secure an impression of the tooth to be clasped. From this develop a model tooth in some good, hard investment compound. To this model adapt a piece of pure gold of the form of the clasp desired, of 32 or 34 gauge. The adaptation can be readily secured first with pliers and finally by burnishing to the model tooth. On this pure gold foundation apply a partial band of clasp metal, slightly narrower than the clasp is to be when finished, and usually of 26 gauge. The adaptation of the strip of clasp metal to the pure gold foundation clasp should be reasonably close, but not necessarily perfect. Between the pure gold and the clasp metal strengthener flow 18 carat solder, contouring the outer surfaces of the clasp at the same time, as conditions require. The soldering of the two pieces is accomplished on the model tooth. This is necessary, because if removed from the tooth the pure gold foundation, which is practically devoid of resiliency, would in all probability be permanently distorted. Final adaptation, which usually consists in slightly reducing the diameter of the clasp, can be accomplished in adjusting to the natural tooth.

The objections to a clasp of this type are, first, the gold which embraces the tooth, because of its softness, will in time be reduced by wear, and second, the resilient index of such a clasp is low in comparison to its bulk. Platinum, or preferably iridio-platinum, being slightly harder, can be used to better advantage for the foundation than pure gold.

Cast Clasps

Clasps of any form desired, including stops and anchorage lugs, can be readily cast by the usual technic employed in inlay work. Clasps of this type, however, are lacking in resiliency, and on account of the more or less granular or crystalline character the clasp metal assumes when cast, are very liable to break under stress.

The Wire Loop Clasp

The construction of a round wire clasp is a comparatively simple operation. It is essential that a hard, resistant die be formed of Melotte's metal, amalgam or some of the cements, to which the wire may be fitted with pliers and by light hammer blows.

A plain wire loop clasp, which embraces a little more than one-half of the periphery of a tooth, may be readily and quickly conformed to the axial walls of the die as follows:

As a preliminary requirement in such cases, the teeth proximating the one to be clasped should be eliminated in forming the die so that the latter may stand alone. The wire, bent in the form of an elongated loop, is conformed to the periphery of the die tooth with pliers. Through the two ends of the clasp a strip of 28-gauge German silver plate from 1-16 to 1/8 inch wide, depending on the distance apart it is deemed advisable to place the occlusal and gingival loops, is threaded and doubled back on itself so as to form a loop. With the flat-nosed pliers the two ends of the strip are grasped and twisted tightly together. The resulting tension draws the wire loop clasp tightly around the die. A few light hammer blows applied peripherally to the wires will permanently set them to the form of the tooth. Stops and anchor lugs are attached by soldering as previously described.

Continuous and Open-Loop Clasp

A number of new forms of continuous and open wire loop clasps have been designed and presented to the profession by Dr. F. E. Roach. In many cases clasps of the type under consideration are most useful and efficient and have the advantage of extensive peripheral contact with the tooth, while the area covered by the clasp is extremely limited.

A piece of 18-gauge clasp wire for open loop, and 19 or 20 gauge for continuous loop, is bent in staple form. This bend or loop, forms an occlusal rest or stop, when a proximating tooth is present. Its principal purpose, however, is to connect the buccal and lingual portions of the clasp, which, if not so joined, would lack inherent strength. From the occlusal bend both buccal and lingual wires drop into their respective embrasures to the gingival third of the tooth clasped when they are conformed to the buccal and lingual surfaces of the tooth, joining on the opposite proximate surface to form the anchorage lug. A continuous loop clasp of this type can be converted into an open loop clasp by soldering the two terminals together, which form the anchorage lug and severing the labial or buccal loop. The two terminals may be doubled back upon themselves and soldered for greater strength or to increase the areal bearing of the clasp if necessary. The forms of these clasps and their range of application seem limited only by the ingenuity of the operator.

In applying clasps of any type to a partial denture the fact should be borne in mind that clasps are not designed to take up the stress of mastication, but merely serve to keep the denture seated on its border in speaking and during masticatory effort. Thus it will be seen that clasps of this type will, in very many cases, fulfill all the requirements efficiently.

Securing the Relation Between Clasps, the Teeth They Embrace and the Baseplate

When a partial clasp denture is finished and introduced in the mouth it should bear evenly and comfortably on the tissues and occasion the wearer no distress or inconvenience. Each clasp should embrace its respective tooth firmly and yet subject it to no leverage, wedging or torsional strain. These conditions can only be developed during the constructive stages, with skillful technic, by securing the correct relationship between the clasps, the teeth they embrace and the baseplate or denture. The following method is practical and accurate and should be carried out in the order detailed in most cases. The clasps, having been conformed, preferably to metal dies, are adjusted to the teeth in the mouth. This step proves the accuracy of their adaptation. Should they shift in any manner or fail to grasp the tooth firmly, correction must be made until satisfactory adaptation is secured before proceeding further. They are then removed and the baseplate is introduced when each clasp is returned to position on its respective tooth. Should either clasp fail to go to correct position, the baseplate or clasp, or both, should be filed away at the points of interference until each factor can assume its correct position without disturbing the other.

Usually the baseplate should fit snugly against all of the teeth involved, including those clasped, the gingival margin of each clasp either resting on or clearing the periphery of the baseplate, and occupying a position to the occlusal of the latter. Variations from this rule are sometimes necessary, as in case a tooth crown is extremely short, to insure grasping properly it may be necessary to extend the gingival margin of the clasp slightly under the free margin of the gum. In such instances clearance for the clasp must be gained by filing the baseplate to accommodate the former. Such relationship between clasp and baseplate, although at times necessary, should be avoided when possible because of the liability of the clasp to set up gingival or peridental inflammation.

Taking the Impression of the Clasps, Teeth and Baseplate

The clasps being in position on the teeth and the baseplate firmly seated on the tissues an impression is taken in plaster. This need not be extensive, but should fully embrace the clasped teeth, both buccally and lingually, and the greater portion of the baseplate.

On removal of the impression each clasp that is not retained in and removed with it is removed from its tooth, brushed free of particles and returned to position in its matrix. The hinged trays mentioned elsewhere can be used to good advantage in taking impressions in this class of work. The ends of the clasp are now sprung apart by means of a small peg of wood inserted between the buccal and lingual flanges to force them against the matrix walls in essentially the same relation they occupied in the impression when on the tooth. Neglecting to carry out this step usually results in permanently establishing an incorrect relationship between the clasp and baseplate. In securing a cast from the impression, a clasp not properly forced against its matrix walls as outlined, instead of embracing the axial walls of the tooth, will be found partially imbedded within them. The extent to which it is imbedded in the lingual surface of the plaster tooth represents the linear movement buccally that has resulted from the recoil of the clasp on removal from the tooth. When this error occurs, if not corrected, and the clasp is permanently attached to the baseplate in such relation, on introduction of the denture the tooth clasped will be forced buccally, oftentimes to such an extent as to render the presence of the denture unbearable.

The clasps having been adjusted as described, the baseplate is set in place in the impression and luted firmly with wax to hold it in place while securing the cast. When varnished the impression is filled with investment compound, and the latter allowed time to set hard before removing the impression.

Soldering the Clasps to the Baseplate

The attachment of a clasp to baseplate is accomplished by flowing solder along the joint between the two. The extent of attachment should be limited, usually to 3-16 of an inch, or less. If joined to a much greater extent the clasp becomes a rigid, unyielding band and will not fulfill the purpose well for which designed. The attachment should be made in as nearly central a location between the two terminals of the clasp as possible, so as to utilize and not destroy the greatest grasping power of the clasp.

When clasp and baseplate are not in contact, connection should be made by inserting a strip of clasp metal or a piece of plate in the space between the two and flowing solder over all, so as to make a firm and rigid attachment.

Sometimes when the tooth clasped is long and the space between the clasp and plate is quite wide, a rigid wire extended lengthwise between the two, the connection being completed with solder, will afford a rigid, self-cleansing bond of union.

The essential point to bear in mind in securing the correct relationship between clasps, teeth and baseplate is that the steps should be carried out as described by assembling the appliances in the mouth and securing the impression first hand from the tissues against which the denture is to rest. Assembling the several parts of the denture on a model, while sometimes satisfactory, more often leads to error, sometimes so marked as to require reconstruction, or at least reassembling of the several parts.

CHAPTER XVII

THE MASTICATORY MECHANISM

At the present time, more than ever before, the fact is realized that the masticatory organs are of the most vital importance in the maintenance and preservation of health. Partial or complete failure of these organs to carry on their important functions in the daily routine of life will, sooner or later, result in the permanent impairment of other functions as well.

When, through accident or by disease, a portion or all of the teeth are lost, it is imperative that they be replaced with artificial substitutes. Such substitutes should have the appearance and perform the functions of the normally arranged natural teeth, and no effort should be considered too great in order to accomplish these ends.

The normal arrangement of the teeth in one arch in their relation to each other and to the centers of rotation of the mandible, insures normal occlusion and correct cusp clearance in lateral movements with those in the opposite arch when the latter are also so arranged.

A single tooth, however, when elongated, rotated, or out of alignment, may impair the efficiency of the entire masticatory apparatus. It is therefore necessary to study carefully the normal human denture in detail, in both passive and active states, to understand what is required in the replacement of the natural teeth with artificial substitutes.

The Masticatory Apparatus

The normal adult human masticatory apparatus consists of four principal factors or groups of hard and soft tissues which, when acting conjointly, and in unison on food, reduce it to a condition suitable for introduction into the digestive tract. One of these factors is practically immovable or passive in masticatory effort, except as the cranium itself, of which it forms a part, moves. The other three groups are active or movable. They may be classed as follows:

First: The upper maxilla or immovable base.

Second: The mandible or principal moving factor.

Third: The group of muscles which control and guide the movements of the mandible.

Fourth: The group of muscles which control the position of the food and keep it within the working limits of the teeth in masticatory effort.

THE UPPER MAXILLA

The two superior maxillary bones join at the median line in a firm, strong suture to form the maxilla. This united bone constitutes the anterior portion of the cranial base, being directly and indirectly firmly united with all of the other cranial bones except the mandible.

Since the maxilla moves only as the entire cranium is subject to movement, it may justly be regarded as the base or fixed factor of the masticatory apparatus. The upper teeth are imbedded in its alveolar process, and against these the food is forcibly carried in the process of reduction.

The body of the bone in general is composed of rather thin, frail plates, but these are reinforced at various points where stress is heavy by what are termed *buttresses.*

The alveolar process in which the teeth are imbedded is especially heavy and resistant to stress. This process in turn is reinforced by vertical ridges or columns running upward and merging into the malar processes opposite the first molars, while anteriorly the cuspid eminences pass upward and merge into the nasal plates. The tuberosities are supported by the thickened perpendicular posterior walls of the maxilla itself.

Each maxillary bone has within its body a cavity known as the *maxillary sinus,* or antrum. The floor of this sinus lies immediately over the roots of the second and third molar teeth, some of which at times penetrate the bony plate. It can thus be seen how easily oral infection may be transmitted to the tissue lining the antrum when these teeth contain diseased pulps.

The several plates composing the upper maxilla enter into the formation of the floor and outer walls of the nasal fossa, the palatal vault, floor of the orbit and spheno maxillary fissure.

THE MANDIBLE

The *mandible* is the active working factor of the masticatory apparatus. In its alveolar process the lower teeth are imbedded, and through its movements they are brought in forcible contact with the upper denture in the reduction of food.

When all of the natural teeth are present in a healthy condition and normally arranged, they constitute a powerful mill, capable of cutting, tearing, crushing and grinding all varieties of food taken into the mouth as such, in a thoroughly efficient manner and with comparative ease.

The mandible is of peculiar form and especially strong and rigid within itself, capable of a wide range of movement and of fulfilling various functions.

AUXILIARY FUNCTIONS

The mandible has various functions and is capable of many movements other than those concerned in masticatory effort. Indirectly, it assists in phonation by enlarging or reducing the size of the oral cavity, and by gauging the distance between the upper and lower teeth, the tongue is enabled to assume its proper position in modifying the vocal tones as they issue from the larynx. By its various movements, the mandible assists in giving expression to the face in speaking, laughing, and in the exhibition of the various emotions. In the lower animals, and occasionally in man, when brute instinct dominates his intellect, the masticatory apparatus becomes a weapon of offence and defence.

GENERAL DESCRIPTION OF THE MANDIBLE

A lever is a rigid arm, capable of turning about a point for transmitting *force* or *motion* or for applying *power* to overcome *resistance.*

A device of this type is composed of three factors, viz.: a point or area where power is applied, designated as P; a point or area where that force is made available for work or weight to be overcome, designated as W; and a point of rotation or bearing called the fulcrum and designated as F.

Levers are divided into three classes, according to the position or arrangement of their factors, as follows:

First Class, P———F———W
Second Class, P———W———F
Third Class, W———P———F

The mandible is a double lever of the third class; that is to say, being double, it has two bearing points which may move in unison, forward or slightly backward at the same or different rates of speed, or one may travel in a definite path and the other merely act as a rotation center.

The power is applied between the working area and the fulcrum or bearing points. The peculiar form of the bone permits of the application of great force, with but little tendency to tip or become unbalanced in masticatory effort.

The mandible consists of a body, a thick, flat bone, curved on itself in the form of a U and of two perpendicular portions, called the ramii, which form the extremities. Each

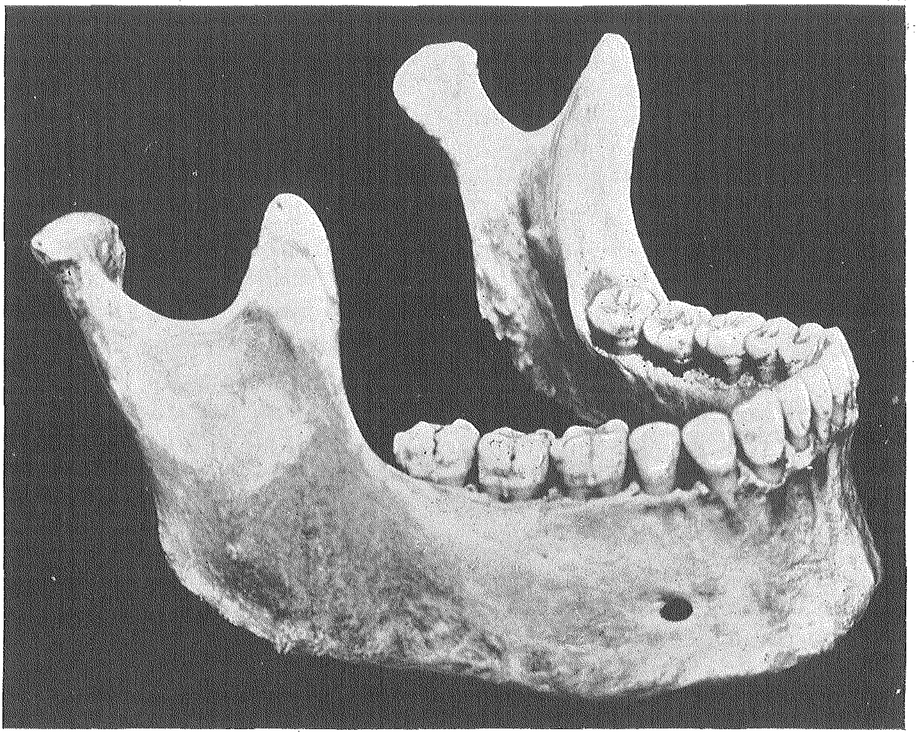


Fig. 144.— The Mandible

ramus is surmounted by two eminences, the anterior called the coronoid process, to which the temporal muscle is attached, and the posterior, called the condyloid process, which forms the articular or sliding joint surface. The upper extremity or head of the condyloid process is called the condyle, and the constricted portion which connects it with the ramus is called the neck.

The upper or articular surface of the condyle is convex from before backward, as well as from side to side. It is elliptical in form, the long axis running from without inward and slightly backward and downward.

In general proportions the mandible resembles an equilateral triangle. Bonwill's researches led him to believe that the average distance from center to center of the condyles and from the center of each condyle to the mesi-incisal angles of the lower central incisors was approximately four inches, these measurements forming an equilateral triangle, and hence this has been termed the Bonwill triangle.

On this basis of measurement he evolved his theory of "anatomical articulation" and constructed his "anatomical articulator."

MOVEMENTS OF THE MANDIBLE

Because of its peculiar form and the manner of its attachment to the base of the cranium, the mandible is capable of, and subjected to, a great variety of movements. So free and varied are these that unless carefully considered they may appear to lack co-ordination.

Although capable of wide range of action, there are but three definite movements of the mandible, however, that may be considered as important in masticatory effort. These should be carefully studied and thoroughly understood by the prosthetist in order that the product of his hand, when constructed and subjected to masticatory action, may perform in an efficient manner the same functions that are carried out by the natural teeth.

The three important movements mentioned may be outlined as follows: First, a hinge-like movement employed in opening and closing the mouth for the introduction, and also to a limited extent for the crushing of certain varieties of brittle food.

Second: A protrusive movement employed in the grasping and incision of food and in rearranging or changing the position of food in the masticatory grooves in process of reduction.

Third: Right or left lateral movements employed in the reduction of fibrous, as well as all varieties of food. These movements are the most effective of any described, since by their action food can be finely triturated with about one-half the expenditure of muscular energy that is required with the hinge motion.

To appreciate these movements in detail it will be necessary to consider the manner of attachment of the mandible to the cranial base, and the form of articulation of the condyles with the temporal bones.

THE TEMPERO-MANDIBULAR ARTICULATION

The condyles articulate with the temporal bones, being received in elliptical concave depressions, called the glenoid fossæ, and from which they travel forward; in some cases, to a limited extent slightly backward, and from side to side. These depressions are situated immediately in front of the auditory canals, from which they are separated by a thin, bony partition which limits the backward movement. In general contour these fossæ resemble, in reverse, the form of the articular surfaces of the condyles, the adaptation of the two surfaces to each other, however, not necessarily being exact.

Between each condyle and its dome-shaped socket is interposed an inter-articular fibro-cartilage, its upper surface convex, its lower surface concave. Synovial sacs partially enter between the cartilage and the condyle. The combined thickness of the three layers of tissue seldom exceeds 3/32 of an inch, and in many cases is less than 1/16 of an inch.

By bearing in mind the average thickness of these tissues, the thickness of the bony plate separating the glenoid fossa from the auditory canal and the antero-posterior diameter of the condyle, which is usually about ¼ of an inch, the location of the outer end of the condyle in the living subject can be determined with comparative accuracy.

The synovial sac contents lubricate the articular surfaces, while the inter-articular fibro cartilage, being but loosely attached to and moving forward somewhat with the condyle in its movement, reduces friction and acts as a cushion as well, when the mandible is subjected to heavy stress.

At the anterior margin of the glenoid fossa is usually an eminence formed by the middle root of the zygoma and called the *eminentia articularis.*

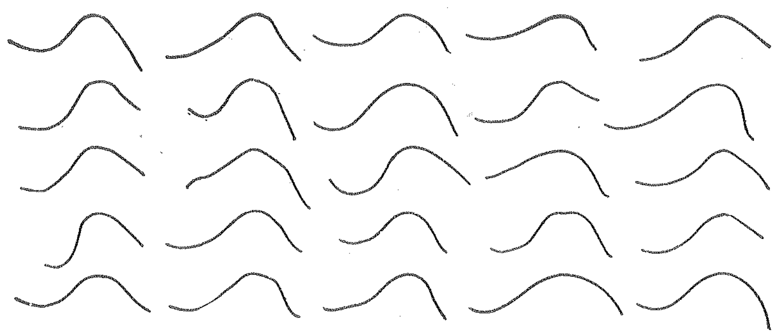
THE CONDYLE PATH

Viewed from the side, the general contour of the roof of the glenoid fossa with that of the articular eminence at its anterior margin and with which it imperceptibly merges, is that of a compound curve.

The condyles, in the various opening, closing, protrusive and lateral movements of the mandible, are guided by and must take the general direction of this concave-convex roof throughout the extent traversed by them in each movement, and hence this surface is called the *condyle path.*

The condyle path, as before stated, is usually curved, being concave posteriorly and convex anteriorly. The central portion is approximately a straight line. This portion, the central one-half of the path, may be considered, and actually is, the working surface which guides the condyle in its movements in carrying the lower against the upper teeth, in their protrusive and lateral excursions in masticatory effort.

For practical purposes, in denture construction it is necessary to measure or record in some manner the angular inclination of the central or straight portion of the path. When, hereafter, it becomes necessary to refer to the *inclination,*



A *B* *C* *D* *E*

Fig. 145.— Variations in Condyle Paths, Left Side (Tomes & Dollamore)

angle of *inclination,* or *pitch,* of the condyle path, these terms will refer to the central or working surface just described, unless otherwise specified.

VARIATIONS IN THE PITCH OF CONDYLE PATHS

The condyle paths vary in different individuals and frequently in the same person, in their length, curvature and angular inclination.

Walker, Christensen, Gysi and many others who have investigated on the living subject, vary slightly in their conclusions. Gysi, whose work is perhaps the most thorough because of more accurate methods employed, estimates the average inclination of the condyle path at 35 degrees.

Variations ranging from horizontal to a pitch of 72 degrees, as recently recorded by the writer, have been noted. It is not uncommon to find a difference of 10 degrees in the pitch of the condyle paths of the same individual.

The contour and inclination of the condyle paths vary in the same individual from infancy to old age, just as the form of the mandible is itself modified by the lapse of time.

Such changes of the condyle path may be ascribed to and are influenced by the partial or total lack or loss of the teeth. Loss of all of the teeth will result in time in a possible decrease in pitch of the condyle path, the change in the path, however, occurring quite gradually.

The loss of a portion of the teeth may produce a directly contrary result. In a specimen in possession of the writer the posterior teeth, except third molars on right, were lost a number of years prior to the death of the subject. That side

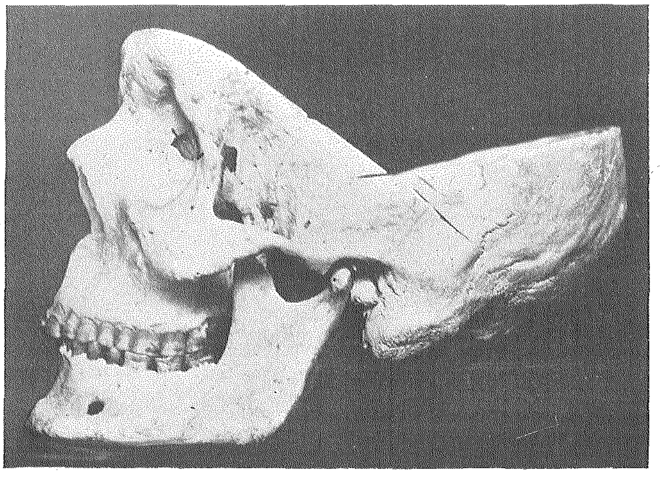


Fig. 146.— A Skull with Abnormally Deep Glenoid Fossa on Left Side. Mandible Thrown to Left. Teeth in Working Relation. Balancing Relation Between Third Molars on Right. All Bicuspids and Molars on Right, Except Upper and Lower Third Having Been Lost

of the mouth on which the loss occurred was useless for mastication, and consequently it became the moving arm of the mandible, or the balancing side of the masticatory apparatus. The bicuspids and molars on the opposite side were all present and in good condition and occlusion, while the condyle on this, the working side, merely rotated in its fossa.

Protrusive and lateral movements of the mandible on the working side in the opposite direction accomplished nothing. So, nature, to maintain the masticatory function in as perfect a condition for as long a time as possible, increased the depth of the glenoid fossa on the working side by enlarging the eminentia articularis and by reducing the pitch of the condyle path on the opposite side, as the cusps and planes of the various teeth were worn away.

It has been suggested that the registration of the condyle paths and the construction of dentures in accordance with such registration is unnecessary, since time and occlusal conditions of the teeth modify the pitch and form of the paths.

This view is entirely unscientific as well as unwarranted by results in practice. In no instance within the experience of the writer has any marked improvement in the way of additional lateral movements been observed with the lapse of time, when such movements were not possible at first. It is not reasonable to suppose, except possibly in rare instances,

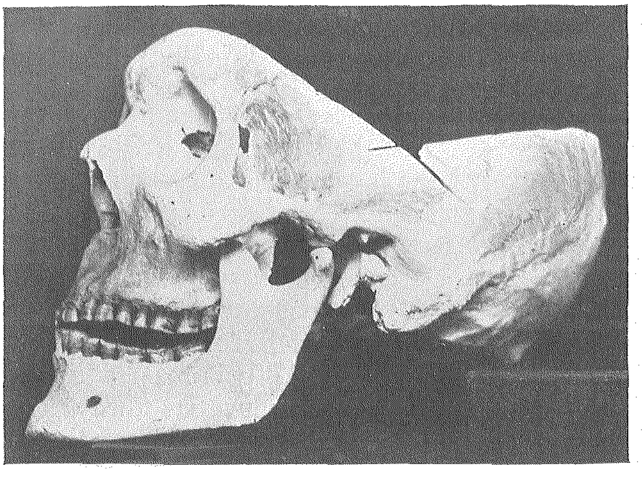


Fig. 147.— A Second View of Preceding Skull, Mandible Thrown to Right. No Balancing Contact on Left. No Occlusion on Right

that any material change does occur, since the artificial teeth in such cases are almost invariably arranged without reference to future possible lateral mandibular movements. Consequently, unless the teeth are so assembled as to permit of anatomic movements other than simple occlusion at the time of constructing the denture, the habit of confining masticatory effort to the hinge movement alone, becomes permanently fixed long before any perceptible change occurs in the condyle paths.

The Muscles of Mastication

The muscles which move the mandible in masticatory effort, particularly those which close the jaw, are capable of developing great power. In tests made a number of years ago by Dr. Black, with his gnatho-dynamometer, and since verified each year in class demonstrations, it was found that a force ranging from 150 to 300 lbs. could be developed by these muscles and delivered between the lower and upper molars.

The two pairs of muscles, the masseters and temporals, furnish most of the power. The internal pterygoids assist in closing and also in protrusive movements.

THE MASSETER MUSCLE

The masseter muscle is composed of a superficial and a deep portion. Each portion has a separate origin and insertion, and since these vary in position, the direction of the fibres of the two layers vary somewhat, and the action of each portion is slightly different.

The superficial layer arises by a tendinous attachment from the malar process of the superior maxilla and from the anterior two-thirds of the lower border of the zygomatic arch. The fibres pass downward and backward and are inserted into the angle and lower half of the outer surface of the ramus. Its action is to draw the mandible upward and forward.

The deep portion of the masseter arises from the inner surface of the zygomatic arch and from the lower border of the posterior third of the zygoma. It is inserted in the upper half of the outer surface of the ramus. Its fibres run perpendicularly downward and its action is to draw the mandible upward.

THE TEMPORAL MUSCLE

The temporal muscle arises from the temporal ridge on the temporal bone, from the under surface of the temporal fascia, and from the temporal fossa. It is inserted in and around the coronoid process of the ramus, some of its fibres passing down the anterior margin of the latter as far as the third molar. In general outline it is fan-shaped, its origin representing a sweeping curve, its fibres converging to their point of insertion in the coronoid process. Its action is to close the jaw and to draw the condyle backward in its fossa when protruded, as in unilateral or bilateral position.

THE EXTERNAL PTERYGOID MUSCLE

The external pterygoid muscle has two origins and two insertions. The upper head arises from the pterygoid ridge

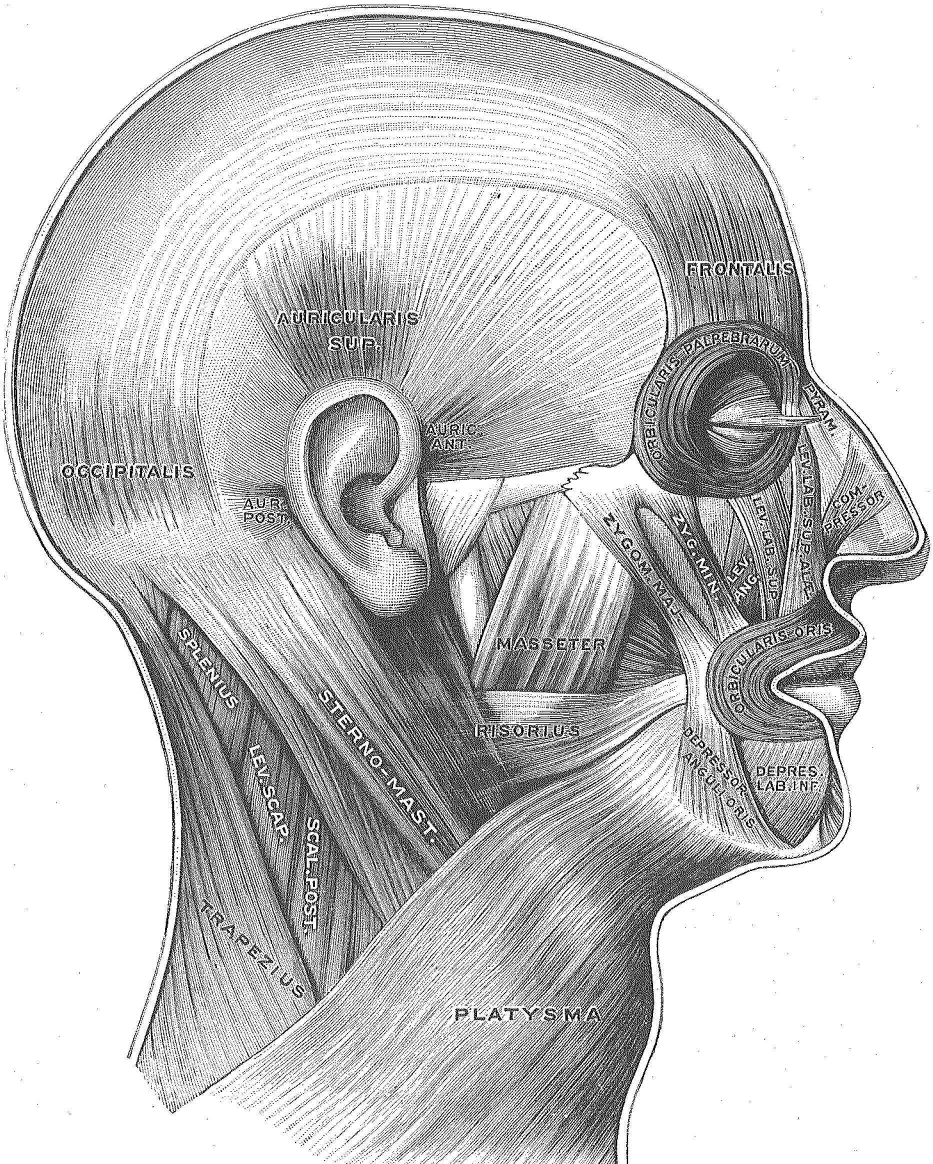


Fig. 148.—A Cut Showing the Direction of Fibres of Various Superficial Muscles Concerned in Facial Expression (Eckley's Regional Anatomy)

of the outer and under surface of the greater ala of the sphenoid bone. Its insertion is in the anterior margin of the interarticular fibro-cartilage, which covers the articular surface of the condyle. Its function is to draw the cartilage forward in the protrusive movements of the mandible, thus furnishing a concave cap for the condyle to rest in as it is carried forward onto the eminential articularis.

Eckley attributes the cracking noise frequently noticed in the tempero-mandibular joint to partial or complete paralysis of this portion of the pterygoid, which results in failure of the muscle to draw the cartilage forward in unison with the condyle and permits the latter, in its forward excursions, to override the anterior rim of the cartilage.

The lower head of the external pterygoid muscle has its origin in the outer surface of the external pterygoid plate of the sphenoid bone. It is inserted in the anterior surface of the neck of the condyle.

The function of the muscle is extremely important. By its action principally, the mandible is given a lateral movement and with its mate on the opposite side protrusion is accomplished. These muscles are not large as compared with the temporals and masseters, nor do they develop very great power, since that is unnecessary.

The crushing of food is accomplished by the masseter, temporal and internal pterygoid muscles in drawing the mandible back to normal position, after having been carried laterally or forward by the external pterygoids.

The combined action of the upper and lower portions of the external pterygoid muscle is to draw the condyle and its interarticular fibro-cartilage forward simultaneously.

THE INTERNAL PTERYGOID MUSCLE

The internal pterygoid has its origin on the inner surface of the external pterygoid plate, from the tuberosity of the palate bone. It passes downward and backward and is inserted in the inner surface of the mandible from the mylohyoid ridge and the inferior dental canal downward to the angle of the ramus. Its action is to assist in closing the jaw and bringing it back to normal from lateral position, in the latter function assisting the posterior fibres of the temporal muscle on the opposite side.

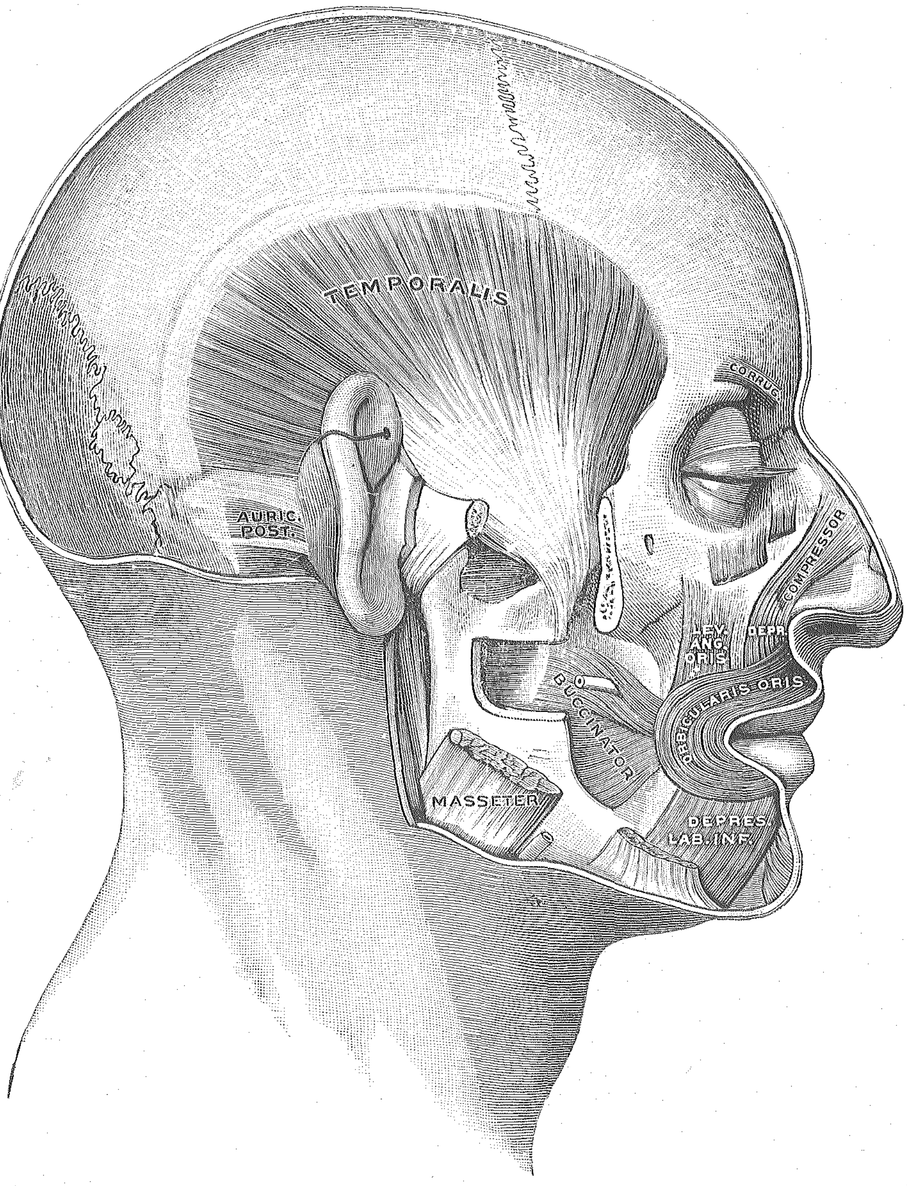


Fig. 149.— The Temporal Muscle, Showing Direction of Its Various Fibres (Eckley's Regional Anatomy)

MUSCLES WHICH DEPRESS THE MANDIBLE

The jaw is opened by the mylohyoid, genio-hyoid, genio-hyo-glossus, digastric muscles and gravity. In fact, most of the supra and infra hyoid muscles take part in the depression of the mandible. The hyoid bone acts as a movable fulcrum when the jaw is opened widely. The supra hyoid muscles contract and tend to lift the hyoid bone upward and draw the

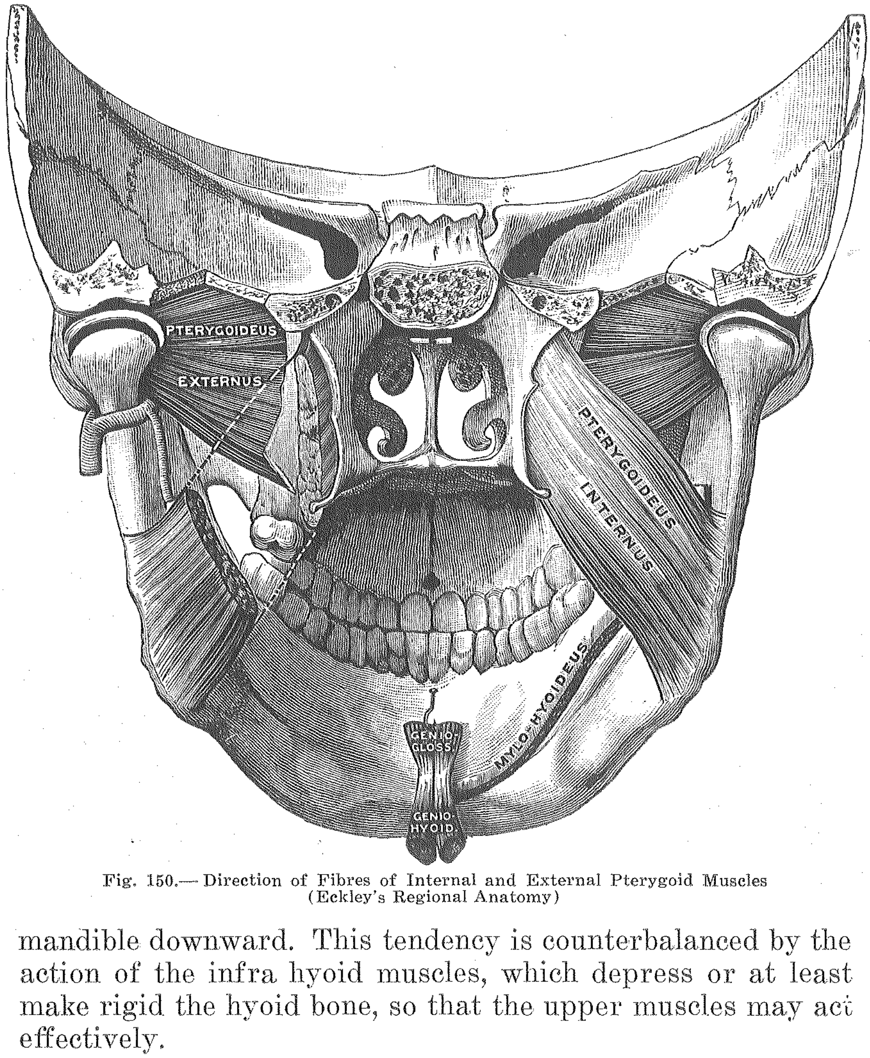


Fig. 150.—Direction of Fibres of Internal and External Pterygoid Muscles (Eckley's Regional Anatomy)

mandible downward. This tendency is counterbalanced by the action of the infra hyoid muscles, which depress or at least make rigid the hyoid bone, so that the upper muscles may act effectively.

Depression of the mandible, which is equivalent to opening the mouth, results in the drawing forward of the condyles in their paths, as well as in a greater or less rotary movement of their articular surfaces.

In other words, the centers of rotation in the hinge action do not lie in the transverse centers of the condyles, but are situated about three-fourths of an inch below and slightly back of the distal margins of the rami. Even this location is variable in the same individual under different conditions, depending on the distance the mandible is depressed, and also whether it has been subjected to protrusive as well as opening movements.

This is explained by Gysi as follows:

"If a man were suspended in the air by ropes attached to each of his hands he could be pulled hither and thither by tugging at either rope. His body would describe certain motions accordingly as force was applied to one rope or another. If an architect were to chart the motions described by the man's body, he would find them to be sections of curves, with centers at the points where the opposing curves met, not at the points to which the ropes were attached to the wrists. When he found these points, he would probably call them 'centers of motion.'

"That illustration of the man suspended by ropes attached to each wrist is not much unlike the suspension of the jaw by ligaments attached to the heads and necks of the condyles. The articulation of the condyles with their fossæ is very loose; a sort of hanging attachment. The jaw may be pulled in any direction by tension of the proper muscles, and when it moves it swings just as the man's body did, *not with its center at the condyles, but at the points where opposing pulls meet and balance each other.*"

Bowditch and Luce, in 1899, and Walker in 1894, first called attention to the fact that the head of the condyle moved forward, and the angle of the ramus moved backward, in wide open movements. Others have since verified the accuracy of these first experiments. No special value attaches to the registration of wide open jaw movements, since they have no bearing on occlusion. Any movement of the mandible, however, which can be registered, increases the sum total of knowledge of the human dental mechanism and aids in solving this most intricate problem.

Muscles Which Control the Position of Food

This group includes the lips, cheeks, palatal and tongue muscles, which when co-ordinating, control the position of food and tend to keep it within the working limits of the teeth.

Specifically, the buccinators on the sides and the orbicularis oris in front, confine the food to a great extent and prevent it from being forced outward into the vestibule during masticatory effort. Within the oral cavity proper the tongue moves the bolus of food outwardly and as the mandible is depressed, moved laterally, elevated and the teeth brought together, the lingual marginal ridges shear off a portion, which is caught, confined, and reduced in the masticatory groove between the teeth as the mandible is returned to normal from the unilateral position.

SUMMARY OF MUSCULAR ACTION ON THE MANDIBLE

Depression, or opening of mouth	Mylo-hyoid Genio-hyoid Genio-hyo glossus Infra-hyoid muscles Digastric Gravity
Elevation, or closure of mouth	Temporals Masseters Internal pterygoids
Protrusion, bilateral	External pterygoids Internal pterygoids Masseters — superficial fibres
Protrusion, unilateral	External pterygoid } On protruding side Internal pterygoid } Masseter — superficial fibres
Retrusion, bilateral	Temporals — posterior fibres Masseters — deep fibres
Retrusion, unilateral	Temporal — posterior fibres Masseters — deep fibres Internal pterygoid on opposite side.

THE MANDIBULAR LIGAMENTS

In addition to the muscles actuating the mandible, some of which in a state of rest tend to hold the condyles in their fossæ, there are three pairs of ligaments, which limit its range of movement and yet permit a variety of excursions to be carried out with freedom. These ligaments are as follows:

The *capsular ligament,* divided into four parts — an anterior, posterior, external and internal segment.

The spheno-mandibular, or long internal lateral ligament.

The stylo-mandibular ligament.

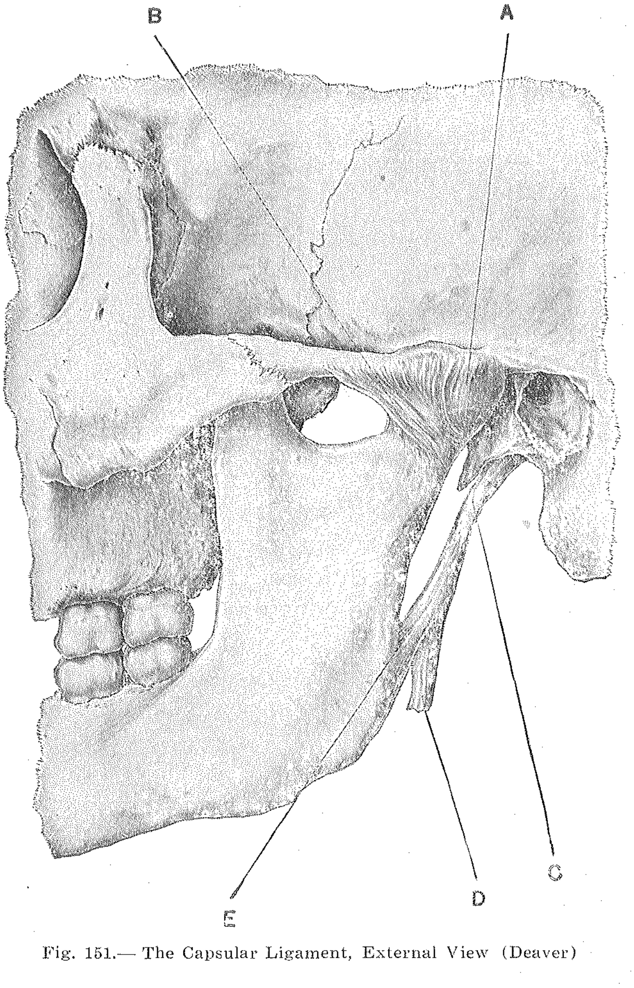


Fig. 151.— The Capsular Ligament, External View (Deaver)

THE CAPSULAR LIGAMENT

The anterior and posterior portions of the capsular ligament are composed of thin layers of loose, flabby fibres. Anteriorly, these fibres are inserted into the anterior margin of the interarticular fibro-cartilage, from which they extend upward and downward. The upper fibres are attached to the front of the eminentia articularis, the lower fibres to the anterior margin of the condyle.

The posterior fibres are attached to the margin of the glenoid fissure and from there extend to and are inserted in the posterior surface of the ramus below the neck of the condyle.

Since the condyle movements to a great extent are forward, it can readily be seen that the anterior and posterior fibres of this ligament must be loose to give freedom of action to the mandible.

THE EXTERNAL LATERAL LIGAMENT

The external lateral ligament forms the outer portion of the capsular ligament, its fibres blending with the anterior and posterior portions of the latter. This ligament is the strongest part of the capsule. It has a broad attachment above to the zygoma and is inserted in the outer surface of the condyle neck.

THE INTERNAL LATERAL LIGAMENT

The short internal lateral ligament completes the capsule. Its fibres are attached above to the inner margin of the glenoid fossa and to the spine of the sphenoid bone. It is inserted in the inner side of the condyle neck.

The four portions of the capsular ligament, by the blending of their fibres, encapsule the joint. Within this capsule is enclosed the interarticular fibro-cartilage, the capsular fibres being more or less closely attached to the cartilage around its periphery.

THE SPHENO-MANDIBULAR LIGAMENT

This ligament is also called the *long internal lateral* ligament to distinguish it from the short internal lateral ligament which forms a part of the capsule.

It is attached to the spine of the sphenoid bone, from which it extends downward and is inserted in the mandibular spine and a portion of the area immediately surrounding the posterior dental foramen.

THE STYLO-MANDIBULAR LIGAMENT

The stylo-mandibular ligament is attached to the styloid process of the temporal bone, its fibres passing downward to find insertion in the posterior border and angle of the ramus, between the masseter externally and the internal pterygoid internally.

These several ligaments being practically devoid of elasticity, resemble so many cables by which the mandible is suspended from the base of the cranium. They limit the action of the various muscles concerned in protrusion, lateral and

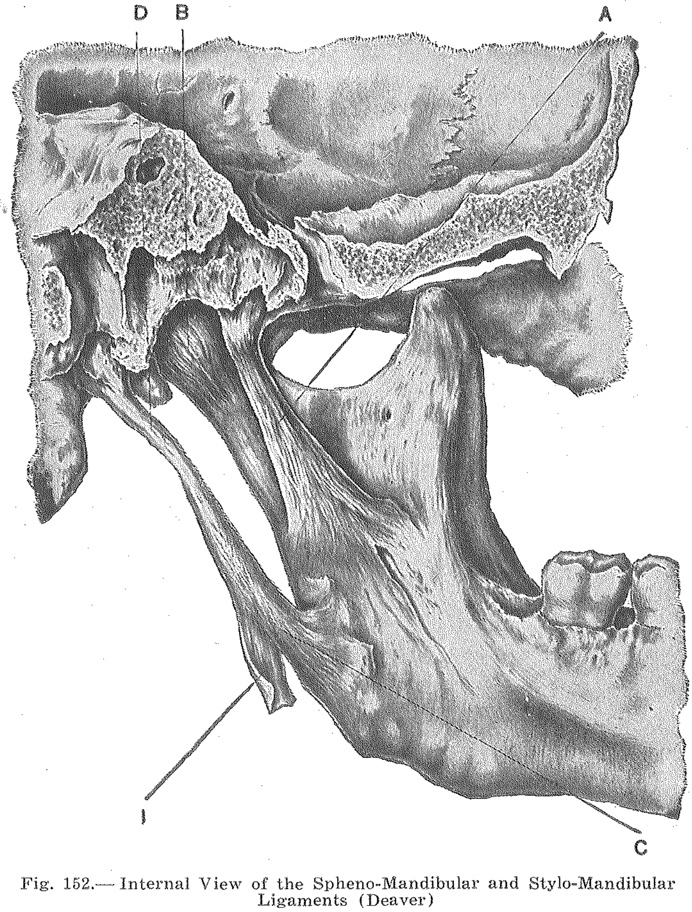


Fig. 152.— Internal View of the Spheno-Mandibular and Stylo-Mandibular Ligaments (Deaver)

wide-open movements. Without their restricting influence, the possibilities of useless mandibular movements can scarcely be conceived.

Usually in dislocations of the mandible, the posterior fibres of the capsular ligament are broken by the excessive strain to which they are subjected, and as they seldom if ever again unite, recurrent dislocations in the same subject are frequent.

The Teeth

The normal adult denture consists of thirty-two teeth, sixteen in the upper and a like number in the lower jaw, the formula of which is as follows:

M.	B.	C.	I.	I.	C.	B.	M.
3	2	1	2	2	1	2	3
3	2	1	2	2	1	2	3

FRICTIONAL OR WORKING SURFACES OF THE TEETH

Those surfaces of the bicuspids and molars in one arch presenting toward those in the opposite arch are known as *occlusal* surfaces, from *occlude,* which means to *shut* or *close* together.

Those surfaces or edges of the incisors and cuspids in one arch presenting toward those in the opposite arch are called *incisal* surfaces or edges, from *incise,* which means to *cut.*

Each cuspid tooth terminates in a point or cusp, with incisal edges, sloping away from it mesially and distally to the mesio and disto-incisal angles of the tooth.

OCCLUSAL SURFACE MARKINGS

The occlusal surfaces of the bicuspids and molars are made up of cusps, inclined planes, grooves, pits and ridges, displayed with more or less definite regularity.

THE CENTRAL SULCUS OR MESIO-DISTAL GROOVE OF THE BICUSPID AND MOLAR TEETH

Traversing the occlusal surface of each bicuspid and molar tooth, mesio-distally, is a general depression, or sulcus, formed by the planes, which slope lingually from the buccal, and buccally from the lingual, marginal ridges.

These planes meet at varying angles near the center of the tooth, to form definite grooves. The grooves, which cross the mesial and distal marginal ridges, are accordingly named mesial and distal marginal grooves, and that which divides the central portion of the tooth is called the central groove.

In normal occlusion these general depressions or sulci in the upper teeth receive the buccal cusps and marginal ridges of the lower teeth, while the central sulci of the lower teeth receive the lingual cusps and marginal ridges of the upper teeth.

THE BUCCO-LINGUAL GROOVES

In addition to the central grooves mentioned, the various cusps, and planes sloping away from them mesially and distally, result in the formation of other grooves, which traverse the occlusal surfaces of the teeth from buccal to lingual.

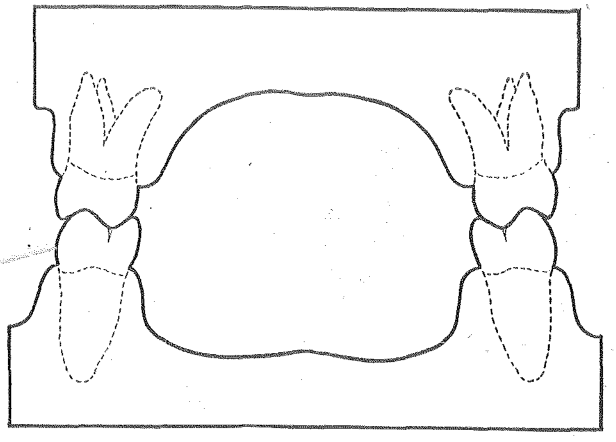


Fig. 153.— Diagram Showing the Relation of Lower to Upper Molars When Occluded

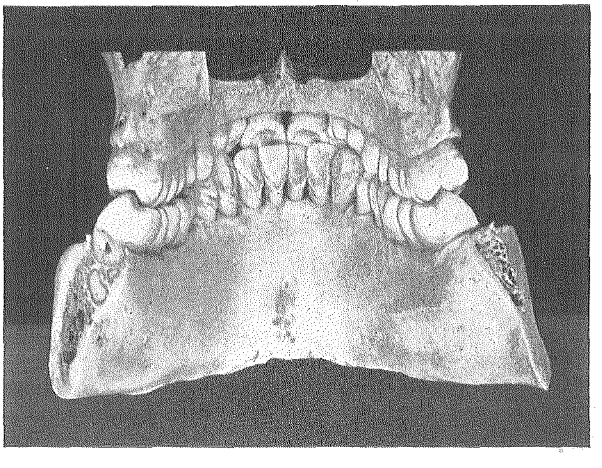


Fig. 154.— Section of Mandible and Maxilla, Showing Upper and Lower Teeth in Occlusion, Distal View

These grooves run nearly at right angles to the mesio-distal grooves, the buccal being slightly in advance of the lingual end.

Each pair of cusps, as, for instance, the mesio-buccal and mesio-lingual cusps of the upper first molar, are situated approximately the same distance from the mandibular rotation center of that side of the arch. The planes, sloping away from these cusps mesially and distally until they meet in the central groove, and finally merging with those from the adjacent pairs of cusps, enter into the formation of grooves, which represent arcs of circles, also developed from the same rotation centers. This arc-like or geometrical bucco-lingual arrangement of cusps, ridges and grooves of the upper teeth permits the cusps and sloping planes of the occluding lower teeth, which bear a similar relation to the rotation center, to

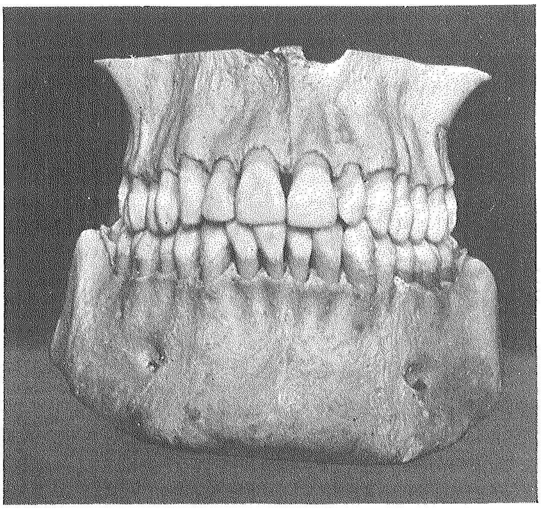


Fig. 155.— Anterior View of Upper and Lower Teeth in Occlusion

be moved freely back and forth, in the lateral swing of the mandible, without cusp interference.

THE MASTICATORY OR RECTANGULAR GROOVE

When the mandible is rotated laterally, so as to bring the buccal cusps and marginal ridges of the lower teeth on the pivotal side outward from the central sulci of the upper teeth, and directly under the corresponding cusps and marginal ridges of the latter, a fairly close and unbroken line of contact between these wedge-like ridges is effected.

At the same time the lingual cusps and marginal ridges of both lower and upper teeth on the same side are brought into similarly close contact. A rectangular space is thus formed, bounded above and below by the occlusal surfaces of the upper and lower teeth, and laterally by their buccal and lingual marginal ridges. This groove extends from the first bicuspid to the third molar, inclusive, when present, and forms the receptacle in which food is held and crushed as the mandible is drawn back to normal position. The form and proportions of this masticatory groove is of the greatest importance. The efficiency of the masticatory apparatus is largely dependent on the width of this space bucco lingually; the wider it is, within normal limits, the greater the radial swing possible for the mandible and the more efficient its effort in the reduction of food.

The definiteness of the angles of the marginal ridges which are formed by the junction of the buccal and lingual surfaces of the teeth with the various planes sloping to the central grooves is also important. These angles should not be too sharp, as the tongue and cheek muscles are liable to be caught between them and injured in masticatory effort.

The closeness of apposition of the various occlusal planes and marginal ridges of the lower to those of the upper teeth, not only in occlusion, but in radial movements of the mandible as well, increases efficiency in both natural and artificial dentures. When loosely approximated, or possibly when only a few cusps or surfaces are in actual contact, the food is merely punctured, and the fibers are not torn asunder, as is the case when many planes and cusps find contact with those of the opposite teeth.

Arrangement of the Teeth in the Dental Arches

OCCLUSAL VIEW

Viewed occlusally, the arrangement of the teeth in each dental arch presents the general appearance of a parabolic curve, or in some cases that of a half ellipse, the central incisors being at the outer extremity of the major half axis. The size and outline form of the curve varies in different individuals, according to structural build.

Since normally, the upper overlap the lower teeth to a greater or less extent, the curve of the upper arch is slightly larger than that of the lower arch.

THE ANTERIOR CURVATURE, INCISAL VIEW

The four incisors at their cutting edges usually present a symmetrically curved arrangement. The laterals may be slightly in or out of a true curved alignment, or, when a trifle rotated, as is frequently the case, their mesio-linguo-incisal angles may overlap the disto-labial surfaces of the central incisors. The variations noted, when not too pronounced, are pleasing rather than otherwise, and give character and individuality to the denture.

The cutting edges of the cuspids usually are in symmetrical labial alignment with the incisors. On account of the

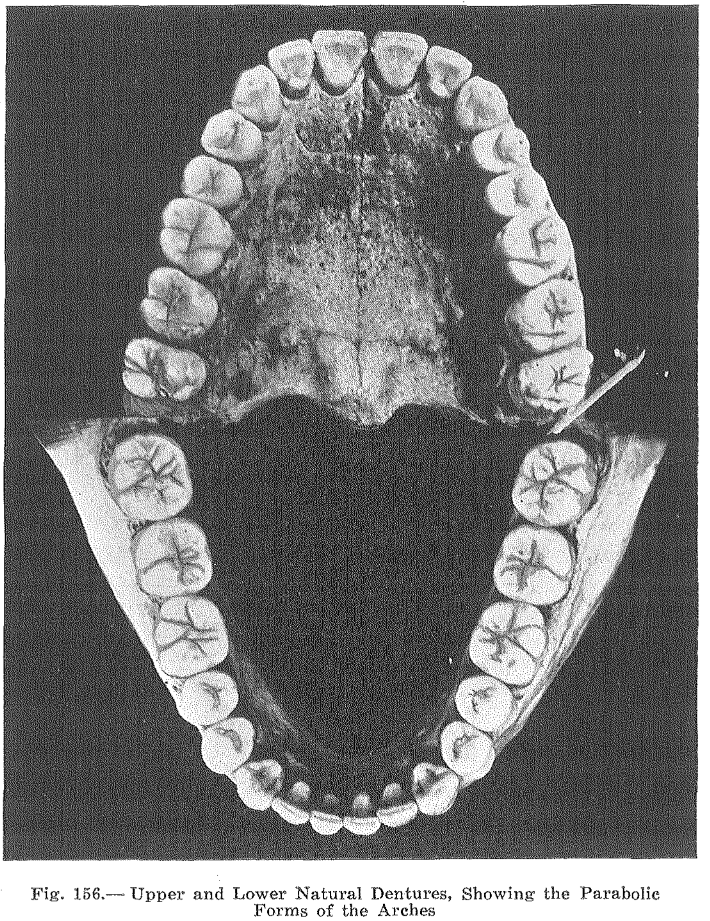


Fig. 156.— Upper and Lower Natural Dentures, Showing the Parabolic Forms of the Arches

greater convexity of the labial face of the cuspids, as compared with the incisors, these surfaces stand out more or less prominently beyond the labial surfaces of the latter, especially at their cervices.

The cuspids are the *corners* of the dental arches, the labial curvature of the incisors merging here with the straighter alignment of the posterior teeth. The general form, size and position of the cuspids, therefore, give them greater prominence than any of the anterior teeth.

ALIGNMENT OF THE POSTERIOR TEETH

From the cuspids, to and including the first molars, the teeth are arranged in practically straight lines, which in passing backward diverge. If projected, these lines would usually fall within and below the inner ends of the condyles.

The second and third molars frequently curve inward somewhat to the lingual of these lines, an arrangement which gives the general arch its parabolic or elliptical form. This inward curvature of the second and third molars is necessary to avoid contact of thin buccal surfaces with the coronoid processes of the mandible in its lateral and wide-open movements.

When viewed anteriorly, less than one-fourth of the first bicuspids, taking their bucco-lingual diameters as a basis, are visible back of the cuspids. The second bicuspids exhibit about the same amount of surface as do the first bicuspids. This *retiring* position of the bicuspids adds very much to the esthetic appearance of the denture, particularly in the upper arch.

Buccal View of the Upper Dental Arch

THE PLANE OF OCCLUSION

In normal occlusion the line of contact of the lower with the upper bicuspids and molars is called the *plane of occlusion,* for here their occlusal surfaces meet in normal closure as well as in lateral movements of the mandible.

The general direction and position of the plane of occlusion is approximately parallel with, and about an inch below, a straight line extending from the base of the nose to the center of the condyle.

CURVATURE OF THE OCCLUSAL PLANE

In reality, however, the occlusal plane usually departs from a straight line, the second bicuspid, first, second and third molars curving upward toward the glenoid fossa, in most cases, in a fairly well-defined arc, the convexity presenting downward.

The amount of curvature of the occlusal plane varies in different individuals, and frequently there is a noticeable difference in the planes on the two sides of the arch in the same subject.

The curvature varies from a well-defined arc in most cases to a nearly or quite flat plane in a few instances. A few cases have come under the notice of the writer where the curvature of the occlusal planes was reversed. In other words, instead of the convexity presenting downward, the occlusal plane was concaved upward. Such cases are rare, however, and, within

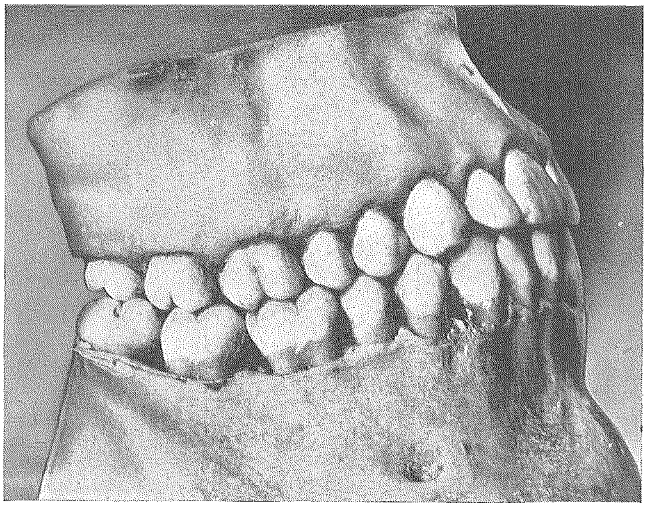


Fig. 157.— Buccal View of the Natural Dentures in Occlusion

the writer's observation, only occur when the occlusion is abnormal, the teeth in the lower protruding beyond those in the upper arch..

Relationship of the Planes of Occlusion to the Condyle Paths

The planes of occlusion and the condyle paths bear a definite relationship to each other, as the following problems will demonstrate:

First. On a photograph of a skull in which the teeth are normally occluded, strike an arc intersecting the tips of the buccal cusps of the bicuspids and molars. The center from which this arc is developed must be located by trial. This can easily be done when the curvature is pronounced, as the center will lie in the region of the frontal prominences. It will be more difficult to locate the center in those cases where the occlusal planes are nearly or quite flat, because its position will be higher up, beyond the range of the ordinary dividers.

Second. Place one leg of the divider on the center from which the occlusal arc was developed; set the other leg on the margin of the middle half of the condyle path, and strike an arc in this location. It will be found that the arc last developed will coincide with the condyle path along its *working area,* and, furthermore, that it will be parallel with the occlusal arc, since both are developed from the same center. These arcs may coincide, or, as is more commonly the case, be concentric, the condyle arc lying above and within the one intersecting the tips of the teeth.

Governing Factors in Mandibular Movements

The mandibular movements which are of the greatest importance to the prosthetist are those which bring the lower in contact with the upper teeth in some of their varied lateral and protrusive excursions.

Any movement which, even to a slight degree, causes separation of the entire lower from the upper denture can have no bearing on occlusal conditions, and therefore need not here be considered. The excursions of the condyles in their paths in wide-open movements, however, are of importance in certain technical procedures, which will later be mentioned.

There are three definite and comparatively fixed factors which guide the mandible in its protrusive movements. These are the *incisor path* and the two *condyle paths.*

THE INCISOR PATH

Protrusion of the mandible carries the incisal edges of the lower anterior teeth forward and downward against the lingual surfaces of the corresponding upper teeth. If projected sufficiently far forward their incisal edges will occlude with those of the upper teeth in an end-to-end relation. The distance traversed by the incisal edges of the lower teeth from the position of rest, or normal occlusion, to that of edge-to-edge contact or incision is known as the *incisor path.* It is obvious that this path controls the movements of the mandible anteriorly, since, with the exception of the last molars in occlusion, the remaining bicuspids and molars in one arch are not usually in contact with those in the opposite arch in protrusive effort.

THE CONDYLE MOVEMENT IN PROTRUSION

As the mandible is drawn forward in protrusion, the condyles, being held in close contact with their paths by the various mandibular muscles and ligaments, must follow closely the direction of the condyle tracts, whatever may be their form or pitch. It naturally follows that these tracts determine the movements of the mandible posteriorly.

These three guiding factors in protrusive effort, the *incisor path* and the *two condyle paths,* are located one at each angle of the equilateral triangle, to which attention has previously been directed.

THE FUNCTION OF THE INCISOR TEETH IN PROTRUSIVE EFFORT

Prehension, or the seizing hold of food by the teeth, is the first act in masticatory effort.

Incision, or the cutting off of a portion of suitable size for reduction by the bicuspids and molars, is the second act.

These functions are performed by depressing, protruding and raising the mandible while protruded, so as to bring the anterior teeth together in edge-to-edge contact, with final return of the mandible to normal position and the teeth to normal occlusion. The final act of retrusion, as outlined, shears off those portions of the morsel of food not completely severed by direct incisive effort. Only the anterior teeth are concerned in the actual work accomplished.

Since, then, the *focus of useful effort* is confined solely to the incisors and cuspids, there is no necessity for the bicuspids and molars of the lower coming in contact with those in the upper arch in the incisive act, except at the extreme distal portion of the arches. Here the last lower molars, which normally occlude (the second molars, usually when the third molars are not fully erupted or are missing), move forward in sliding contact with those in the upper arch. Contact of the molars in this region does not increase the *field of effort* or working area, since no food is being reduced here. It serves the purpose, however, of steadying or balancing the denture, and further of distributing or equalizing the force of closure, thus avoiding the undue stress that would be exerted on the central portion of each lateral half of the mandible if the incisor teeth and condyle, without such central bearing points, were required to sustain all of the force of masticatory incisive effort.

LATERAL MOVEMENTS OF THE MANDIBLE

In actual masticatory effort the lateral mandibular movements are the most important and effective of any of those mentioned. By such movements the food is crushed, torn asunder, finely triturated and insalivated as it cannot be in any other manner or by any other action. Food subjected to the hinge action is merely punctured, or at most slightly crushed. It cannot be torn and shredded as when caught between sliding contact surfaces, any more than can wheat be reduced to flour by the lifting and dropping of the upper upon the lower millstone. Flour is produced by the grains of wheat being caught and broken up from contact with many sliding surfaces. So food, when caught and confined in the masticatory groove, is torn asunder by being brought in contact with the many sliding planes of the opposing teeth.

To produce artificial dentures that will fulfill the functions of the natural masticatory organs it will be necessary to study the radial swing of the mandible and the relation of the teeth in the lower to those in the upper arch when subjected to such action.

Analysis of the Lateral Mandibular Movements

In the lateral movements one condyle is drawn forward, or protruded in its path, while the other remains comparatively stationary, serving, in a general way, as a pivotal or rotation center to guide the mandible in its radial movements.

THE CENTERS OF MANDIBULAR ROTATION

The centers of the condyles may be, and frequently are, the true centers of mandibular rotation. Oftentimes, however, the rotation centers are situated inside or outside of the condyle centers at varying distances. Both actual rotation centers may be inside, or both outside, of the condyles, or one may be inside and the other outside, or, again, one may be located in the true condyle center and the other outside or inside of the opposite condyle. To determine their exact location special appliances designed for such purposes must be used, the most accurate as well as convenient of which are those suggested by Dr. Gysi.

When the rotation centers are located between the condyles the pivotal condyle has a slight backward movement as the other one is protruded. When the rotation centers are located outside the pivotal condyle moves slightly forward.

Gysi's appliances indicate that the true rotation centers may lie within two and three-fourths inches of each other,

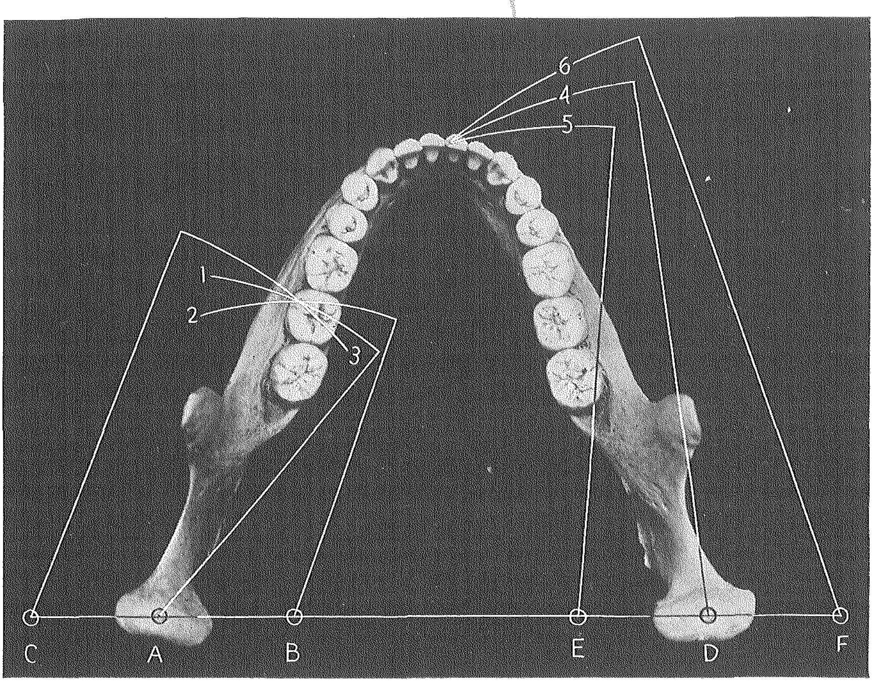


Fig. 158.— Diagram Showing Direction of Movement of Teeth from Various Rotation Centers, A, B, C — D, E, F

and vary from that distance anywhere up to a trifle over five inches apart.

The position of the teeth in the arches and of their various occlusal surface markings in relation to the rotation centers are of extreme importance. When the teeth are incorrectly located co-ordinate movements between those in the lower against those in the upper arch will be inhibited.

RELATION OF THE LOWER TO THE UPPER TEETH ON THE PIVOTAL SIDE

The working limit of the mandible in lateral masticatory effort is reached when the buccal and lingual cusps and marginal ridges of the lower bicuspids and molars, on the pivotal side, are directly under and in contact with the corresponding cusps and marginal ridges of the upper teeth.

The amount of side movement necessary to bring the teeth in this relation to form the masticatory space was designated the "differential limit" by the late Dr. T. W. Pritchett. Used in this sense, it means the limit of side movement of the teeth for doing effective work, and is a very appropriate term. "Differential" means a difference in rate or distances of movement of the parts of a mechanism in a given period. In true rotary movements of the mandible laterally the bicuspids travel a greater distance in the same period than do the molar teeth, since the former are situated farther from the rotation center.

SIDE MOVEMENTS OF THE MANDIBLE NOT CONTROLLED BY THE ROTATING CENTERS

In reality the rotation centers do not absolutely confine the mandible to an exact radial swing at all times or under all circumstances. Dr. Bennett of London has shown that there is frequently a side movement of the entire mandible independent of the ordinary rotation points.

In some experiments carried out by the writer this side movement was found to be involuntary, or automatic, in some, and entirely volitional in other cases. In most instances it is so slight as to be of little importance in general masticatory effort, and need not be considered in denture construction as a separate or vital factor.

A method of adapting artificial dentures to this side movement, when present and involuntary, will later on be described.

RELATION OF THE LOWER TO THE UPPER TEETH ON THE PROTRUDED SIDE

The lateral movement of the mandible carries the lower teeth on the protruded side lingually. During this movement the disto-buccal cusp of the lower second molar moves along the inclined planes leading from the central sulcus to the lingual marginal ridge of the upper second molar, and there finds contact with its mesio-lingual cusp. This is known as the *balancing contact,* and this, the protruded side of the mandible, is known as the *balancing side,* in contradistinction to the opposite, or pivotal, side, which is the *masticating* or *working side.*

Balancing contact, as just stated, is usually developed between the lower and upper second molars. Similar contact, however, may be developed between the lower and upper third molars, when fully erupted, although it frequently happens that these teeth, even after a lapse of many years, fail to come into normal occlusion with each other. For this reason, therefore, balancing contact is most commonly developed and remains most persistent between the lower and upper second molars. In radial movements of the mandible no contact exists, nor is any essential to the balancing of the masticatory apparatus, from the second molar forward to the opposite central, or even lateral, incisors. The actual work of mastication is being performed on the opposite of the mouth, and therefore the close interlocking of planes and cusps on the protruded side, exclusive of the balancing point, would tend to disturb, rather than aid, masticatory effort.

THE COMPENSATING CURVE

As previously stated, the tips of the buccal cusps of the bicuspids and molars, when viewed buccally, assume a curved arrangement, the convexity being downward. This curved arrangement of the teeth in the upper arch is called the *compensating curve.* The reason for it being so designated is as follows:

When the occlusal plane is flat, and the condyle path is inclined downward and forward, separation occurs between the lower and upper bicuspids and molars in lateral movement, the lower teeth being carried downward to the lingual and away from the upper teeth on the protruded side. Balancing contact, therefore, is not possible under such conditions, because of inco-ordinate movements the occlusal planes of the upper teeth being practically horizontal while the occlusal planes of the lower teeth are carried downward in an angular direction by the condylar movements. When arranged on a proper curve, however, the disto-buccal cusp of the lower second molar occupies a higher position in the occlusal plane than the mesio-lingual cusp of the upper second molar, which occupies a position forward, downward and to the lingual in the occlusal plane. In lateral movements the disto-buccal cusps of the lower second molar moves downward, forward and lingually, in contact with the plane leading from the central groove to the mesio-lingual cusp of the upper second molar.

This balancing area is present, and the disto-buccal cusp of the lower second molar, under normal conditions, is in contact with it at some point throughout the entire lateral excursion of the condyle, both out of and back to its fossa.

The curved arrangement of the upper teeth, therefore, *compensates* for the dropping down of the condyle in its path in radial and forward movements, and makes possible the

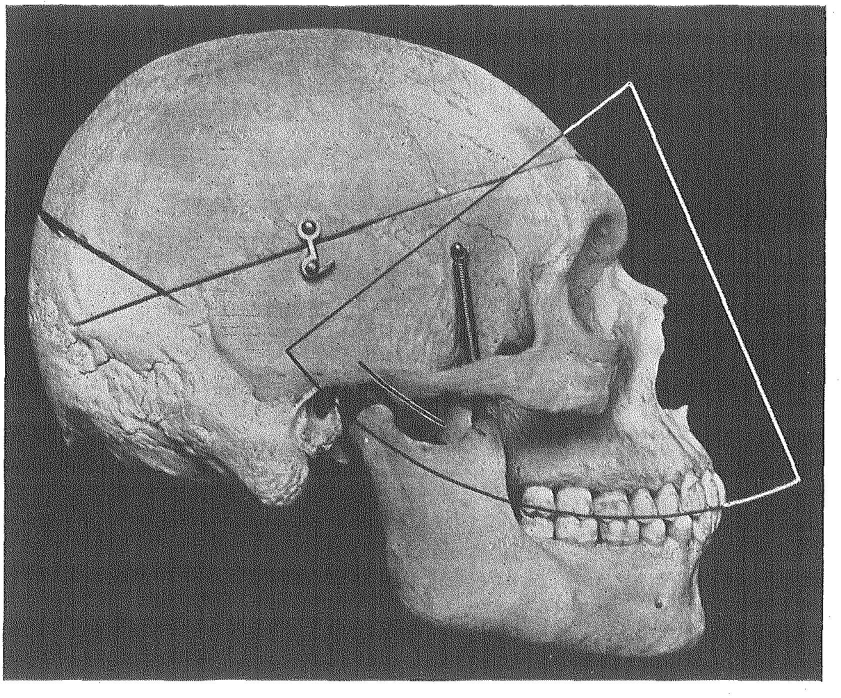


Fig. 159.— Diagram Showing Parallel Relation of Condyle Path and Compensating Curve

contact just described. While the compensating curve represents a fairly accurate arc where it intersects the tips of the buccal cusps of the bicuspids and molars, when projected forward, it passes above the incisal edges of the anterior teeth sometimes as high as the incisal third of the central incisors. This is due to the overlapping of the upper anterior over the lower teeth, there being a more or less definite correlation existing between the curvature of the teeth plane and the overbite. Variations as to the amount of overbite naturally occur, one of the most common being a deep overbite, with a comparatively shallow or flat compensating curve. In such cases some space must be present, when the teeth are in occlusion, between the lingual surfaces of the upper and the incisal edges of the lower teeth, otherwise interference will occur with normal lateral and protrusive movements.

THE CURVE OF SPEE

The lower teeth, including the incisors and cuspids, usually present a very-well-defined arc-like arrangement when viewed buccally. This curved plane assumed by the lower teeth is sometimes called the "Curve of Spee," because Graf von Spee, the German anatomist, first called attention to it, about 1890.

Spee says, in regard to the relation existing between the condyle paths and the teeth planes: "In the forward bite the teeth and condyles describe the same circular movement. The steeper the path of the condyle the more pronounced the tooth curve will be, because both will have the same radius."

This latter statement is incorrect, for, while the condyle path and the teeth plane may both be arcs of circles having a common center, their radii may vary, and the two curves will often represent concentric arcs.

Spee's writings refer especially to the curvature of the lower teeth plane and its relation to the condylar movements, and therefore the term, "Curve of Spee," should not be applied to the upper teeth plane.

MODIFICATION OF THE COMPENSATING CURVE

Occasionally the occlusal surfaces of the upper molars present a series of parallel planes, instead of assuming a symmetrical curve, as described. The second molar is slightly higher than the first, and the third slightly higher than the second. The lower molars assume a similar relation, with the result that the occlusal plane when analyzed presents a step-like instead of a curved arrangement.

It is claimed by some that this is the logical manner in which to arrange teeth in the construction of artificial dentures. First, because balancing contact can be more easily secured; second, that there is less liability of the dentures becoming dislodged in masticatory effort. The argument is that the force of muscular effort is delivered upon the food more in the nature of an end thrust against right-angle surfaces, rather than against inclined planes; third, that such an arrangement of the teeth is anatomical, natural and more common than the curved arrangement.

It is the opinion of the writer, based upon the examination of many specimens, first, that the step-like arrangement is the exception, and not the rule, or at least occurs no more frequently than the curved arrangement; second, that balancing contact can as readily be secured by placing the second molars in a relation similar to that which they sustain in the natural denture, when the curvature is well defined, as previously outlined; third, that the varying planes on the occlusal surfaces of the intercuspating molars tend to prevent displacement of the dentures in masticatory effort; fourth, that better esthetic results can be secured by arranging the teeth by the curved rather than by the stepping method. However, either method is productive of satisfactory results if due attention is given to details, so it is largely a question of esthetics, in which neither comfort nor utility is concerned.

CHAPTER XVIII

CONSTRUCTION OF FULL DENTURES

Anatomic Method

GENERAL FEATURES

In the construction of good dentures, as has been previously stated, the accomplishment of three objects is desirable, necessary, and, in most cases, possible, when careful attention to detail is observed. These three objects — *usefulness, good looks* and *comfort* — when attained in prosthetic, as well as in all dental operations, represent that quality of service which our patients have a right to expect, and which the tenets of our profession impose upon us.

It is therefore the duty of every practitioner to perfect himself in the highest degree, not only in theoretical knowledge, but in the acquirement of technical skill as well in all that pertains to his calling, whether it be the general or a specialized field of dental practice.

Anatomic occlusion of artificial teeth consists in following nature's plan of arrangement as observed in the normal human masticatory apparatus.

Occasions arise, however, when this course is not possible, but such cases are rare. When occurring the causes may be traced to some abnormality of the glenoid fossæ, usually the result of mandibular movements having since early youth been restricted because of malocclusion, or, in some cases, to the sequela of temporo-mandibular inflammation.

Whatever the character of the abnormality an attempt should be made to discern the cause and discover such useful mandibular movements as are possible. With a thorough knowledge of existing conditions and the application of anatomic methods far better service can be rendered a patient than when such abnormality is ignored.

By way of introduction to anatomic methods a brief review of masticatory movements in general will be in order.

Masticatory Movements of the Carnivora

The most effective masticatory movements of the carnivora (flesh-eating animals) are hinge-like, no extensive lateral movements of the mandible being possible for two reasons:

First, because of the form of the temporo-mandibular articulation, which does not permit of much unilateral action; and, second, because of the excessive length and relation to each other of the upper and lower canine teeth. In general, the posterior teeth of this class of mammalia have strongly marked cusps which intercuspate closely. Their function is to tear and cut food.

Masticatory Movements of the Herbivora

In the herbivora (animals that live on herbs and vegetation), the effective mandibular movements are almost exclusively lateral, or from side to side. The occlusal surfaces of the teeth are not strongly cusped, but are ridged for grinding food.

Masticatory Movements of the Omnivora

In the omnivora or herbi-carnivora (subsisting on both flesh and vegetation), the effective masticatory movements are hinge-like as well as from side to side, or lateral. The occlusal surfaces of the teeth consist of planes, ridges, grooves and cusps, usually so arranged that in unilateral movements the cusps of the lower may glide between those of the upper teeth in definite paths, without interference.

Since man is omnivorous, the human masticatory apparatus, while modified somewhat from that of the lower animals because of different habits of life, corresponds in general to mammalia of this class. A more complete general description of the human masticatory apparatus will be found in the preceding chapter.

In the chewing of meats, the hinge action of the mandible is most effective at first until the meat fibres have been more or less torn and shredded by the cusps of the bicuspids and molars, after which the lateral movements are just as essention in still further reducing the mass to a pulpy condition suitable for action by the digestive fluids.

Cereals, fibrous vegetables and most all varieties of starchy foods require active lateral movement for proper reduction. Dr. G. V. Black in "Physical Characters of Human Teeth" (Cosmos, 1895), states:

"In the mastication of cereal foods — those made from grain of almost all kinds — the lateral or grinding motions are largely employed. This is true also of all the brittle foods of whatever nature. Indeed, many of these are so difficult to crush by direct pressure that it becomes impracticable. Many kinds of food will simply be packed together between the teeth, and a stress of two or three hundred pounds will be insufficient to crush it out as meats are crushed. Many of the crusts from ordinary baker's bread, when subjected to stress between the molar teeth, will not be cut through with a stress of two hundred and fifty pounds; and they are not very hard crusts, either. They are readily broken up, however, with a much lighter stress combined with a little lateral movement, especially as they become moistened with the secretions. It seems probable, however, that many persons unconsciously exert an enormous force upon such foods as are inclined to pack between the teeth. I am no longer surprised at the frequent breaking of frail teeth on bread crusts *that are not very hard.* It is but little wonder that porcelain facings on crowns and bridges are so often broken."

In carrying out a line of experiments to determine the amount of direct stress required to crush various kinds of food, Dr. Black used an instrument called a phago-dynamometer. The action of this instrument on the food tested was practically identical with that exerted by the natural teeth on food when the hinge-like action of the mandible is employed.

Some years later Dr. Joseph Head carried out a line of experiments to determine the amount of force required to reduce similar classes of food with lateral movements. He used for this purpose a human skull in which the natural teeth were present and occluded well. The following table of comparison shows that it requires only about one-half the effort to reduce food under lateral movements that is required under the hinge action of the mandible:

Meats	Dr. Head's Experiments	Dr. Black's Experiments
Corned Beef	18 -22 lbs.	30 -35 lbs.
Tongue	1 - 2 "	3 - 5 "
Tenderloin of Beef, very tender	8 - 9 "	35 -40 "
Round of Beefsteak, tough	38 -42 "	60 -80 "
Roast Beef	20 -35 "	35 -50 "
Boiled Ham	10 -14 "	40 -60 "
Pork Chop	25 -30 "	20 -25 "
Roast Veal	16 -30 "	35 -40 "
Average	17 -20 "	32¼-41⅞ "

Vegetables	Dr. Head's Experiments		Dr. Black's Experiments		
Raw Cabbage	16	lbs.	40	-60	lbs.
Head Lettuce	16	"	25	-30	"
Radish, whole broke at..........	20 -25	"	20	-25	"
Radish, pieces pulverized at.....	10 -15	"	35	-40	"
Average	12½-16	"	30	-38¾	"

(Dental Cosmos, 1906, P. 1191)

Dentures constructed on a plain line, or similar articulator, or on an anatomical occluding frame, when all of the details are not carefully attended to, limit the wearer to the hinge action of the mandible in the reduction of food.

The advantage of the anatomic system of denture construction over the generally prevailing methods wherein masticatory effort is limited to the hinge action of the mandible, have become an established fact. Dentures of the anatomic type *balance* when in action, while those constructed on plain line articulators become readily unseated when lateral movements are attempted. This fact alone is of sufficient importance to warrant the adoption of anatomic methods, because of greater efficiency, as well as comfort, derived by the patient from the use of dentures of this type.

The normal human denture, and the various relations the lower sustain to the upper teeth in full and partial occlusion, is the ideal working model for the prosthetist, although at times departure from ideal conditions must be made. To carry out the many steps of denture construction by this method a knowledge of the mechanism of the masticatory apparatus is the first essential, while the use of suitable apparatus constitutes a second factor of equal importance.

Main Features of Anatomic Methods

The essential practical features of anatomic denture construction, therefore, aside from a knowledge of mandibular movements, involve the use of special appliances and require that certain steps be carried out in logical sequence. The main factors of importance are as follows:

First — An occluding frame capable of reproducing the most essential masticatory movements of the mandible.

Second — A face bow, or caliper, for mounting the casts on the occluding frame in correct relation to the lateral centers of rotation.

Third — Some means for registering the condyle path pitch of the patient and of recording the same on the occluding frame.

Fourth — The selection of teeth of appropriate size, shade and anatomic forms to meet the requirements of each case.

Fifth — Trial of the *model dentures* in the mouth under masticatory movements to verify their efficiency and esthetic appearance.

Sixth — Testing and correction of occlusion of the finished dentures by means of carbon paper and engine stones, to compensate for variation of the natural lateral mandibular rotation centers from those of the occluding frame on which the teeth were arranged.

Present Methods of Technic in Anatomic Denture Construction

Two general methods of anatomic denture construction are in vogue in this country at the present time, each of which requires special appliances and the following of a rather closely defined system of technic.

The two systems referred to are the Snow methods and appliances, a logical outcome of, with improvements on, the Bonwill and Christensen ideas, and the Gysi methods and appliances, which are based on similar principles but differ in many important details. Both systems in the hands of competent prosthetists lead to the same desired results, viz., the production of high-type dentures, which for efficiency and comfort far surpass those produced by any other system in which lateral mandibular movements are not considered. Both methods involve the carrying out of many steps in common, in some of which the same technic is employed, while in others considerable variation occurs. The essential details of these two systems will now be rendered sufficiently clear, it is hoped, to enable a prosthetist of average skill, who undertakes the work, to secure satisfactory results.

The Snow Appliances and Methods

The appliances used in the Snow method consist of an occluding frame, or as it is termed, an "articulator," the condyle or lateral rotation centers of which are four inches apart, this being about the average distance from center to center of the human condyles. The lateral rotation centers of the frame are fixed at four inches and cannot be increased or diminished. The condyle paths of the frame are capable of adjustment and of being clamped at various angles, depending upon the pitch of the condyle paths of the patient, as registered. The upper and lower bows of the occluding frame, to which, when the casts are attached, represent the maxilla and mandible, respectively, are adjustable for the accommodation of thick or thin casts. The back spring, by its tension, holds the mandibular portion of the frame in the back end of the condyle slots, or in that position representing the condyles at rest in the glenoid fossæ.

THE FACE BOW

The face bow is a measuring device or caliper designed for registering the antero-posterior, as well as horizontal plane relationship of the alveolar ridges to the condyles when the latter are at rest in the glenoid fossæ, as in normal closure. It is used in conjunction with the wax bite, or with occlusion models. This appliance is indispensable in order that the casts may be mounted in true relation to the rotation centers of the frame. By thus establishing the correct radial distance of the casts from the hinges, the teeth, when occluded on the frame and adjusted with clearance paths for the cusps of the lower to traverse laterally between those of the upper teeth, will follow the same lines of travel when the dentures are completed and fitted in the mouth. Increasing or decreasing the radial distance of the teeth on the frame from that which they will occupy in the mouth, will cause cusp interference in lateral movements.

The face bow consists of a U-shaped frame, in the extremities of which are two graduated sliding rods to enable the bow to be evenly balanced on the face. These are the condyle rods, the inner ends of which, in adjustment, are to be placed opposite the outer ends of the condyles and there clamped on points previously marked on the integument before adjusting the bow. The bow in its central portion carries a universal clamp for receiving the bite rod after the latter has been firmly fixed in the occlusion model and for clamping it to the bow when proper adjustment of the condyle rods to the face has been secured.

THE BITE GAUGES

Two small flat plates of metal called *bite gauges,* having the edges turned down to engage with the lower wax rim, and with tapering pins projecting on the upper surfaces to engage with the upper wax rim, are used for taking the protrusive bite — the means by which the condyle paths are registered. The details for the application of these appliances will be given in the following described case of full upper and lower denture construction.

General Constructive Steps

The construction of full dentures anatomically involves the securing of suitable impressions; production of casts; development of wax contour models, first on the casts and afterward in the mouth, to develop lost facial contour and

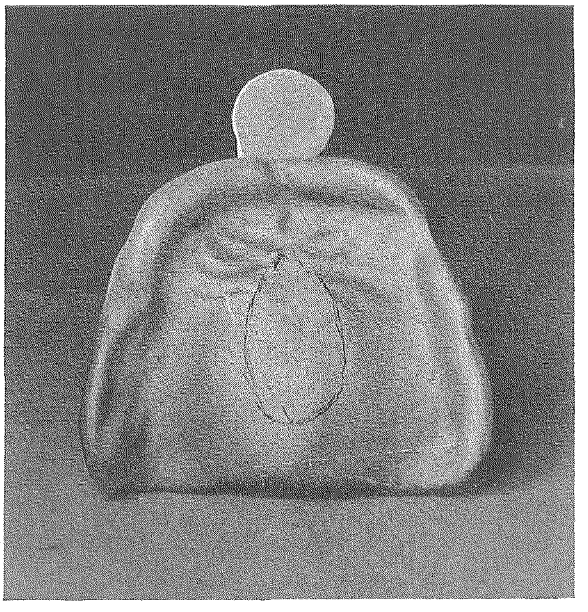


Fig. 160.— Upper Modeling Compound Impression, Showing Outline of Relieved Area

establish the normal bite; the mounting of the casts on an anatomical occluding frame; registration of the condyle paths of the patient and the adjustment of the condyles of the frame to correspond; development of the compensating curve on the wax occlusion model; selection of teeth of suitable form and color to harmonize with anatomic and esthetic requirements of the patient, and their arrangement in upper and lower arches so as to develop the greatest efficiency and present the best appearance; duplication in permanent materials of the wax model dentures, and finally, the fitting and adjustment of the dentures to the respective arches within the oral cavity.

More than one hundred individual steps must be carried out in sequence in the production of full dentures of any type. It is therefore imperative that the greatest care be constantly exercised to arrive at satisfactory results, since a single error in some particular step may minimize the efficiency, or result in the total failure of the substitutes.

The technic of impression taking, cast construction and the formation of base plates of various kinds, has been previously presented. Also a brief description of the oral cavity and the masticatory movements has been given. These various subjects should be thoroughly considered by the student before undertaking the work now to be presented.

Assuming that suitable casts have been derived from accurate impressions of the mouth, the next step in the construction of a full denture (upper and lower) is to form in wax, or some easily workable but comparatively rigid material, models of the dentures to be constructed. These model dentures, before being duplicated in permanent materials, are tried in the mouth and tested as to occlusion, appearance and comfort. Should any modification be required, such changes as are necessary may be accomplished with less effort and loss of time while the dentures are in a plastic condition than subsequently.

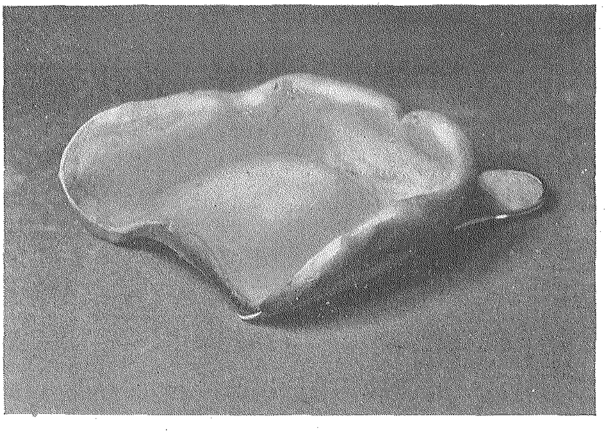


Fig. 161.— Side View of Impression Ready for Forming Cast

The model dentures are developed in two stages: first, base plates are fitted to the casts before the latter are mounted on the occluding frame, and on these, rims of wax are adjusted to represent approximately in depth and contour the lost teeth and absorbed borders. These are ordinarily called *trial base plates*.

Dr. G. H. Wilson suggests the use of the terms *occlusion* and *contour models,* because by means of them occlusal relations are determined, while subsequently by additions to, and trimming of the wax rims, the contour of the face is restored

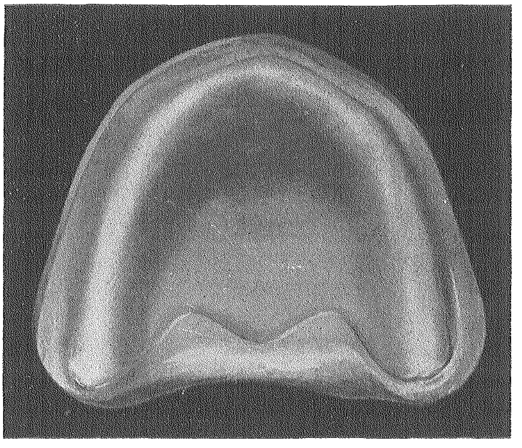


Fig. 162.— Upper Cast with Baseplate Applied and Trimmed to Correct Outline

to normal outline. They also represent, in a crude way, models of the dentures to be constructed.

The second stage is described as follows: After certain sequent steps, to be described later, are carried out, sections

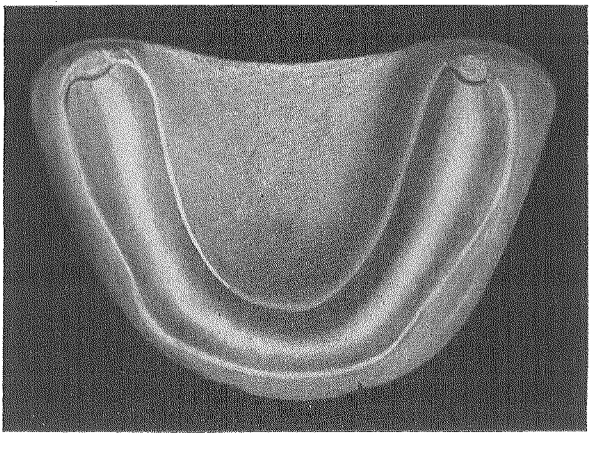


Fig. 163.— Lower Cast with Baseplate Fitted to Border

are cut out of the wax rims, and in the spaces so formed the selected teeth are adjusted, the lower to occlude with the upper. The gums are then carved in the wax and the surplus material removed, which steps convert the wax occlusion and contour models into *wax model dentures,* by which term they will be designated in this description of denture construction. This term is appropriate because they are the models by means of which the matrices are produced in which the permanent dentures are molded.

Occlusion and Contour Models

In the construction of full dentures the upper and lower occlusion models represent two masses of crude material from which the prosthetist carves and shapes in outline and

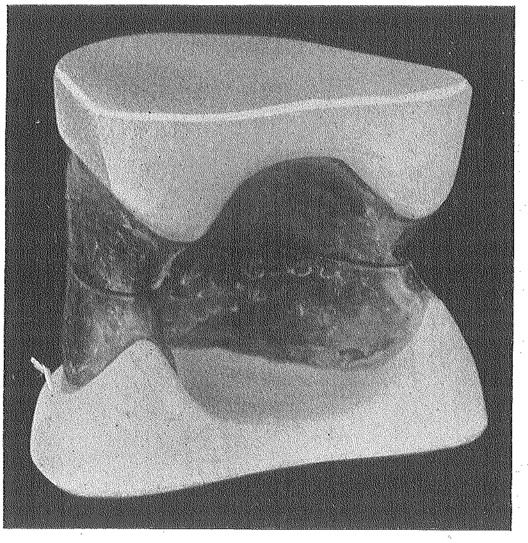


Fig. 164.— Distal View of Upper and Lower Occlusion Models

contour the forms of the permanent dentures, just as a sculptor molds in clay the model of a permanent statue.

An occlusion model is usually developed in two steps and may be composed of different classes of materials.

First, a base plate, either permanent or temporary, is formed over a die or cast, derived from an impression of the mouth.

Second, to the base plate a rim of plastic material, usually wax, is firmly attached and by trial in the mouth is carved and molded to the required contour of the future denture.

Requirements of a Baseplate

The base plate, of whatever class decided upon, should be rigid and unyielding, capable of withstanding oral temperature without softening or bending under masticatory stress. It should be closely adapted to the oral tissues on which it rests and should not become dislodged by its own weight, or tip from the action of adjacent muscles.

The prospect of success of a permanent denture is slight when the base plate of the occlusion model fails to show an equal amount of adhesion required in the finished denture. The most exact technic, therefore, should be carried out in forming the base for an occlusion model, for by this means the adaptation of the permanent denture can be determined at a time when corrections can be made with little loss of time.

When a permanent base plate of swaged gold, platinum or aluminum fails to show good adaptation and adhesive properties in preliminary trials it should be reswaged over a new die derived from a new impression, since in no case do subsequent steps tend to improve defective adaptation, but rather to increase it. The same holds true of vulcanite or cast metal bases and of base plates constructed of the more rigid temporary materials. Under no conditions should an elastic substance or a material that readily distorts by heat or pressure be employed in the construction of bases for occlusion models, because distortion of the pattern denture from any cause will result in similar errors in the permanent denture.

Requirements of the Occlusion Rim

The wax used in forming the occlusion rim must be of a hard variety, not softening at oral temperature or mashing down under masticatory stress either before or after the teeth are imbedded in it. The rim should not be built up in layers as is frequently the case, but the wax should be kneaded into a compact, solid mass before being attached to the base plate. A rim composed of a hard variety of pink wax will present a better appearance and enable to prosthetist to dedevelop a more esthetic temporary, or model denture, than when yellow or brown waxes are employed.

Construction of Occlusion Models

The base plate, of whatever material determined upon, should be formed, introduced in the mouth and tested as to its fitness in peripheral outline, stability on and adhesiveness to the tissues. When found satisfactory in every respect the occlusal rim is formed and attached to it as follows:

The wax to be used in forming the rim is softened in water not exceeding 130 degrees Fahrenheit. When thoroughly plastic it is kneaded into a compact mass with palm and fingers, then transferred to a dry towel and the kneading process continued until all moisture is eliminated.

The mass, while plastic, is then formed into a roll about one-half inch in diameter and four and one-half inches long. This roll is then bent around and placed upon the maxillary portion of the base plate, against which it is only slightly pressed. A heated spatula is passed along the line of junction of the roll with the base plate on the labial, buccal and lingual surfaces to melt the wax and cause it to adhere firmly to the base plate throughout the entire extent of the border. The angles are then filled in with melted wax until approximate contour on all surfaces is developed. Considerble heat is required to properly attach the wax rim to the base plate. When the latter is composed of temporary material it should rest upon the cast on which formed to prevent distortion while applying the rim and melting the wax.

When the rim is firmly adherent and the wax has cooled somewhat, the labial, buccal and lingual surfaces are developed approximately to the desired contour by additions and trimming as indicated.

APPROXIMATE DEPTH OF OCCLUSION RIMS

For ordinary cases, where an average amount of absorption of the borders has occurred, the rim should be about three-eighths of an inch thick from maxillary to occlusal surfaces and about the same breadth from buccal to lingual. The occlusal surface should be flat from before backward, as well as from side to side. This may be accomplished by paring off the excess occlusal wax with a knife, softening this area somewhat and pressing against any true flat surface as a slab or the top of the bench. During this step the base plate should rest upon its cast and the applied pressure should be uniform to prevent thinning the rim more on one side than the other.

BUCCO-LINGUAL POSITION OF THE UPPER AND LOWER WAX RIMS IN RELATION TO THE BORDER CRESTS

The rim should be set as nearly on the border as possible to reduce to the minimum the tipping leverage, which increases in direct proportion to the distance the teeth are placed labially or buccally from the maxillary ridge.

There are two important factors, however, which largely control the labial and buccal position of the occlusal rim of an upper occlusion model. First, the width of the lower arch from buccal to buccal and its relation to the upper border; and second, the extent of loss of the upper alveolar ridge on labial and buccal surfaces by absorption. In full cases the teeth in the lower must occlude with those in the upper, regardless of the disparity in size of the two arches. When the lower arch is excessively large and the upper is under size in arranging the teeth on the upper base plate they must be placed out beyond the ridge, while the lowers must be set inward as much as possible without interfering with tongue

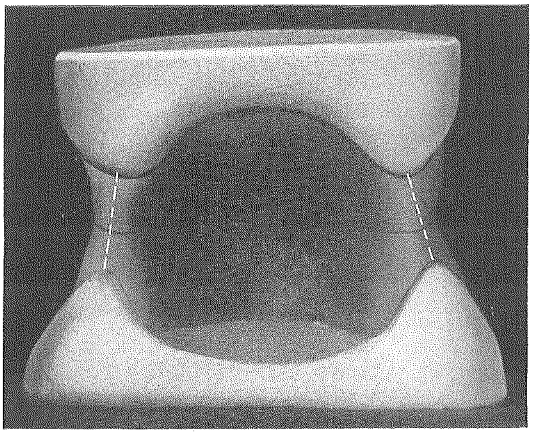


Fig. 165.—Distal View of Upper and Lower Occlusion Models (Trial Plates), Showing the Relation of Wax Rims to Upper and Lower Border Crests

movements. A general rule to follow is to so adjust the wax rims in full cases that the buccal and lingual surfaces of both rims will be parallel with, and about an equal distance from, a line drawn between the crests of the two borders.

The second factor, which must frequently be considered in the development of the labial and buccal surfaces of an upper occlusion model, is the extent of contour necessary to develop on the rims to restore lost facial profile. The amount of such restoration varies in different cases, being greatest in those where the teeth were extracted early in life and dentures have been worn continuously for many years, the borders having constantly become reduced in size. In such cases the best judgment of the prosthetist must be exercised to determine just how far labially and buccally the upper teeth may be carried beyond the fulcrum line, or crest of the border in restoring lost facial contour, without endangering the stability of the substitute. Since anatomic methods have been developed, however, it is found that in most cases the teeth in both arches can be lined up in accordance with esthetic requirements, the tendency to tip being practically overcome by the *balancing contact*.

It is best, however, to establish the parabolic arch lines conservatively — that is, within rather than at the extreme outer position demanded by esthetics. Quite frequently in these most difficult cases the arch lines of the teeth may be

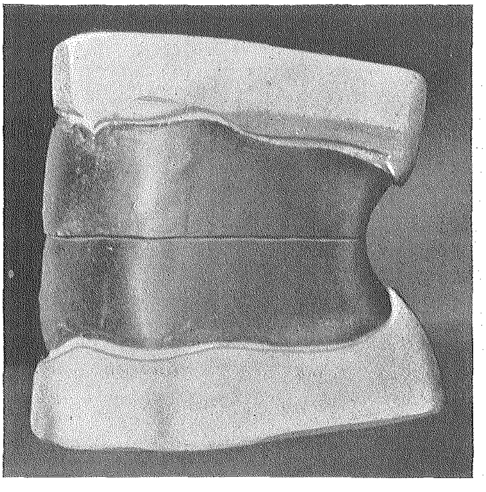


Fig. 166.— Side View of Finished Occlusion Models

kept within normal limits and yet the required facial restoration may be accomplished by means of *plumpers* — reflections of the upper peripheral margin of the base plate. The necessity for this means of restoration cannot be determined beforehand and therefore in the preliminary formation of the occlusion model it is not attempted. Trial in the mouth will determine the position and extent of such reflected margins and they can be developed accordingly.

All surfaces of the wax rim should now be smoothed up so that when introduced in the mouth the patient may feel no special discomfort, and further, so that the occlusion model may present as good an appearance as possible.

The foregoing outline, although referring more particularly to the construction of an upper occlusion model, applies in most essentials to the development of a lower model as well. In lower cases the slant of buccal and lingual surfaces of the occlusion rim is usually to the lingual, from the border crest occlusally, in order that its periphery may coincide with that of the upper rim at the common occlusion plane.

Trial of Occlusion Models in the Mouth

The upper and lower occlusion models having been developed to approximate form, they are introduced in the mouth. There are a number of important points to be considered and recorded by means of the occlusion models before they are finally removed from the mouth, the usual order of procedure being as follows:

First, testing the adaptation of the base plates to their respective ridges.

Second, determining the correct occlusal plane.

Third, restoring disturbed facial profile and contour.

Fourth, marking the high and low lip lines on the wax rims.

Fifth, marking the median line of the face.

Sixth, locating the ends of the condyles and marking same on the integument.

Seventh, removing the upper contour model, inserting and removing the bite rod.

Eighth, "taking the bite" and locking the contour models together.

Ninth, applying, adjusting and clamping the face bow.

Tenth, removal of the occlusal models from the mouth.

Testing the Adaptation of Each Baseplate to Its Ridge

Each occlusion model is independently fitted to its border and tested as to closeness of adaptation, freedom from muscular impingement and whether or not it will retain its position on the border under muscular action.

When the periphery of a base plate impinges on the frænum or muscular attachments, even though it may rest firmly on the general surfaces of the ridge and vault under pressure, yet displacement may readily occur when pressure is discontinued and muscular tension is applied. Any points of interference not previously disclosed during trial of the base plate should be relieved before proceeding with the subsequent steps.

Determining the Correct Occlusal Plane

Various plans are suggested for determining the correct position of the occlusal plane between the two maxillary surfaces. One of these is to draw a line on the face extending from the tragus of the ear to the ala of the nose and trim the planes of occlusion parallel with this line. While perhaps in the average case this rule might apply, variations are so frequent that it cannot be relied upon. Many cases have come under the writer's notice where, if this plan had been adopted, the occlusal planes, while anteriorly correct, would have intersected one or the other borders in the region of the second molars, thus unequally dividing the space between the crests of the two processes in which the teeth are subsequently to be placed.

The following plan is accurate and easy of application: First determine the correct length of the occlusal rim of the upper model anteriorly. In the largest percentage of cases the anterior teeth in normal arches extend about one-sixteenth of an inch below the upper lip when the latter is relaxed, as can be seen when the lips are slightly parted. This amount of margin of the upper occlusion model should be seen under similar posing of the lips. Should the rim be too short an addition is made, and when too long the excess is pared off until the proper amount of wax is exposed. Whatever changes may be made to the rim anteriorly should be followed by corrections to the entire occlusal plane, keeping it flat and of uniform thickness antero posteriorly from incisal region to the tuberosities, until subsequent changes are found necessary.

The length of the upper rim having been determined and such changes as may be necessary effected, the lower model is introduced and the patient instructed to close. Usually the rims strike in the molar region, while anteriorly there is more or less space between them. Instruct the patient to bring the lips together and notice the amount of muscular effort required to effect their closure.

Both occlusion models are now removed and pared off equally at their contact points, being careful to preserve the flat occlusal planes by shaving off long bevel slices of wax. The main point to keep in mind in this trimming process is to preserve an equal thickness of wax on each side of each rim from occlusal to maxillary surfaces, so that in occluding the teeth they may be placed in the space thus provided.

Briefly stated, an effort should be made to establish the occlusal plane midway between the crests of the upper and lower borders. The only exception to this method is in those cases where absorption of the borders has progressed unequally, the teeth in one arch having long been lost and in the other having been extracted at a much later date. In such cases the occlusal plane must be located nearer the border showing the least absorption.

Establishing Height of the Lower Occlusion Rim

The depth of the upper wax occlusion rim — that is, its thickness from the maxillary surface of the border to the occlusal plane — is to a very great extent determined by the length of the upper lip anteriorly, while posteriorly it commonly fills about one-half the space between the crests of the two maxillary borders, the mandible being in normal position, which position usually places it parallel with the upper maxillary crest.

With these two factors as a basis it is a comparatively simple task to develop the upper occlusion model. It is more difficult, however, to develop a correctly proportioned lower occlusion model, because of the absence of any fixed landmark, by means of which the height of the lower rim can be established.

Let us consider the relation of the mandible to the maxilla, first, with the natural teeth present and in occlusion, and second, after the jaws become edentulous. In the first instance the masticatory muscles bring the mandible upward until when the teeth are in occlusion it is in a state of rest. In this position the facial profile is normal, while the lips rest easily against each other without apparent muscular tension, or conscious effort on the part of the individual. Since, however, it is possible for the patient to compress the lips and give them a strained appearance — a purely voluntary act of the orbicular muscles in which the mandibular take no part — it is well to instruct the patient to relax muscles of lip closure.

Could a registration of the normal profile be made when the natural teeth are present and in occlusion, say by placing one leg of a caliper on the under side of the mandible and the other on the cranium on points that could afterward be located and the distance between the two be recorded, this measurement would enable the length of the face to be re-established after loss of the teeth.

This method is not practical, but the illustration shows what we hope to and should accomplish by means of occlusion and contour models of suitable height.

Instead of the calipers the esthetic judgment of the prosthetist is the court of last resort. His eye should be so trained as to detect defective profile or contour and restore his patient's face to normal appearance.

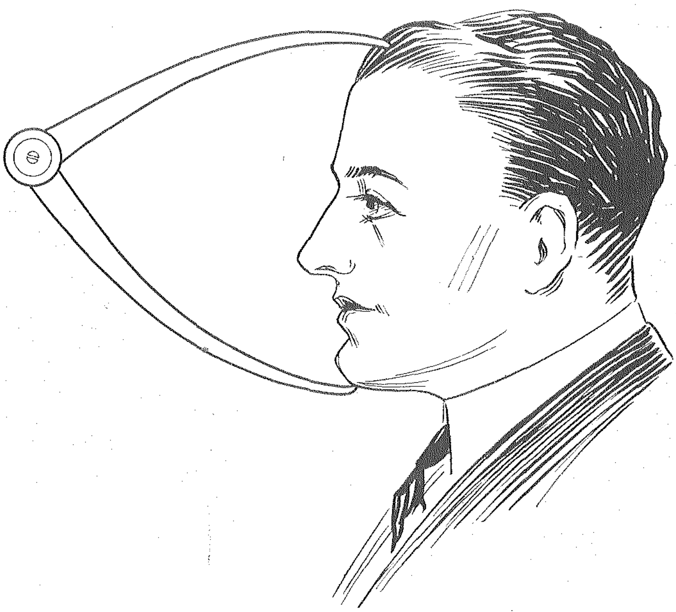


Fig. 167.—Theoretical Measurement of Facial Profile

In edentulous cases, there being no teeth present to arrest the progress of mandible toward the maxilla, restoration of the normal pose of the lips and the general profile and contour of the face must be depended upon in establishing the height of rim of the lower occlusion model. This can only be done by repeated trial and testing, building up or reducing the rim as facial contour and the pose of the lips indicate.

The depth of the upper rim having been determined by the length of the upper lip, the height of the lower rim is established at such point that the lower lip may rest easily in contact with the upper without requiring muscular effort to effect closure. Pursing out of the lip indicates that the rim is too short, while muscular effort in closing the lips indicates that the rim is too high.

When the rims have been developed correctly labially the contour models should be tested posteriorly to determine whether there is uniform and equal contact between them and their respective borders. This test is made by having the patient maintain moderate mandibular pressure while the prosthetist endeavors to force the occlusion models apart, first on one side and then on the other. If on moderate pressure the two base plates separate while contact is maintained labially, it indicates that the occlusion rims are too short where separation occurred, one or the other of the base plates having tipped or left its border. Such imperfect contact should be corrected by additions of wax to one or both rims until uniform bearing on both sides of the mouth is established.

In making such additions care should be taken to preserve the flat plane areas of both occlusion models.

Should the upper plane be flat and the rim of proper length the lower rim on the deficient side may be corrected by adding a sheet of soft wax to the occlusal plane where deficient, introducing in the mouth and having the patient exert gradual and uniform pressure upon it. The lower wax model is then removed and the surplus trimmed off to correct peripheral outline.

Restoring Lost Facial Contour

One of the most important results of full denture construction, when the steps are properly carried out, is the correction of disturbed facial contour.

The teeth, the borders in which they are imbedded, with the overlying soft tissues in the natural masticatory apparatus, when viewed anteriorly present a generally convex appearance from side to side and a nearly perpendicular arrangement from above downward. The labial and buccal surfaces of the teeth and alveolar arches support the lips and cheeks and in this manner aid in giving form and contour to the lower half of the face.

When the teeth are lost and the alveolar borders absorb to a greater or less extent from without inward, as well as in height, the lips and cheeks lose their support and fall backward and inward. The symmetry of the face is thus disturbed to a marked degree and unless corrective measures are resorted to the patient becomes disfigured for life. By the introduction of suitably formed dentures disturbed facial profile and contour can in a great measure be overcome.

The first stage in denture construction, where corrective measures can be developed and tested, is during the trial of the wax occlusion models in the mouth. Later on the final test occurs with the introduction of the wax model dentures. By molding and carving, varying the thickness of the labial and buccal rims of the wax occlusion models, introducing them in the mouth, having the patient close and bring the lips together in a normal relation, or state of rest, the prosthetist can determine the measure of success attained. Repeated modifications and trials are sometimes necessary to secure satisfactory results, while in other cases but little difficulty is encountered.

The occlusion rims, by their perpendicular height, establish the profile and length of the face. Their labial and buccal surfaces lift out the sunken areas, particularly from the bicuspids forward.

In order to correct the wrinkles which extend from the alæ of the nose outward, over the angles of the mouth, it is usually necessary to extend the periphery of the occlusion model upward in the region of the cuspids. Such extensions, however, should be neither too high nor too bulky, or they will interfere with the movements of buccal and orbicular muscles and displacement of the denture will result.

In those cases where considerable restoration is required and the extension upward of the peripheral rim of the base plate is limited by muscular attachment the required contour can usually be developed by reflecting the peripheral margin of rim, as previously mentioned, outward and downward in the form of flanges, or so-called *plumpers,* shown on page 547. The width and slant of a flange of this type depends on the amount of restoration required and the tension of the muscles peripherally. In all cases they must be so disposed as not to interfere with freedom of muscular action or denture displacement will most certainly occur.

The usual prominent features of an upper occlusion model when developed are as follows:

The contour model is notched anteriorly, to allow free play for the labial frenum.

There should be slightly depressed areas between centrals and cuspids above the laterals, thus reproducing the incisive fossæ such as are noticeable in the maxilla. These depressions allow freedom of movement of the alæ of the nose. Prominently contouring the labial rims above the lateral incisors oftentimes restricts the size of the nasal orifice, interferes with respiration and is generally uncalled for.

Prominent cuspid eminences do, partially, but not usually wholly, obliterate the wrinkles extending from the alæ of the nose outward over the angles of the mouth. A slight suggestion of these wrinkles in persons of middle age, or past, produces a more esthetic result than when completely obliterated.

Peripheral margins, from median line to tuberosities more or less notched, as indicated by the muscle-marking exercise carried out in impression taking. (See Fig. 85.)

Marking the High and Low Lip Lines

The high and low lip lines are marked on the upper and lower occlusion models respectively, to serve as guides in determining the length of teeth to select for the case.

The upper central incisors should extend from the incisal plane to the high lip line, or slightly above it, so that when the artificial gum material is applied over the cervical ends of the teeth, the highest curves of the gingival line coincide with the high lip line. The same arrangement can be followed in selecting and arranging the lower incisors and carving the gums, although the gums of the lower teeth seldom show to the same extent as in upper cases.

The object in selecting teeth of the length indicated by the high lip line is to avoid exposure of too much artificial gum, as would occur when shorter teeth are used, and also to obviate the monotony which is apparent when longer teeth and only the porcelain is visible.

The patient is instructed to raise the upper and depress the lower lip as in broadly smiling, and while in this position the prosthetist marks on the occlusion models the lines of lip peripheries as they lie against the wax surfaces.

Marking the Median Line of the Mouth

The human face is seldom, if ever, symmetrical. Usually the nose is bent to one side; one eye may be slightly higher or nearer the median line than the other, or set at a different slant; the general line of the lips from side to side may not form a right angle with the perpendicular line of the face. In fact, the most symmetrical faces, when studied closely, will be found unsymmetrical.

It is therefore a difficult matter at times in denture construction to determine just where the two central incisors should be placed because there is no fixed landmark to serve as a basis, or to indicate the position once occupied by the natural teeth. Usually the center of the philtrum of the lip will serve as a guide, but when the nose, chin and other features are out of alignment a general average must be struck to arrive at harmonious results. This may be done by placing a straight edge, or the edge of a card, flatwise against the face extending from the center of the chin to a point located midway between the inner ends of the eyebrows and making a slight mark on the occlusion models. The card is then removed and a point directly under the center of the philtrum is marked. When there is much variation in the two lines a third line midway between the two, yet favoring a location near the philtrum, will give a harmonious median line.

When the correct position is determined a perpendicular line extending across both base plates should be distinctly marked in the wax. Care should be taken in subsequent steps not to obliterate it until the arrangement of the teeth is begun.

Locating the Outer Ends of the Condyles

Previous to taking the bite the outer ends of the condyles should be located and their exact position indicated by dotting the integument directly over their locations with a soft pencil. The outer ends of the condyles in most cases approach the outer margins of the glenoid fossæ, sometimes coming quite to the margins so as to be detected with little difficulty. More frequently, however, they are slightly overhung by the glenoid rims. When the integument is thick and the interarticular fibrocartilages and capsular ligaments are well developed it is sometimes difficult to locate them, either at rest or when in action.

In the largest percentage of cases the condyle end will be found about one-half inch in front of, and on a horizontal plane with the upper margin of the external auditory meatus.

The index finger should be placed perpendicularly against the side of the face, with that portion of the ball immediately below the finger nail resting on the immovable glenoid rim. The patient is then instructed to open and close slightly with the hinge motion. Wide open movements are confusing as the condyle not only rotates but moves forward in its path as well. By applying steady pressure with the finger against the glenoid rim with slight opening and closing movements of the mandible a point of perceptible movement will be detected close up along the glenoid margin and in about the same relation to the external auditory meatus as stated. While varia-

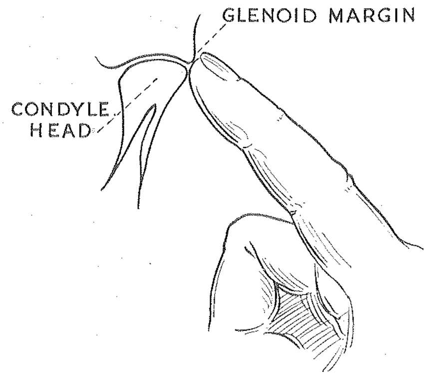


Fig. 168.— Position of Finger in Locating Condyle End

tions in position of the condyle ends occur in different individuals, and frequently in the same person, they will not be very marked and usually are not difficult to detect.

The greatest care should be exercised in determining the correct antero-posterior, as well as perpendicular position of the condyle ends when at rest in their fossæ, as the measurement secured with the face bow becomes the basis of radial movement of the casts when mounted on the occluding frame.

Application of the Bite Fork to Upper Occlusion Model

The bite fork, with its crescent-shaped plate for insertion into the occlusion model, is heated and the plate inserted in the labial surface of the wax rim. The occlusion model is

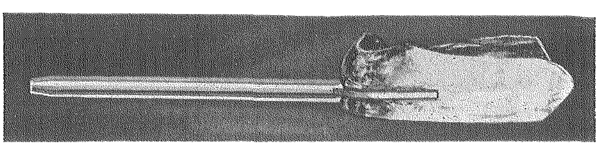


Fig. 169.— Upper Occlusion Model with Bite Fork in Position

removed from the mouth during this step, since if carried out in the mouth the melted wax caused by the insertion of the heated fork is liable to burn the lips.

The fork while heated is pressed into the rim until its entire inner periphery engages with, and is firmly imbedded in the labial surface of the wax. The rod should be parallel with the occlusal plane and point as nearly forward, parallel with the median line of the occlusion model, as possible, so that the universal clamp of the face bow may grasp it firmly when tightened.

After insertion it will be found most convenient to remove the bite fork from the occlusion model before taking the bite, as its weight tends to dislodge the upper occlusion model. When the latter step is carried out and the bite locks are inserted the fork is returned to the groove previously made for it, the lip protected with a napkin and a hot spatula passed around the upper surface of the fork to lute it firmly to the occlusion model.

Meaning of the Term, "Taking the Bite"

Taking the bite refers to establishing the correct antero-posterior, as well as perpendicular, relation of the mandibular to the maxillary ridge. When the natural teeth are present and in normal occlusion, the condyles are at rest in the glenoid fossæ. Since in edentulous cases the occlusion rims, when properly formed, take the place of the natural teeth, they establish the correct perpendicular distance of the mandible from the maxilla. The final step of taking the bite consists in having the patient close the mouth normally, that is, so that the condyles are at rest in the glenoid fossæ while the occlusion rims are in contact, and registering the relation of the occlusion models to each other in this position.

Difficulty Encountered in Taking the Bite

More or less difficulty is encountered in taking the bite because of the tendency of patients to unconsciously protrude the mandible, either uni- or bi-laterally. It is also a noticeable fact that the more interested the patient is in this step, and the greater effort he displays in giving a correct bite, the greater is the liability of error resulting. It is therefore best not to inform the patient of the importance of the step about to be carried out, but merely instruct him at the proper time what to do.

Various Methods of Securing the Bite

Various methods are adopted for securing a normal bite, any one of which might prove successful in some cases and result in failure in others. Some of these methods are as follows:

First — The patient is instructed to swallow and at the same time close the mouth, the culmination of this muscular effort being supposed to — and in some cases does — bring the condyles back in their position of rest in the fossæ.

Second — A small pellet of wax is attached to the distal margin of the central vault portion of the baseplate. The patient is instructed to touch the pellet of wax with the tip of his tongue, and at the same time close the mouth until the occlusion rims are in contact.

Third — A chin cup is applied to the mentum, to which straps are attached which pass around the head. When these straps are properly adjusted, tension is exerted on the mandible to force it backward. Repeated opening and closing of the mandible will frequently, but not in all cases, result in establishing the correct bite. An apparatus similar to the one just described is known as Garrison's Bite Guide.

Fig. 170.— The Garrison Bite Guide

Fourth — Pressure may be exerted upon the point of the chin, while the patient repeatedly opens and closes the mouth, attention in the meantime being given to the relation the occlusion rims sustain to each other when brought in contact.

Fifth — It is a noticeable fact that when the masticatory muscles are wearied by rapid and repeated exertion, they draw the mandible backward until the condyles are in normal resting position on the fossæ.

By combining the two methods last mentioned, a correct bite may, in practically all cases, be secured.

A Practical Method for Securing a Correct Bite

The patient should be instructed to open and close the mouth rapidly many times, say for a period of one-half to one minute, the operator in the meantime paying but little attention, further than to see that his instructions are followed. He will then say to the patient, "Relax your muscles and let me open and close your mouth." The point of the chin is then grasped lightly with the tips of the fingers and thumb so as not to displace the lower occlusion model, and the mandible is moved up and down, the lips being raised to note position in which the occlusion rims strike. Slight pressure may also be applied on the mandible to force it upward and backward. Undue pressure should be avoided, as it would result in compression of the tissues in the temporo-mandibular joint, and thus give a slightly backward or retruded bite.

Under the slight pressure exerted, together with repeated opening and closing movements, the occlusion rims will finally

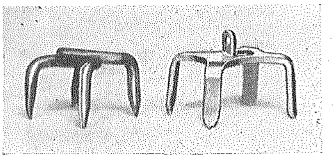


Fig. 171.— Bite Locks. Left, Formed of Wire. Right, Dr. Snow's Design

meet each time in the same relation to each other. The patient is then instructed to "keep the mouth closed." The bite locks are then warmed and forced into the upper and lower occlusion models, about in the region of the bicuspid teeth. Care should be taken in placing them to avoid encroaching on the groove previously made for the bite fork. A third bite lock is sometimes inserted in the labial region to prevent possible change of relation between the baseplates in removal from the mouth.

In some cases where the wax occlusion models are large and the oral opening small, it is impossible to remove the two models when locked together. By cutting cross grooves in both occlusion rims opposite each other, one on either side and one anteriorly, placing small pellets of warm wax directly over them, and having the patient bite, the wax will be forced in the grooves and will serve as guides in placing the models in correct relation to each other on removal from the mouth.

The bite lock having been inserted or the grooves cut as described, the next step is to return the bite fork to position.

Inserting the Bite Fork in the Upper Occlusion Model

The bite fork is now warmed slightly, the lips opened and the fork inserted in the groove previously made by it, and from which it was removed previous to taking the bite. To secure it firmly in place, a heated spatula should be passed along the upper surface of the fork, the upper lip being held up and the lower protected with a napkin. When firmly fixed the face bow can be applied.

Adjusting the Face Bow to the Occlusion Models

As will be seen, the bite has been established, although the occlusion models have not yet been removed from the mouth. *The face bow is now applied so that when the base-*

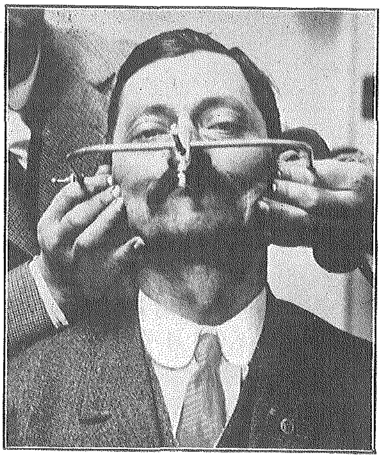


Fig. 172.— Adjusting the Condyle Rods

plates are removed from the mouth, and the casts are inserted each in its respective baseplate and attached to the occluding frame, their maxillary surfaces will bear the same relation to the frame hinges that the natural ridges sustain to the condyles when the latter are at rest in the glenoid fossæ.

The condyle rods of the bow are now drawn outward so as to allow them to pass on either side of the face without interference. The universal clamp in the center of the bow is carried over the projecting rod of the bite fork, and the back ends of the bow are dropped down until the condyle rods are opposite the points previously marked in pencil to indicate the condyle ends. The condyle rods are then pressed inward until their ends rest on the points marked.

Care should be taken to see that the condyle rods show the same number of gradations between their inner ends which rest on the face and the inner sides of the bow. Should the bow be unequally balanced when clamped, the casts will, as a result, be mounted to one side instead of on the center of the occluding frame, and their radii of movement will be in-

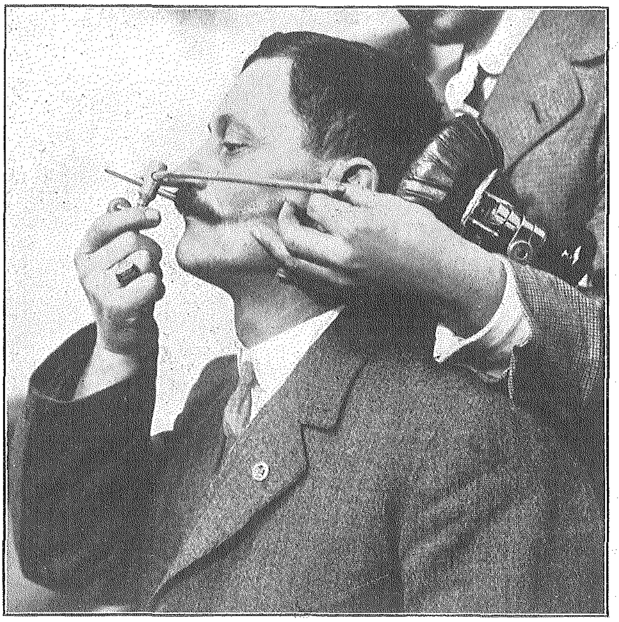


Fig. 173.— Patient Tightening the Bite Fork Clamp

correct. When balanced, the clamps which lock the condyle rods are tightened, the rods readjusted to the natural condyle ends by springing the bow away slightly to allow the integument to assume its normal position, then returned to place and held in correct relation by the operator while the patient, or assistant, is instructed to tighten the central clamp, thus fixing the relation of the bite fork to the face bow. The operator should forcibly tighten the clamp to insure against any possible change from stress while removing the occlusion models. The condyle rods are now released and drawn outward, the patient instructed to open the mouth and the occlusion models and face bow are removed, using the bite fork as a handle.

Adjustment of the Face Bow, with Occlusion Models Attached, to the Occluding Frame

On removal of contour models from the mouth, the condyle rods of the face bow are pressed inward their full extent, and tightly clamped.

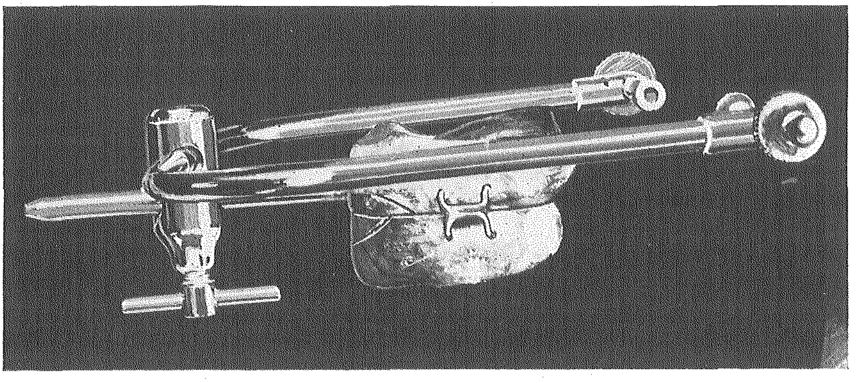


Fig. 174.— Occlusion Models, Attached to Face Bow, Removed from Mouth

The sheet metal base is slipped on the lower bow of the occluding frame, to prevent the latter tipping backward. The occlusion models are carried between the upper and lower bows of frame, the ends of the face bow sprung apart, and

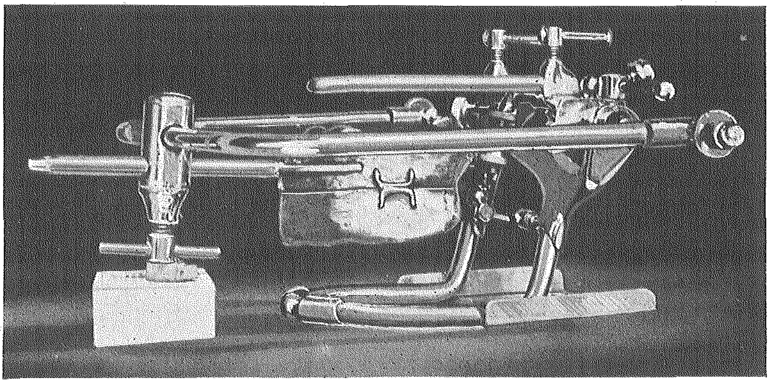


Fig. 175.— Face Bow, with Occlusion Models Attached, Adjusted to Occluding Frame

the condyle rods are attached to the projecting lugs of the frame hinges.

The face bow should be made parallel with the bench on which the occluding frame rests. This may be done by placing a cork, or small block of suitable thickness, under the central clamp as illustrated in Fig. 176.

Attaching the Casts to the Occluding Frame

The upper bow of the frame is thrown back, the upper cast is seated in its baseplate and luted with wax, if necessary, to hold it steadily in place. The bow is now dropped

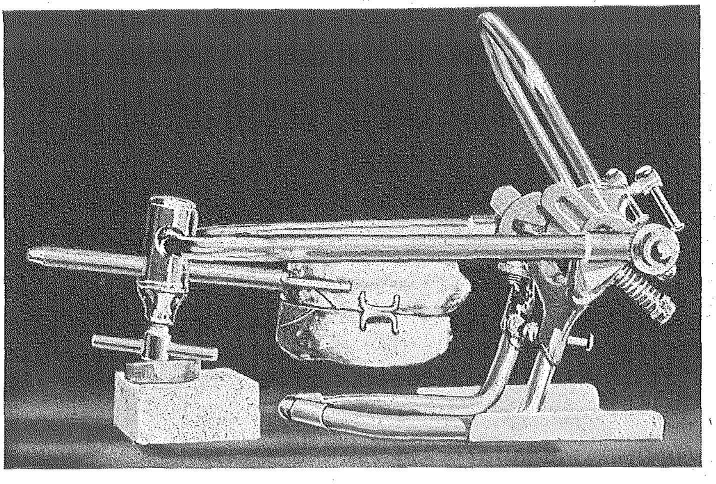


Fig. 176.— Upper Bow of Frame Thrown Back to Receive Upper Cast

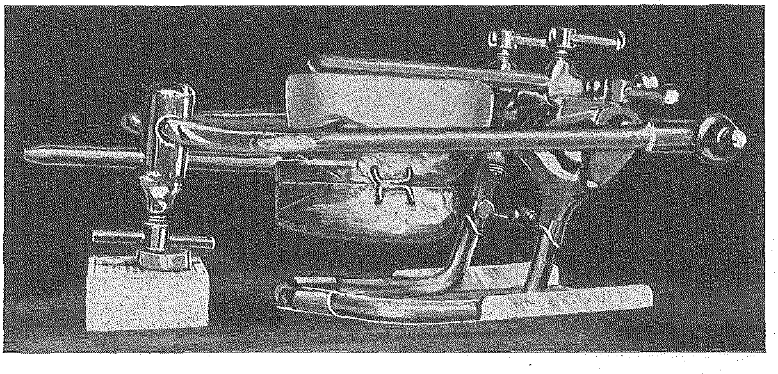


Fig. 177.— Upper Cast Seated in Its Baseplate

down on the base of the cast, to which a mix of moderately thin plaster is applied. The bow should be fully enclosed in plaster and the latter given time to set before mounting the other cast.

The face bow and frame are now inverted, the sheet metal base removed, the lower bow thrown back, the lower

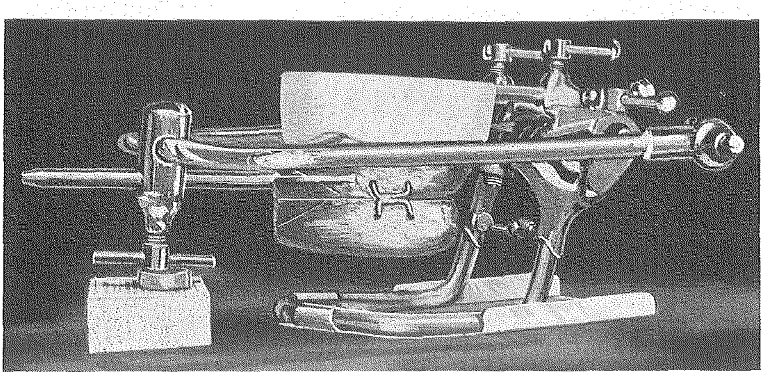


Fig. 178.— Upper Cast Attached to Frame Bow

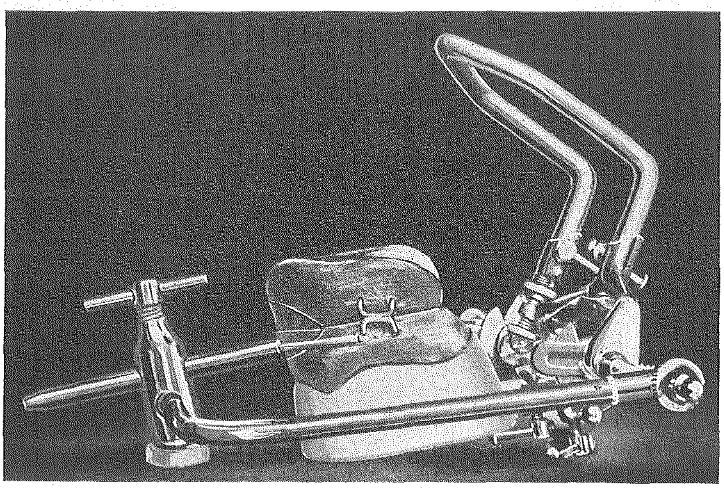


Fig. 179.— Occluding Frame Inverted. Bow Thrown Back to Receive Lower Cast

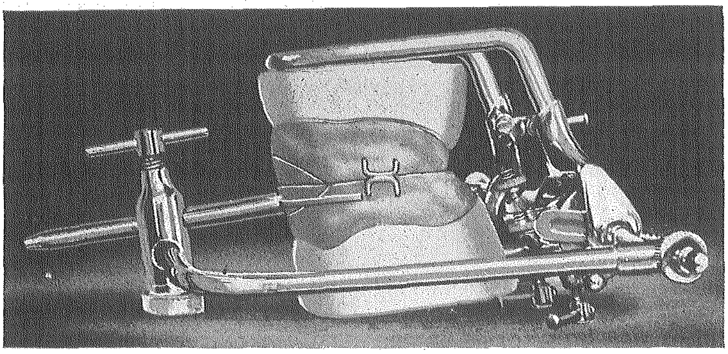


Fig. 180.— Lower Cast Seated in Its Baseplate

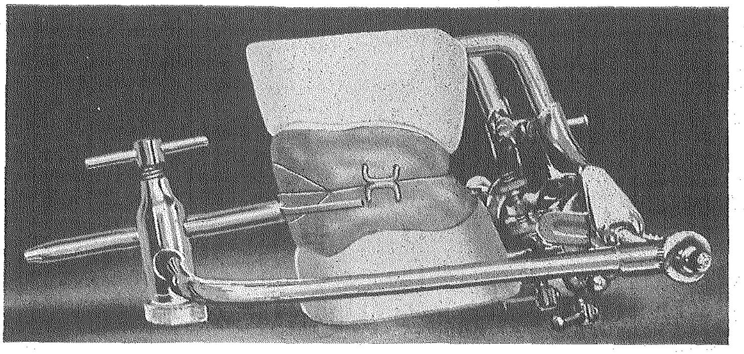


Fig. 181.— Lower Cast Attached to Frame

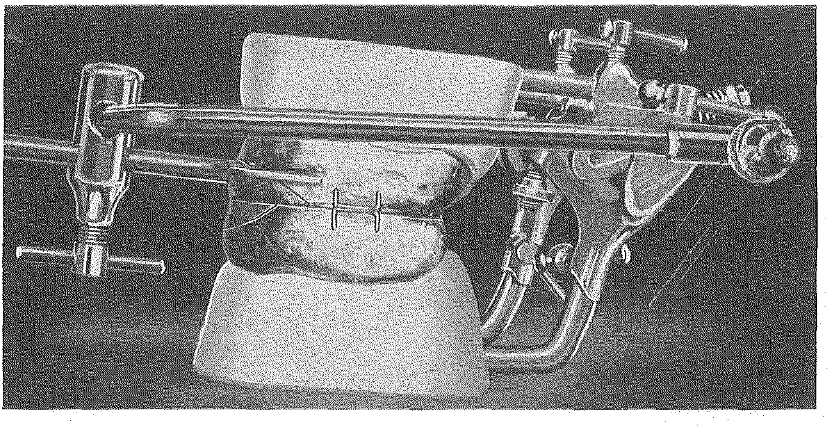


Fig. 182.— Casts Mounted Ready for Removal of Face Bow

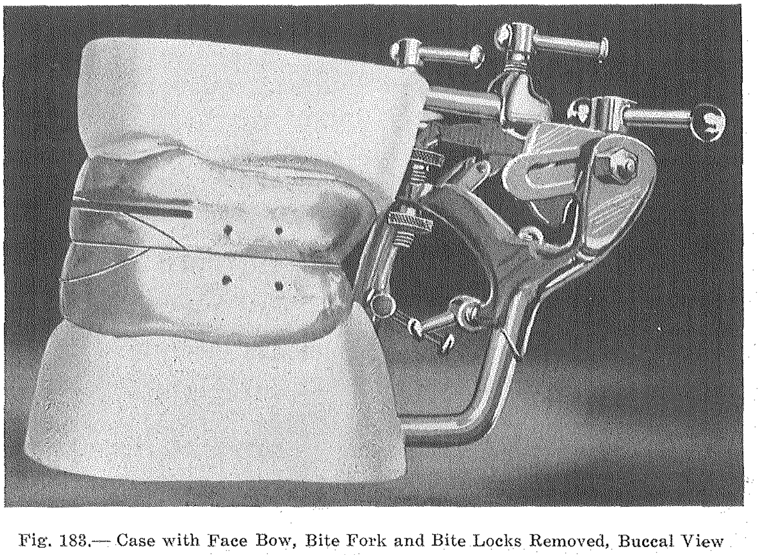


Fig. 183.— Case with Face Bow, Bite Fork and Bite Locks Removed, Buccal View

cast inserted and luted to its baseplate, and the mandibular bow dropped down upon the base of cast.

By loosening the set screws of the mandibular bow, the latter may be raised or lowered in the frame sockets until it lays flat upon the base of the cast. When adjusted, the set screws of the bows should all be tightened so that the relation of casts to frame hinges may not be disturbed by slipping of the bows in subsequent steps. The lower bow and cast are united with plaster, as in the preceding step, the plaster allowed to harden and the frame righted.

The face bow is removed first, then the bite fork, and finally the bite locks, after which the surplus plaster is

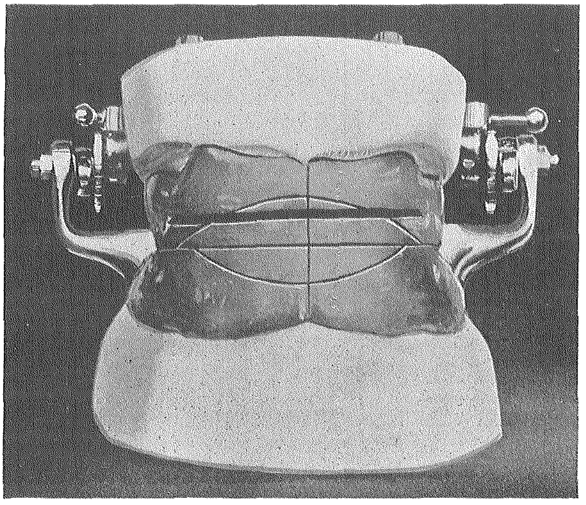


Fig. 184.— Labial View of Mounted Casts and Occlusion Models

trimmed from the casts and occluding frame bows. This latter step, although apparently unimportant, adds to the appearance of the case, and where much surplus is present, enables the frame to be handled more conveniently.

Registering the Condyle Paths of Patient

There are two fundamental steps of vital importance in the construction of anatomic and scientific dentures that cannot be ignored without lessening the quality and efficiency of the substitute.

The first is mounting the casts in correct horizontal plane relationship to, and radial distance from, the rotation centers of the occluding frame. This step just described is accomplished by means of the face bow or some similar device.

The second consists in registering the pitch of the condyle paths of the patient, and setting the condyle paths of the occluding frame at corresponding angles. This may be accomplished by two somewhat different methods, the very simple Christensen-Snow plan and appliances, and the more elaborate registration suggested by Gysi by means of his Condyle Register. The first method will be described here, the second subsequently in connection with the Gysi appliances on page 465.

Christensen's Method

Dr. Carl Christensen of Copenhagen noticed that when correctly formed occlusion models were introduced in the mouth and the mandible was protruded, in all cases where

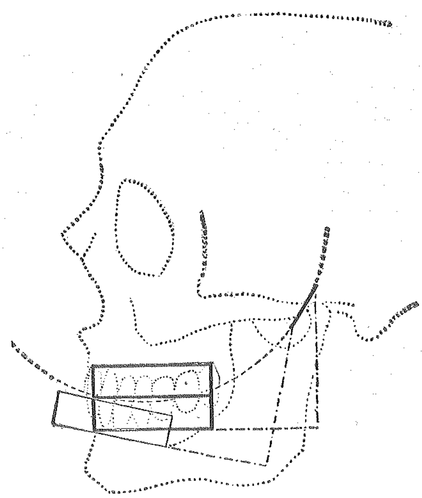


Fig. 185.— Christensen's Theoretical Diagram of Space Between Distal Ends of Occlusion Rims

the condyle paths inclined downward, the occlusion models separated in the molar region, while anteriorly they remained in contact.

He further noticed that the amount of separation of the occlusal planes in the molar region increased in direct ratio to increased pitch of the condyle paths.

He then conceived the idea that by rigidly fixing the occlusion models together while in the mouth, in the separated relation produced by mandibular protrusion, on returning them to the occluding frame and seating each cast in its respective baseplate, the condyle paths of the frame, which previously were released, would assume the same angular inclination as those of the patient. The condyle paths of the frame thus automatically adjusted were then fixed in this position.

While subject to errors from various causes, in the main points the idea is practical. Christensen's efforts, therefore, have contributed much to solving the problem of anatomic occlusion.

To hold the occlusion models in their separated relation, he introduced rolls of soft wax in the molar region, instructed the patient to protrude and close, after which the occlusion models were locked together with staples or bite locks. By exercising care in carrying out the steps, this method is accu-

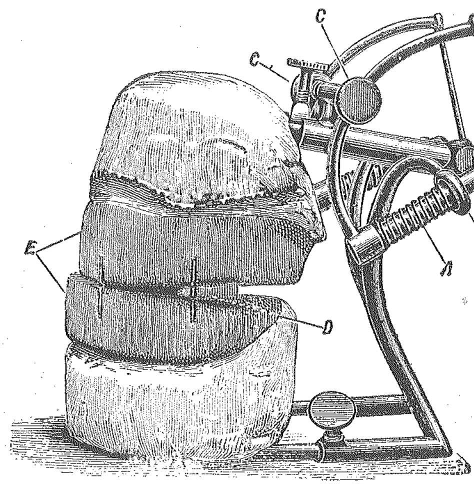


Fig. 186.— Christensen's Method of Registering the Condyle Paths with Wax Rolls

rate, but lack of precision on the part of the prosthetist will usually result in a distorted relation between the occlusion models in the various steps of removal from the mouth and readjustment on the occluding frame.

Dr. Geo. B. Snow devised "bite gauges" to take the place of the rolls of wax, and by means of these simple appliances the liability of error occurring is greatly reduced.

Technic of Condyle Registration

The occlusion models are now removed from their casts on the frame, the two bite gauges heated slightly and pressed downward into the occlusal surface of the lower wax rim about five-eighths of an inch in front of the distal ends. The metal plate of the bite gauge should rest on the occlusal plane of wax.

The object in placing the bite gauges forward of the distal ends of the baseplate is to prevent the lower occlusion model from sliding forward when the patient closes. Placed in the position mentioned, the pressure on closure comes between the two extremities of the model. Before introducing

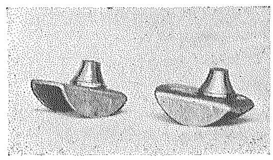


Fig. 187.— The Snow Bite Gauges

in the mouth, the patient should be shown the occlusion models, his attention called to the bite gauges, and a brief explanation be made of what is expected of him.

The occlusion models are now introduced and the patient instructed to protrude the mandible, or "bite forward" until the occlusion rims touch anteriorly, while the pyramidal pointed pins of the bite gauges presenting upward enter the upper and keep the occlusion models apart at their distal extremities, in direct proportion to the drop of the condyles in

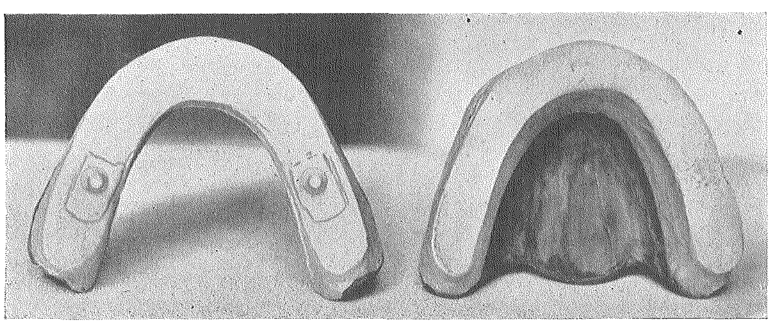


Fig. 188.— Lower Occlusion Model with Bite Gauges in Position

their paths. The occlusion models are now locked together with three bite locks, one on either side and one anteriorly, and when firmly fixed are removed from the mouth.

Limit of Protrusive Movement of Mandible

The extreme forward limit of mandibular protrusion varies greatly in different individuals, the average distance being about one-fourth inch. When the protrusive movement exceeds this amount, the condyle-bearing surfaces in some cases pass beyond the normal working slant of the condyle paths, onto the more nearly horizontal surfaces of the articu-

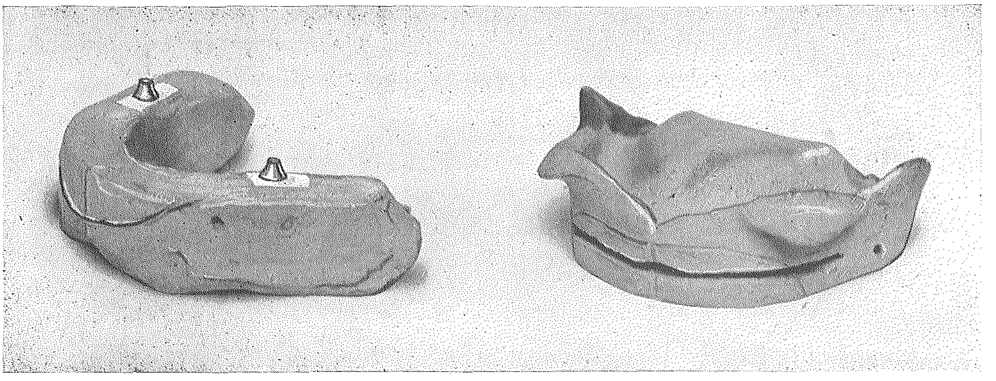


Fig. 189.— Perspective View of Upper and Lower Occlusion Models. Plumpers on the Upper Model. These Additions Are Usually Situated More to the Distal Than as Shown in Cut

lar eminences, and an incorrect registration will result, the pitch of the condyle paths of the frame being less than in the actual working area of the natural paths.

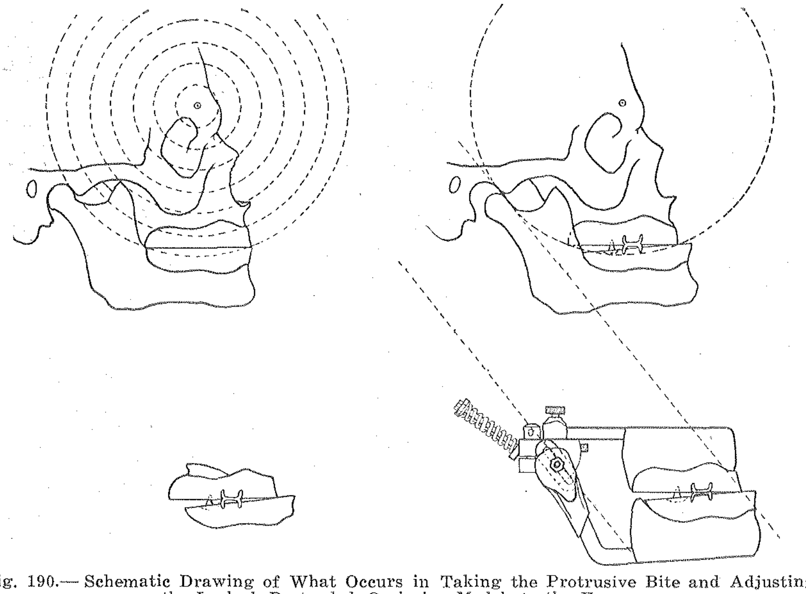


Fig. 190.— Schematic Drawing of What Occurs in Taking the Protrusive Bite and Adjusting the Locked, Protruded, Occlusion Models to the Frame

On the other hand, a protrusive movement of one-eighth inch or less, while capable of being registered, will not be sufficient to properly adjust the condyle slots of the occluding frame, on account of the short distance the hinge pin will travel in the slot in adjustment of the casts to their occlusion models. A slight amount of lost motion also contributes to further error, the hinge pins being a trifle less in diameter than the width of the slots.

It may be stated definitely that the amount of protrusion should range between three-sixteenths and one-fourth inch, in order that a correct record may be made on the occluding frame.

Adjusting the Condyle Paths to the Occluding Frame

The condyle slot clamps of the occluding frame are released and the back spring unhooked, as a preliminary step in

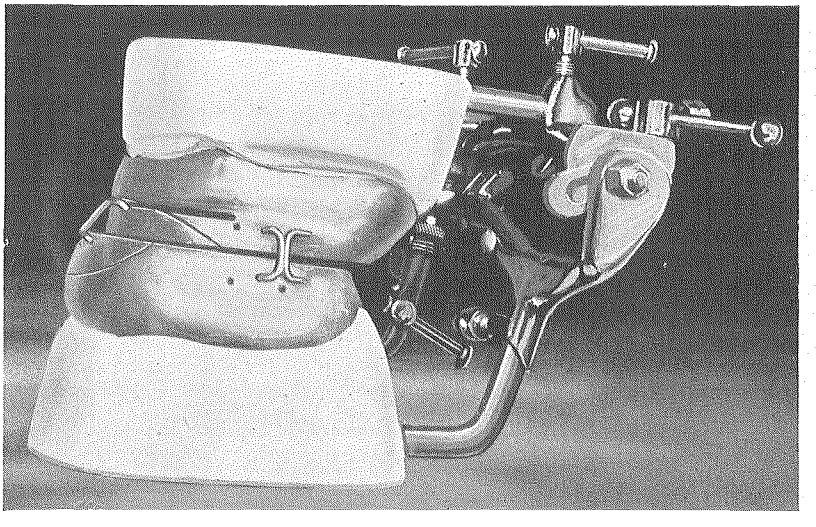


Fig. 191.— Upper and Lower Casts in Protruded Relation, Seated in Their Respective Baseplates

the adjustment of the casts to the occlusion models in their protruded or unilateral relation.

The lower occlusion model is now set upon its cast, the upper bow of the frame is moved backward until the upper cast enters its baseplate and is accurately seated.

In seating the casts in their baseplates care should be taken to direct the pressure upon them in line with their centers, to prevent tipping. Grasping the bows of the frame near the hinges will unseat the casts anteriorly and reduce the pitch of the condyle slots below that recorded by the protrusive bite, while exerting pressure on the casts anteriorly will increase the pitch of the paths.

The most accurate method of adjustment is to place the thumb in the center of the base of the lower cast, the middle finger in the center of the upper, and exert sufficient pressure to firmly seat and hold the casts in their baseplates while adjusting and clamping the condyle slots. The casts being seated and held firmly in their baseplates as described, the

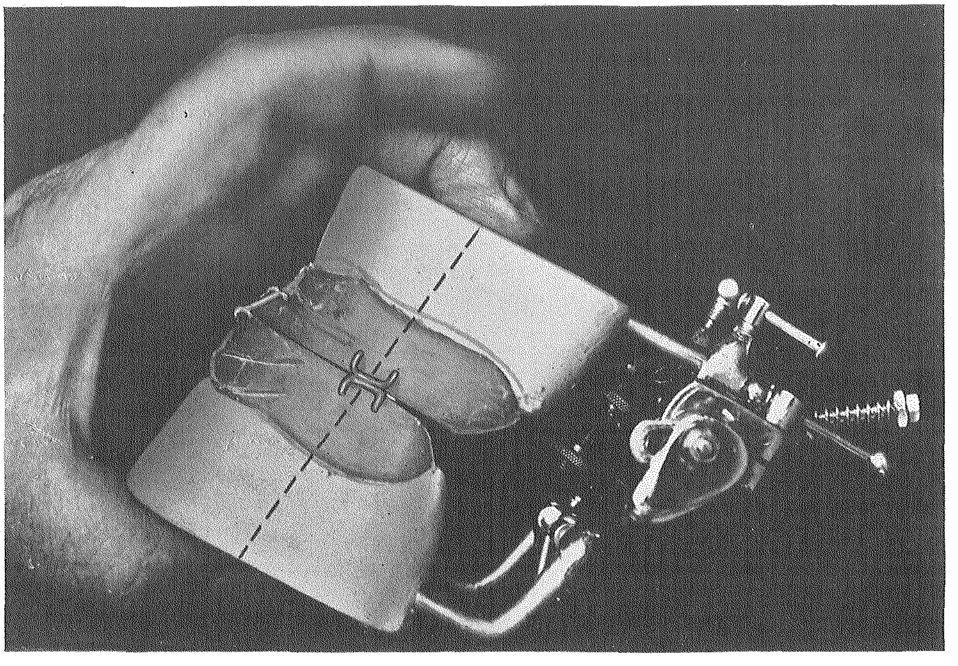


Fig. 192.—Manner of Applying Pressure to Avoid Tipping in Seating Casts in Protruded and Locked Occlusion Models

projecting end of one condyle slot plate should be grasped with the thumb and index finger of the other hand, and subjected to gentle traction until a position of rest is found, where neither side of the condyle slot impinges on the hinge pin of the frame. When correctly adjusted, the condyle slot plate is clamped in that position, and similar steps carried out in adjusting the opposite condyle slot.

The condyle paths of the frame being adjusted in the manner described, the bite locks and gauges are removed from the occlusion models and the back spring again hooked on its pin, the tension of which returns the hinge pins of the frame to the distal ends of the condyle slots, the same position they occupied when the casts were first mounted.

The occlusion models, therefore, sustain the same relation to each other as before. The only change effected by adjusting the occlusion models in their protruded relation to the unlocked frame is in the slant of the condyle paths which, if the steps have been accurately carried out, now coincide with the pitch of the condyle paths of the patient.

Some patients cannot protrude the mandible directly forward to any extent, but usually are capable of moving it to either side in lateral effort. In such case the bite gauges are inserted as usual, and the patient is instructed to "bite to one side." The bite locks are then inserted, the occlusion models removed and returned to the occluding frame. The condyle slot of the frame on the protruded side is adjusted and locked, the clamps on both sides of the frame being released while seating the casts in their baseplates. The bite locks are then removed, the occlusion models returned to the mouth, and the patient instructed to "bite sideways" in the opposite direction. The occlusion models are again locked together, removed from the mouth, returned to the frame, and the other condyle slot adjusted and locked as before.

Developing the Compensating Curves

While it is not absolutely essential to the correct arrangement of teeth anatomically, it will be found much more convenient for the beginner when the condyles move downward as well as forward, to change the occlusion rims from flat to curved planes, thus indicating the alignment of the teeth from before backward. When properly developed, these curved planes represent a plane section of a convex sphere in the upper, and of a corresponding concave sphere in the lower occlusion model, which may be moved against each other in protrusive and lateral effort without loss of contact. Theoretically, the working area of the condyle paths also represent sections of a convex sphere which have a common center with the occlusal sphere sections.

In taking the protrustive bite, the condyles traversed a distance along the condyle path sphere equal to the forward movement of the mandible. The incisal plane of the lower occlusion model traveled a like distance along the occlusal sphere incisally.

Now since the condyle spheres are fixed factors, and the incisal rim need not be modified, these areas become the basis for developing the compensating curves in the occlusion rims.

or in correcting the flat planes of the upper and lower occlusion models so that they will remain in contact in lateral and protrusive effort.

Fundamental Principles of Developing the Compensating Curve

While the following example is not exactly applicable to developing the compensating curves, it will serve to illustrate the fundamental principle involved.

In developing a cylindrical column from a square piece of

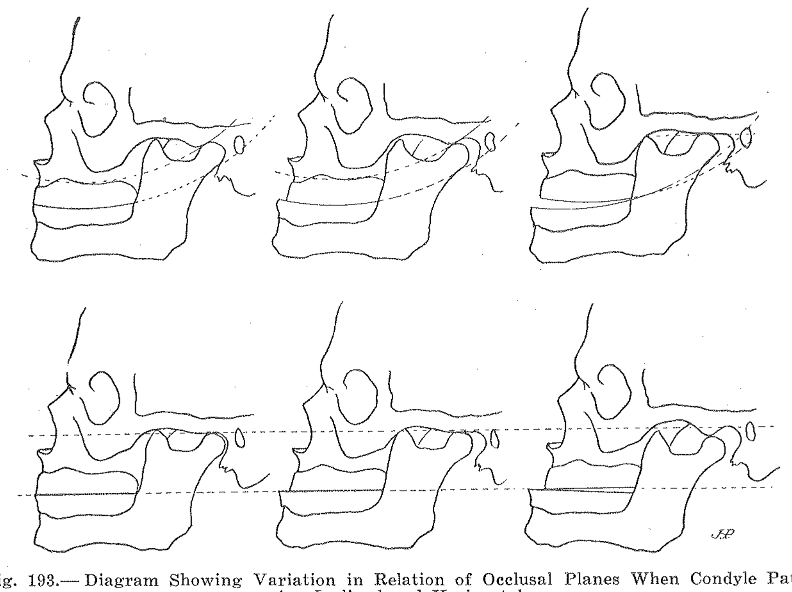


Fig. 193.—Diagram Showing Variation in Relation of Occlusal Planes When Condyle Paths Are Inclined and Horizontal

timber, when for any reason it cannot be turned in a lathe, the woodworker will first square the ends of the material, and on each end describe a circle of the same diameter as the column to be developed. Around these circles he will circumscribe polygons — usually octagons — the sides of which touch the circles tangentially and are parallel to each other. By drawing connecting lines from the angles of the polygon on one end, to the corresponding angles of the polygon on the opposite end, the surplus is marked off, which, when removed, reduces the square timber to polygonal form. Accurate mechanical reduction of the remaining surplus may be accomplished by again drawing polygons having twice the number of sides, on each end of the timber, their sides also tangential to the circles, connecting their angles and reducing the surplus in a similar manner. The remaining surplus is then reduced by planing off the line angles and testing with templets of proper curvature as the work proceeds.

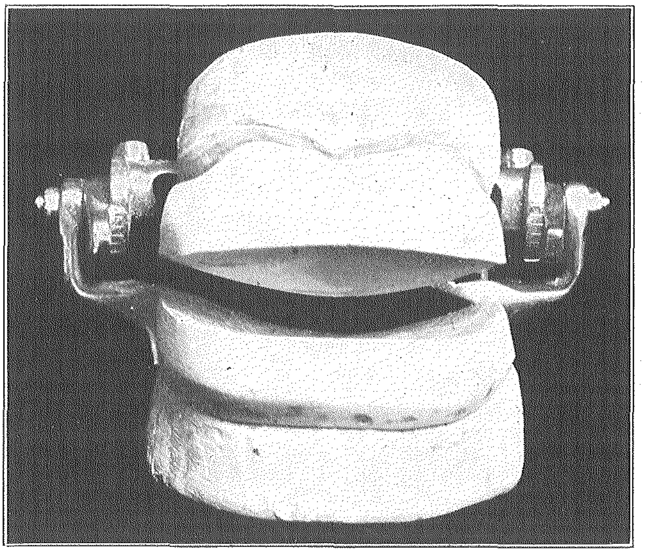


Fig. 194.— Convex and Concave Sphere Occlusion Models, Diagrammatic

In a similar manner the sculptor blocks out his statue in the rough, and the lapidist grinds off the rough and superfluous parts of gems, after which both apply the finishing touches.

A simple yet comparatively accurate plan of blocking out the compensating curves in the rough is as follows:

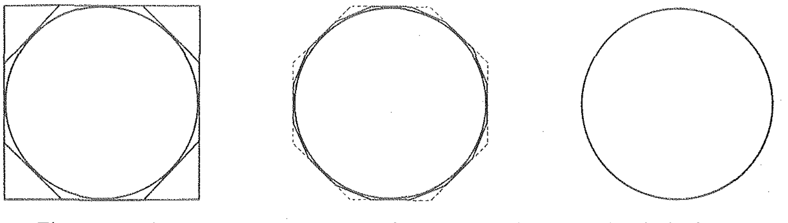


Fig. 195.— Diagram of Steps in Converting a Square Into a Cylindrical Figure

The slight protrusive mandibular effort required to bring the teeth in working and balancing relation seldom exceeds one-eighth of an inch. This distance represents the forward movement of the protruded condyle in its path, which for all practical purposes can be considered as a straight line tangential to the condyle path sphere. The slight deviation from a horizontal line of the lower occlusion model in the incisor region in its protruded position is scarcely perceptible, there being only one two hundred and fifty-sixth of an inch of separation, one-eighth of an inch from the labial surface of the wax when the drop of the condyle in its path is one-eighth of an inch.

The flat plane of occlusion in the incisor region may therefore be considered as another line or plane, tangent to the compensating curve.

Since the only object in developing the compensating curve, aside from esthetics, is to secure balancing contact, and since balancing contact is developed between the upper and lower second molars, it follows that if a tangent can be correctly located in the area to be occupied by the second molars, the plane thus developed will serve as a guide in setting the occlusal surfaces of these teeth.

The average distance from the condyle centers to the mesio-incisal angles of the lower incisor teeth is four inches in a straight line. The second molars are situated practically half-way between these two points, but being below a straight line, drawn between the points mentioned, they are usually about two and one-fourth inches from the second molar position.

The problem then may be stated as follows: Given two tangents of arcs developed from a common center from which to develop a third tangent between the two, having a similar angular inclination to each, or an angular *mean* between the two. This is an extremely simple problem to solve on a sheet of paper, and is accomplished as follows:

Project the two given tangents until they intersect. From the point of intersection lay off a point on each tangent equidistant from the point of intersection and connect the points so located with a straight line. If for any reason the two tangents cannot be extended to intersect, lines drawn parallel to them, which will intersect, may be developed, and the line of direction of the third tangent can easily be determined by these construction lines.

Now the difficulty met with in developing the third tangent on occlusion models is that the condyle path tangent if projected may strike the occlusion tangent too far forward in case of slight, or not at all in case of steep, pitch of the former. Neither is there a flat surface on which to make the measurements required. Yet with these difficulties encountered, a knowledge of a few fundamental facts will enable the prosthetist to develop the third tangent in a very short time.

The first fundamental fact to keep in mind is that under any and all conditions the occlusal plane, whether flat or curved, should be so located as to divide the space as equally as possible between the crests of the two borders, in order that there may be room for placing the teeth in each arch.

The second relates to how this space may be approximately divided evenly. Since the flat occlusal rims have previously been formed in most cases so as to divide the space between the borders equally, it follows that if the flat plane is to be changed to a curved plane, the change must be effected

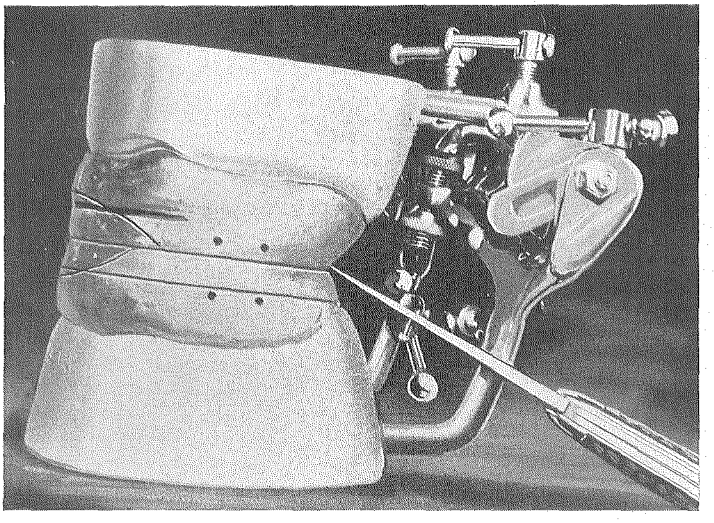


Fig. 196.— Locating Point A

by modifying both occlusion rims, paring off the upper and adding to the lower at the distal terminal, and reducing the lower and adding to the upper in the bicuspid region.

The third point is that the condyle path and the occlusal plane represent short tangents of a common arc, or concentric arcs having a common center, and therefore since they are tangents of common or parallel arcs, the position of the third tangent may be determined by developing one or more lines parallel to them to find the angle of intersection.

The direction of the third tangent, or, as it may be called, the second molar tangent, may be determined in several ways, the simplest being to project the occlusal plane backward beyond the point of intersection with the condyle path plane, and bisect the included angle, the bisection line giving the direction of the third tangent, but the line when developed may be too far forward or back of the required position.

Again the line of direction of the second molar tangent may be determined by laying off equidistant points from the point of intersection on both condyle path and occlusal plane tangent, and connecting the two points, as stated previously. This method places the position of the second molar tangent above and at times too far forward or back of the required position.

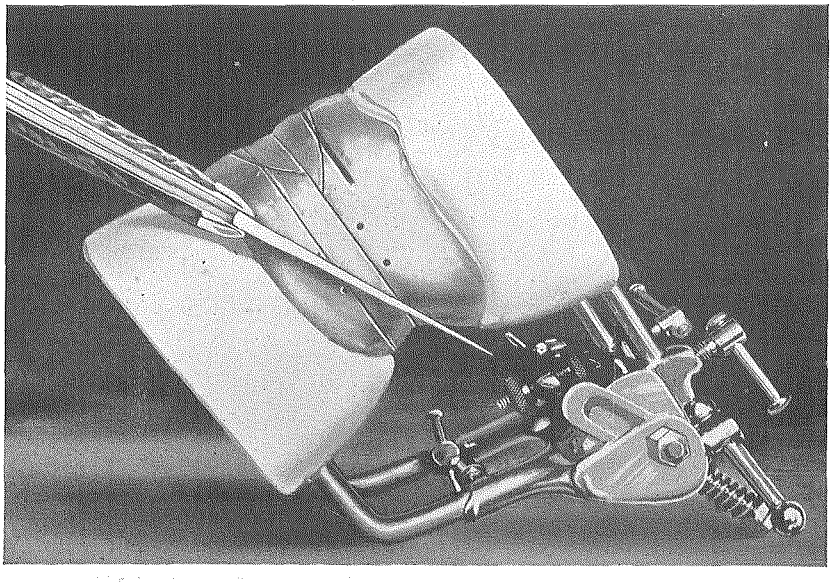


Fig. 197.— Marking Line B-C Continuous with or Parallel to the Condyle Path

The objections mentioned, together with the fact that the point of intersection is often back of the distal ends of the occlusion models, and therefore in space, frequently render both of these methods impracticable.

By the use of one or, in some cases, two parallel lines, these objections are overcome and the second molar tangent can be laid in its proper position without difficulty. The plan is as follows:

PRACTICAL STEPS

Locate on the upper occlusion model at its distal termination point A, Fig. 202, page 351, through which the compensating curve must and should pass. This point should be about one-sixteenth of an inch above the flat occlusal plane, since the latter, when changed to a curved plane, must be so developed as to divide the space between the upper and lower border crests equally, or as nearly so as is possible with a curved

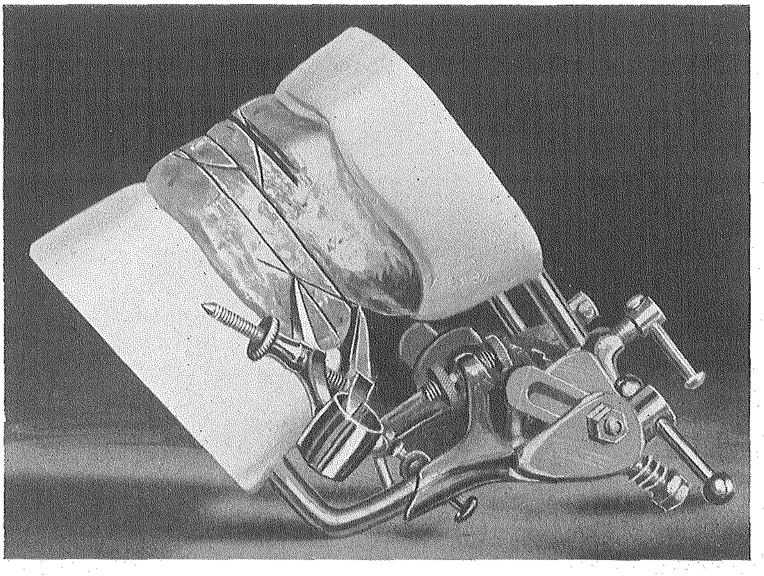


Fig. 198.— Calipering A-F on Condyle Line

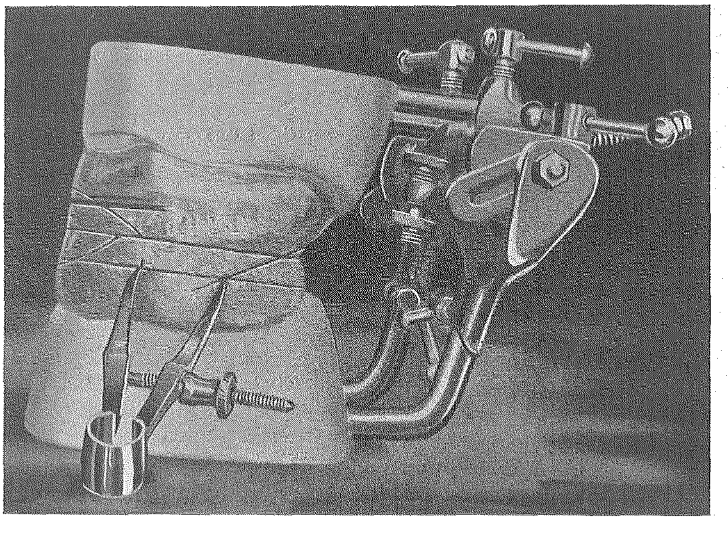


Fig. 199.— Laying Off Distance A-F on Sub-Occlusal Line

plane. This is necessary, as before stated, in order that space may be preserved for reception of the lower teeth. When the compensating curve is developed so that its distal termination coincides with the flat plane of occlusion, its curvature is developed at the expense of the lower occlusion model entirely.

Through point A draw line B, C, continuous or parallel with the condyle path, extending it diagonally across the lower occlusion rim. With a pair of dividers scribe line D, E, on the buccal surface of lower occlusion model, and about one-fourth inch below the flat occlusal plane. This subocclusal line intersects the projected condyle path line at F.

Place one leg of a divider on F, the other on A, with this as distance set off, F, G, on D, E. Draw line A, G, which represents a short tangent of an arc developed from the same center as the compensating curve and condyle path. At a point one-fourth inch in front of the distal terminal of line A, G, project a symmetrical, curved line forward, terminating it just in front of the cuspid eminence.

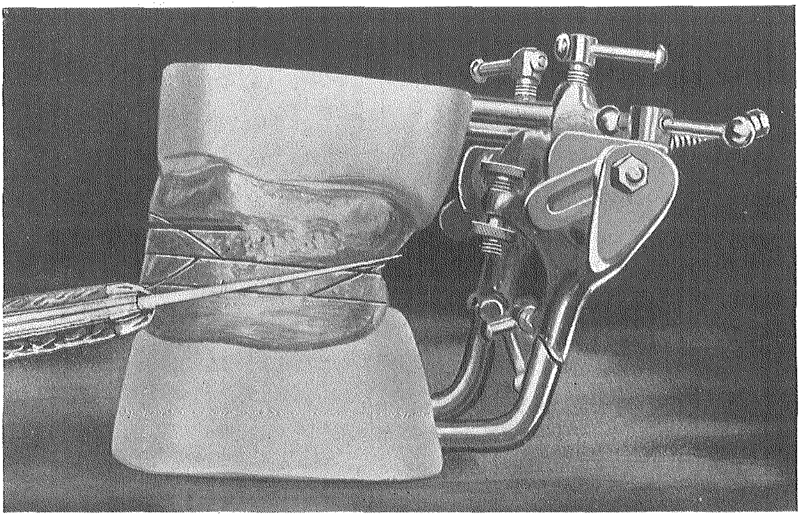


Fig. 200.— Connecting A-G. This Line in the Position of Second Molar Represents a Tangent to the Compensating Curve

The distal one-fourth inch line of A, G, represents the second molar tangent, both in position and line of direction, and is not changed in this blocking out of the compensating curve. Later it may or may not be slightly modified in the final correction of the curved occlusal plane.

With a condyle path pitch of 35 degs., the compensating curve will cut into the upper wax rim about one-sixteenth of an inch, as stated, and in the lower occlusion model about the same amount. When the condyle pitch is greater than the average, the curvature should be increased, and when less, decreased proportionately.

With the exception of the second molar areas, the curved line is developed with the eye. With a little experience a

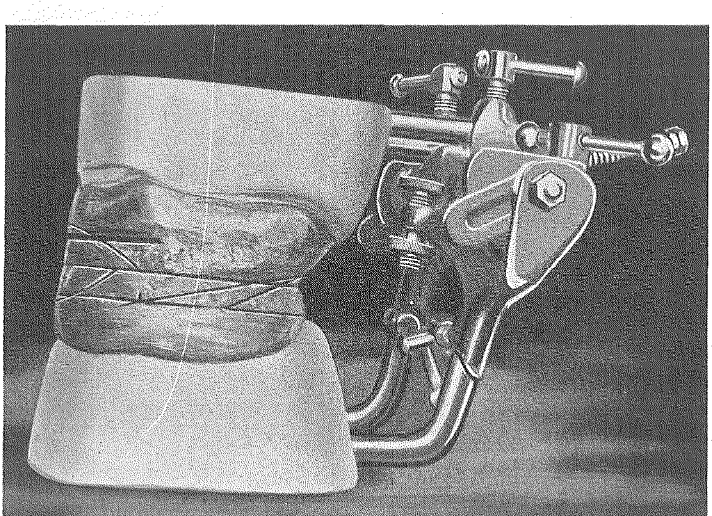


Fig. 201.— Completed Diagram Showing All Lines Except the Curve from Second Molar Forward to Mesial of Cuspid

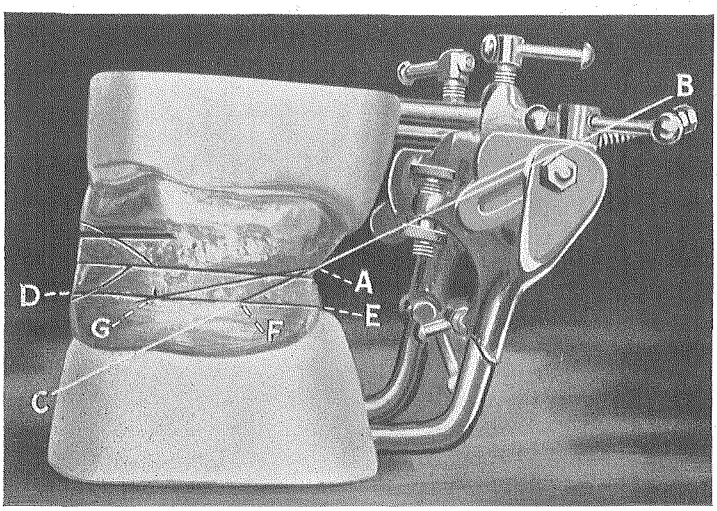


Fig. 202.— Diagram of Lines and Points Used in Developing the Posterior End of Compensating Curve A-G

just estimate of the correct curvature can be almost instantly determined.

A thin, hot blade spatula is used to divide the wax along line marked, from distal to cuspid terminals. That separated from each occlusion model by the blade is transferred to the opposite occlusal surface, and there attached with a hot spatula.

Test the accuracy of the balancing area of the blocked-out compensating curve by subjecting the occluding frame to protrusive and lateral movements.

By warming the occlusal surfaces of the rims, and rubbing talcum powder on them to prevent adhesion when brought

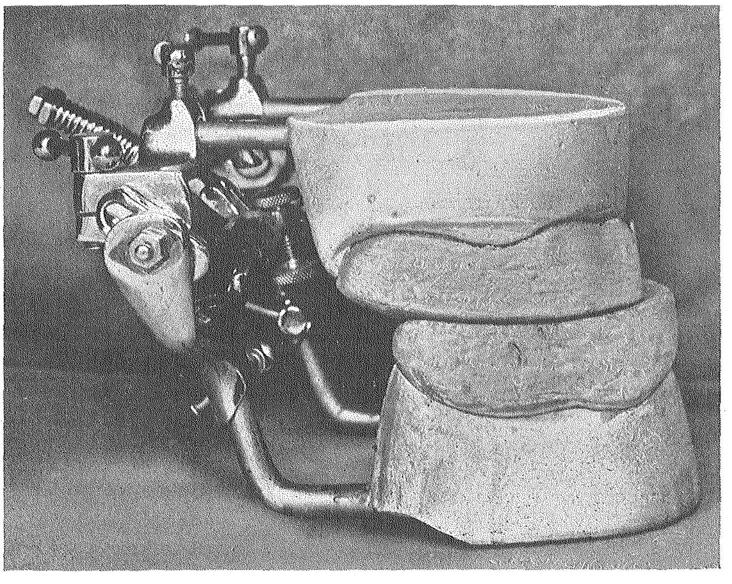


Fig. 203.— Compensating Curve Developed, Buccal View

together, corrections can readily be made by subjecting them to slight pressure in lateral movements of the occluding frame.

The Ulsaver Method

Dr. E. S. Ulsaver suggests attaching a softened mass of wax on the distal end of the lower occlusion rim, throwing the frame forward on that side to a distance of an eighth of an inch or possibly a little more, and closing the frame in this protruded lateral position.

Separate the occlusion models and trim off the excess wax, buccally and lingually. On closing the frame, it will be seen that the occlusion rims are prevented from striking by the wax addition, which presents the form of an inclined plane, the distal end being the thickest.

The upper wax rim is now trimmed to accommodate itself to the form of the built up, distal end of the lower rim. This is done by paring away with a knife, a little at a time, until the two rims again occlude.

With this incline as a basis, which is really the beginning of the compensating curve, it is a comparatively simple matter to develop symmetrical curves on both rims. The opposite side is developed in a similar manner. The addition of talcum powder to the rims prevents the softened wax from sticking in lateral and protrusive movements.

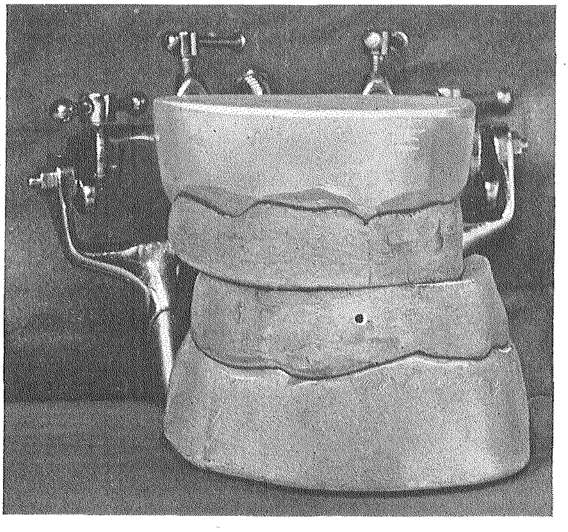


Fig. 204.— Occlusion Models Showing Lateral Curvature, Labial View

The only serious drawback to this otherwise excellent method of developing the compensating curve is that the curve is usually formed entirely at the expense of the upper rim.

Omitting Development of Compensating Curve

It is a fact that the teeth can be arranged to occlude, and balance as well, without previously developing the compensating curve on the occlusion models. To do so, however, departure from the flat occlusal plane must be made, either in the initial arrangement of the teeth or subsequently. This change involves the development of a similar curvature of the general occlusal surfaces of the teeth to that developed in the wax rims, as detailed. Comparison of the merits of the two methods is largely in favor of preliminary development of the compensating curve in the occlusion models, both from the standpoint of accuracy of result, and saving of time as well.

A method of developing balancing contact and which does not require the changing of the flat occlusion rim to curved planes has been suggested by Dr. G. H. Wilson.

This consists in *stepping* the upper second molar slightly above the first and raising the lower second molar correspondingly. In lateral movements, the mesial margin of the lower second molar engages with the distal margin of the upper first molar and in this manner balancing contact is secured. In reality, this method of arrangement is a *curve of steps*.

CHAPTER XIX

THE ESTHETICS OF TOOTH SELECTION

GENERAL CONSIDERATION

One of the most difficult problems of esthetics in prosthetic dentistry relates to the selection of teeth of such size, form and color as will harmonize with the features of edentulous patients.

Could the human race be classified into a few, or even many groups, the face forms of the individual members of each group being alike, or so closely similar that when the peculiarities of one were known all of the other members of that group would immediately be recognized, the problem would be simple. As a matter of fact, the faces of no two individuals in all probability were ever exactly alike in contour, proportion, disposition of lines or color effects of the complexion; hence the difficulty of establishing an accurate classification.

Numerous attempts have been made since Hippocrates' time, 2,400 years ago, to classify the human race into groups according to dominant characteristics. Practically all of these classifications were based upon the form, color and activity of the individuals.

In the older classifications, the cause of the differences noted in various individuals was attributed to the influence of four fluids, or humours, of the system, viz., the blood, phlegm, yellow and black bile. These several fluids, it was supposed, tempered or influenced both the form and habits of the individual, according to their relative predominance and potencies.

The older classification of temperaments was given as follows:

Sanguine (full blooded).
Phlegmatic (excess of watery fluids supposed to be elaborated in the brain).
Choleric (excess of yellow bile from the liver).
Melancholic or atrabilious (black bile supposed to come from the spleen).

Within the last century, when physiological functions became better known, the fallacy of this ancient temperamental basis was disclosed, and various writers on this subject have at different times suggested modifications. Among those most prominently identified in this field may be mentioned Gregory, Jacque, Laycock, Hutchinson and Spurzheim. A classification suggested by the latter is the best known of any at the present time, and is here presented with an abbreviated table in which the fundamental points of interest to the prosthetist are outlined:

Sanguine (dominance of circulatory system).
Nervous (preponderance of nervous element).
Bilious (excess of bile in system).
Lymphatic (superabundance of lymph).

CLASSIFICATION OF TEMPERAMENTS

Basal Temperaments	Eyes	Hair	Teeth	
			Color	Shape
Lymphatic	Pale blue or gray	Fine and silky, but without luster	Pallid, opaque or muddy yellow	Poorly shaped, broad and flat
Sanguine	Blue, brilliant and expressive	Blond-red or chestnut, seldom dark or black	Cream-yellow, darker at neck	Well-proportioned, curved and rounded
Nervous	Light gray or blue, restless, often morbidly brilliant	Fine, light and soft	Pearl gray, or blue tinge	Long, conical and rounded
Bilious	Black or brown, small and piercing	Coarse, dark, often black and abundant	Strong bronze yellow	Conical, long and angular

That the classification of temperaments just outlined, as a basis for the selection of teeth, is not without glaring defects, and very imperfect, cannot be denied; yet until quite recently, although much has been written, but little advancement has been made in this field.

Dr. Hutchinson, as quoted by Dr. Ivy, says: "Are we not obliged to confess that we have but little to guide us in a classification excepting the conditions which go to make up what we mean by complexion? In complexion we include the color of the hair and eyes, the state of the skin as regards thickness, thinness or transparency, and the various degrees of freedom of distribution of blood in the capillaries of the face. It is easy to apply with tolerable accuracy such words as blond, fair, dark, brunette, sallow, pale, florid, clear, muddy, and the like, and these and many others are epithets applicable to the complexion. Temperament, however, although to a large extent indicated by complexion, is generally held to include something more. If it did not, I fear we should find it but a sorry basis upon which to build a knowledge of the vital peculiarities of the individual. Yet again I ask what have we to which we can make appeal? We may examine a man's features, note the size of his bones, the shape of his jaws, the brilliancy of his eyes, the coarseness or fineness of his hair, his stature, his muscularity, his abundance or otherwise of cellular tissue and fat; but in observing all these things we shall be reminded that some of them are simply

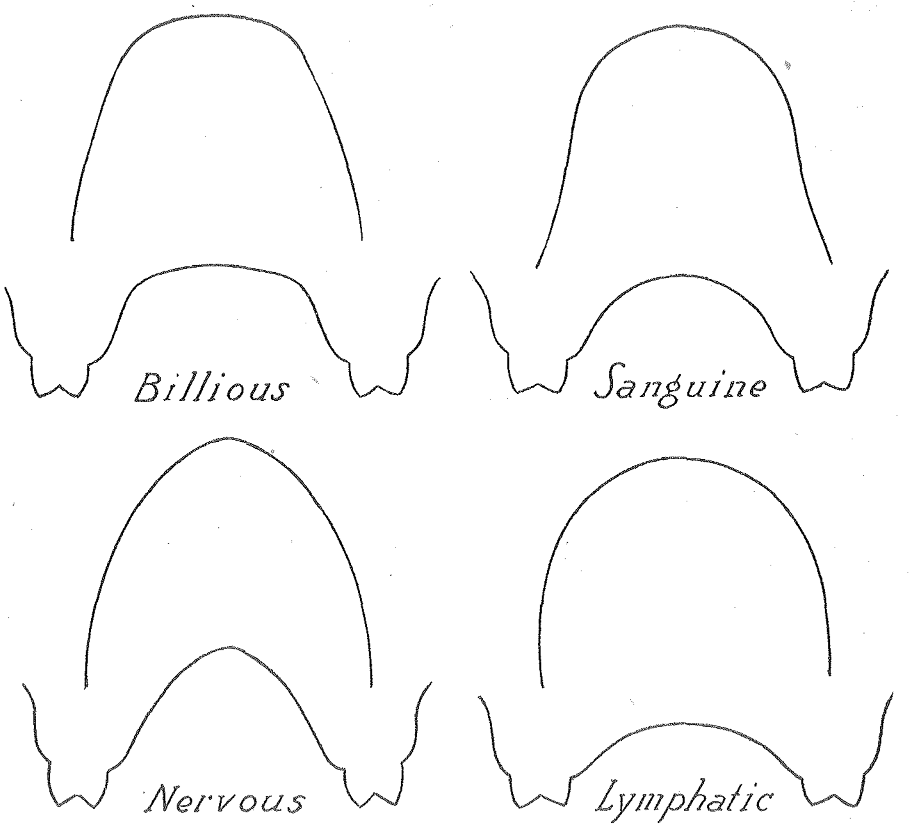


Fig. 205.— Diagrammatic Cut Showing Correspondence in Form of Alveolar and Palatine Arches (American System of Dentistry)

peculiarities of family or of race, and have little or nothing to do with health, while others are conditions which may vary much at different periods during the same life." (American System of Dentistry, p. 1031.)

Because of the comparatively rare occurrence of true basal types of temperament as given, and the innumerable variations from these types observed, the Spurzheim table is extremely limited in its scope. That it has served a useful purpose in a general way cannot be denied; first, in suggest-ing the possibility of form and color harmony of teeth with the individual, although lacking in adequate data for accomplishing the desired results; and, second, by keeping before the eyes of the dental profession the need of a better and more scientific method for the selection of teeth.

With the recognized imperfections of the temperamental table and the daily growing demands on the prosthetist in the esthetic field, some solution of this most intricate problem of tooth selection is not only desirable, but imperative. The basis of the solution lies apparently in a proper application of the laws of harmony of form and color, regardless of the age, nationality, race or temporary physical condition of the individual.

Harmony Defined

Harmony is defined as: "Completeness and perfection resulting from diversity in unity; agreement in relation; order; in art, a normal state of completeness and order in the relation of things to each other; an essential in form as an element of beauty; as the harmonies of nature; the harmony of a plan well thought out; the harmony of a ship's lines." (Standard Dictionary.) "Any arrangement or combination of related parts or elements that is consistent or esthetically pleasing; agreement of particulars according to some standard of consistency or the esthetic judgment." (Century Dictionary.)

Esthetics Defined

Esthetics is defined as "The philosophy of the beautiful." (Standard Dictionary.) "Esthetics, the science which deduces from nature and taste the rules and principles of art; the theory of the fine arts; the science of the beautiful, or that branch of philosophy which deals with its principles; the doctrine of taste." (Century Dictionary.)

Intuitive and Acquired Esthetics

We look upon certain recurring things in the material world as right and natural, because we are accustomed to them and because they are associated together. When one thing is mentioned, other things which usually occur with it are brought to mind. When mountains are spoken of, or seen in the distance, we immediately think of a range of them varying in elevation, more or less covered with forests, the home of flowers and birds and beasts, and through which streams flow.

When a particular color is seen, as, for instance, green, an artist will think of that color, its components, yellow and blue, and its complementary color, red.

When an architect, or one familiar with architecture, sees a structure, say, of the Grecian Doric order, even at a distance, he immediately recognizes it as such, and recalls to mind its massive, well-proportioned columns, its plain, substantial capitals, its undecorated architrave, the decorated frieze, the cornice, the triangular ends of the structure — usually sculptured — called the *pediment,* bounded above by the sloping cornice of the roof, and below by the horizontal cornice of the entablature. Structures of this type, as the Parthenon at Athens before its partial destruction, are conceded to be the most pleasing and perfect from an esthetic standpoint, of any that the hand of man has ever produced.

The production of such structures was rendered possible only by the gradual growth and development of the artistic sense and esthetic judgment, beginning with the dawn of civilization — a growth in development of the sense of proportions, harmony and fitness of things. To combine in such a structure as the Parthenon some of the more radical elements of the Byzantine or other dissimilar styles of architecture, would detract from its dignity and grandeur, and shock the esthetic taste of all beholders.

In these and innumerable other examples, the esthetic judgment is a law unto itself. It cannot be formulated by rule, but is dependent upon and has its origin in man's innate sense of the fitness of things. This sense of harmony, although totally dormant in some and a natural gift in others, is capable of cultivation, and in no profession or calling is there more need for its enhancement than among the members of our profession. The prosthetist must be able, not only to keenly appreciate beautiful things and recognize them when harmoniously arranged, but he must be able to execute them as well.

These examples, although apparently abstract, have a direct bearing on the subject under discussion — the selection of teeth of appropriate size, form and color for each edentulous patient who presents. Since, as is generally conceded, the temperamental table affords only the most meager assistance in this regard, some other means must be employed.

Basis for Tooth Selection

The basis of tooth selection, as previously stated, consists in judging what size, form and color of teeth will harmonize with the facial lineaments and color scheme of the individual. Just as in architecture, the openings of a building, the lines of its doors and windows must harmonize with the more massive lines of structure, so must the teeth, in their size and outline form, harmonize with the more massive lines of the face.

Again, in the decoration of a building, the color schemes employed must harmonize. Violent contrasts are oppressive and should be avoided, while lack of contrasts, or absence of complementary colors, produces a sense of dull monotony.

In the selection of teeth, the first two factors, size and form, are determined by the sense of proportion, the third by color judgment.

The teeth occupy a comparatively central position in the face, and since observation clearly shows that there is a general similarity in form between face outline and tooth outline in the same individual, a study of facial outlines is essential as a basis in tooth selection.

Facial Outlines

In Dr. Wilson's "Dental Prosthetics" is an illustration reproduced from a work published 100 years ago on the "Science of Beauty" by an English writer, Mme. Schimmelpennick, and which, by his permission, has been here introduced. The outlines of faces here shown are, of course, diagrammatic, and conform too rigidly to geometrical forms; yet they embrace practically all of the types of faces one sees nowadays, with perhaps the exception of the ovoid, and even that is a combination of the square with the round. Other combinations are, of course, possible, as the tapering with the round, or square or rectangular.

Naturally a tapering face indicates a tapering tooth. Since the outlines of such a face converge from forehead to chin and the taper of the tooth, when in position, is reversed, harmonious results will be secured if color and size are right.

An oval face calls for an oval tooth — one with sides slightly convex and angles rounded.

A square, or rectangular face, requires a tooth with nearly parallel sides, and with moderately well-defined angles, sometimes sharply angular, as in cases where the incisal edges are reduced to stimulate wear.

The width of a tooth should bear a similar relation to its length as the corresponding dimensions of the face bear to each other.

The problem of harmony in form and shade of teeth, with the individual, is of vital interest to both patient and pros-

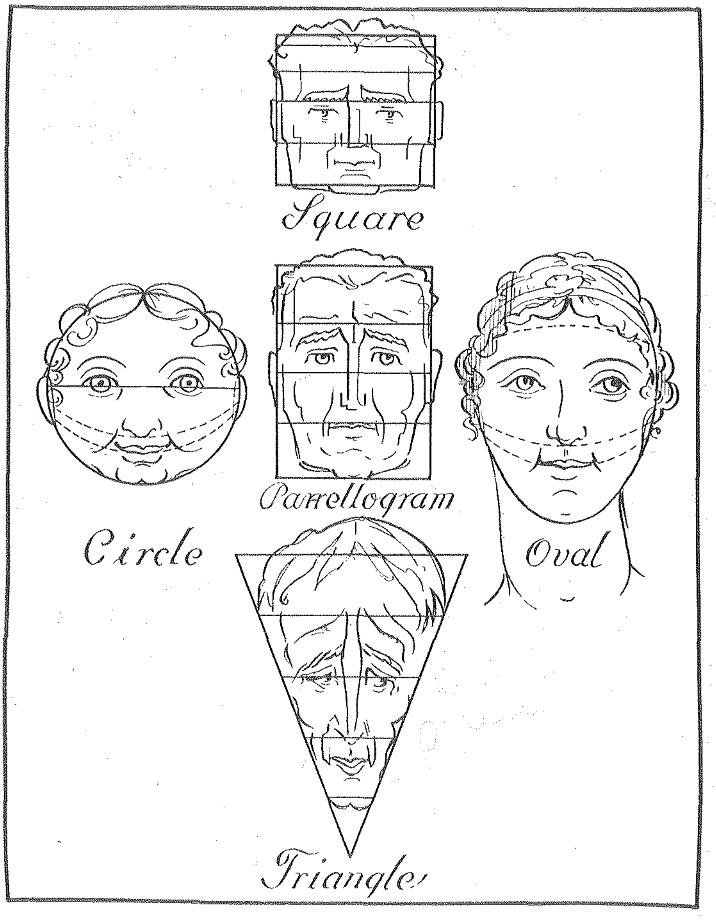


Fig. 206.— Reproduction of Madame Schimmelpennick's "Facial Forms"

thetist. To the patient, because the denture is a *part of himself*, to be worn in public and private life. To the prosthetist, if inharmonious, the denture, like Banquo's Ghost, which would not down, rises up at most inopportune times to remind him of his deficient technic and lack of esthetic judgment. It is furthermore, figuratively speaking, a standing monument, before the world at all times, of inartistic and misapplied dental effort.

Since human faces vary in outline, form, contour and general proportion, and since there are no fixed measurements available, to indicate with precision the exact length and width of teeth to select for edentulous cases, the necessity for cultivating the sense of proportion — esthetic judgment — becomes plainly apparent.

Every practitioner and student should interest himself in the collateral studies of clay modeling, free hand drawing and coloring, to acquire a rudimentary knowledge, at least,

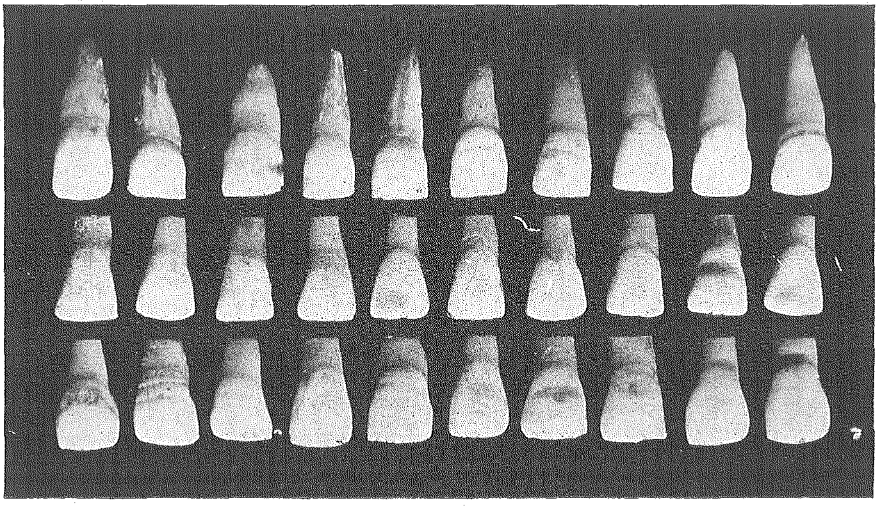


Fig. 207.— The Three Typal Forms of Teeth (Dr. J. Leon Williams)

to serve as a working basis in this most esthetic branch of dental science — prosthetic dentistry.

Natural Tooth Forms

Within recent years Dr. J. Leon Williams in his studies of natural forms has shown quite conclusively that although there are many variations in form and proportion in the teeth of different individuals of many races, there are but three *distinct typal forms.*

While variation from these three types are of frequent occurrence, such variations show certain characteristics common to the more distinctly marked types. Dr. Williams has classified these three most persistent typal forms, together with certain variations, as follows:

Class or Type I. Square Type.	Mesial and distal sides straight and parallel for one-half or more of the length of crown from incisal edge toward the cervix.

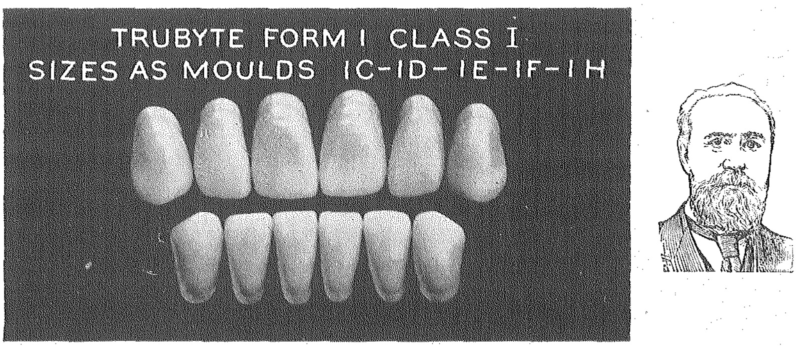


Fig. 208.— Class I, Form 1, Severest Modification of the Square Type

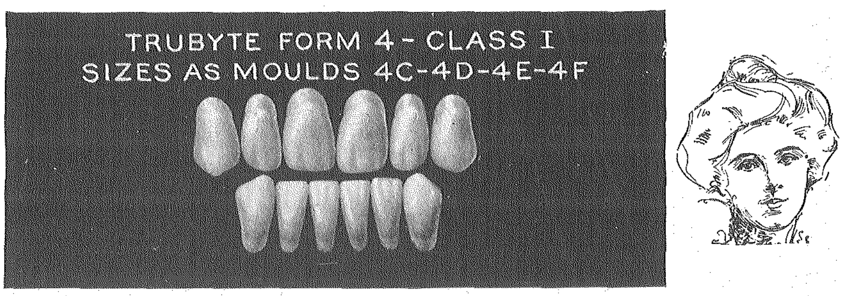


Fig. 209.— Class I, Form 4, Softest Modification of the Square Type

Class or Type II. Tapering Type.	Mesial and distal surfaces comparatively straight lines, but converging toward each other from incisal edge cervically.

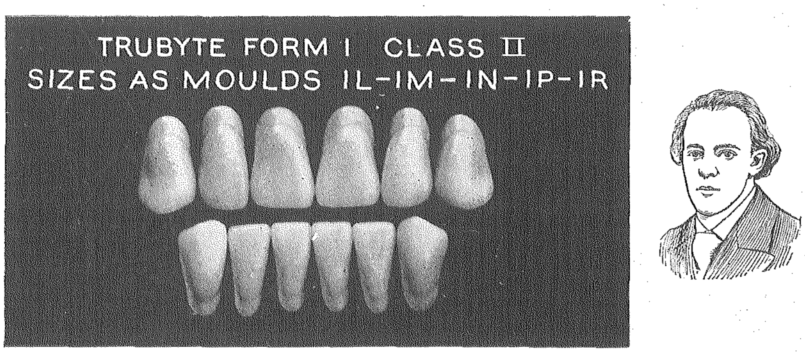


Fig. 210.— Class II, Form 1, Severest Modification of the Tapering Type

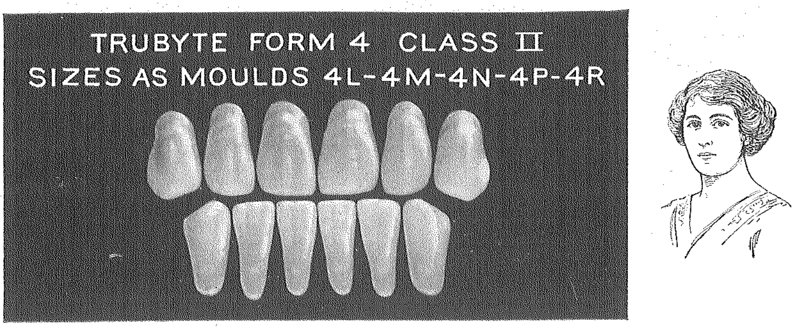


Fig. 211.— Class II, Form 4, Softest Modification of the Tapering Type

Class or Type III. Ovoid Type. — Mesial surface slightly convex, distal surface a compound curve, convex incisally, changing to concave as it passes toward the cervix.

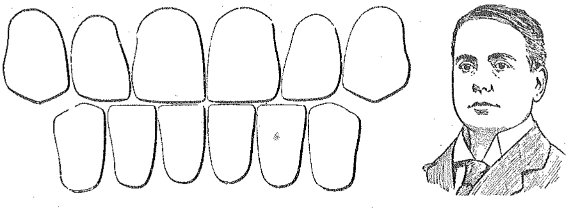


Fig. 212.— Class III, Form 1, Severe Modification of the Ovoid Type

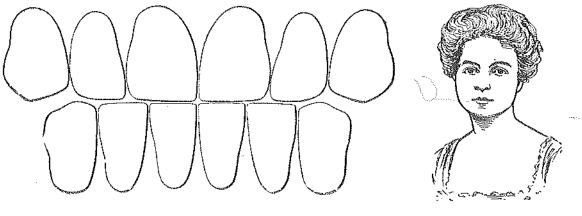


Fig. 213.— Class III, Form 4, Softest Modification of the Ovoid Type

Reproduction of Natural Tooth Forms in Porcelain

Using Dr. Williams' data as a basis, the Dentists' Supply Co. have reproduced in porcelain, from models carved by Dr. Williams himself, the three typal forms of teeth enumerated, in varying sizes, together with a sufficient number of modified types to meet average prosthetic requirements.

Class I contains five, Class II, four, and Class III, four modifications of form. Since each class and each modification is produced in several graded sizes, a large variety of sizes are thus available for use.

Dr. Williams' efforts have been devoted to the production of typal forms and modifications of the anterior teeth, and in this field he has arrived at most commendable and esthetic results.

Dr. Gysi, whose distinguished work in the field of anatomic occlusion is most widely and favorably known, has collaborated with Dr. Williams in the designing of full sets of typal

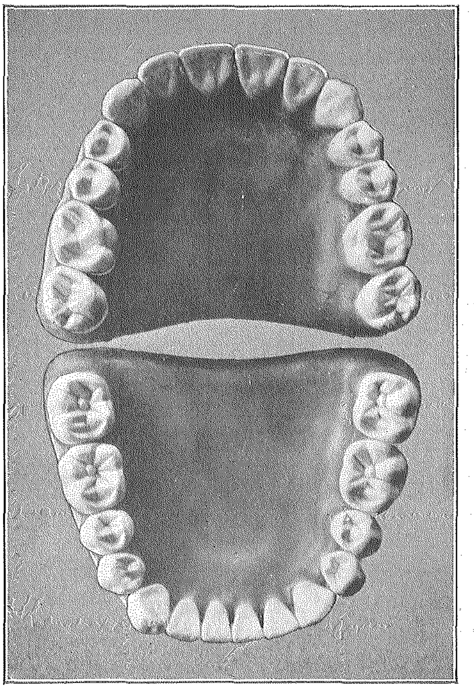


Fig. 214.— Occlusion View of True Bite Teeth Patterns Carved by Dr. Gysi

forms of teeth in porcelain. The patterns for the bicuspids and molars were furnished by Dr. Gysi. The upper and lower teeth of these classes are so proportioned in their mesio-distal diameters and their occlusal surfaces so formed that close-locking occlusion can be secured with comparative ease.

Clearance paths for the cusps of the lower between those of the upper teeth can be developed with but little, and in some cases no change of form, thus leaving the occlusal surfaces, which are strongly ridged and grooved, undisturbed for the more effective reduction of food.

Observed Outlines of Natural Teeth in the Mouth

The fact should be borne in mind that in the living, human subject the typal forms of teeth, as illustrated, do not show as distinctly as in extracted teeth, or in skull dentures, from around the teeth of which the gum tissues have been

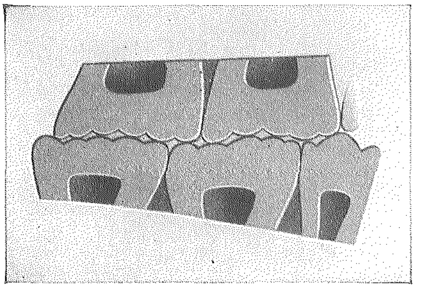


Fig. 215.— Sectional View of Molar Teeth, Showing Strongly Ridged Occlusal Surfaces

removed, because these tissues, particularly in early life, often cover some of the characteristic or determining class lines. Later on, or when gingival absorption at any time occurs, the class to which the teeth belong becomes apparent.

To know the typal forms of natural teeth is of vital importance, and time spent in analyzing these forms and variations will be well expended. Such knowledge will enable the prosthetist to produce esthetic effects not otherwise possible.

In the literature which the Dentists' Supply Co. furnish, descriptive of these typal forms of teeth, are also illustrations

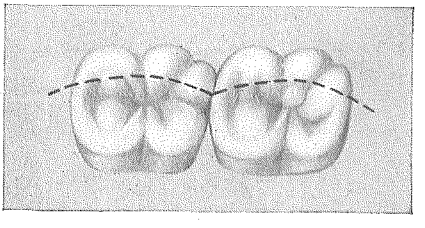


Fig. 216.— Occlusal View of Molar Surface Markings

showing not only mold forms of the teeth themselves, but of types of faces for which each mold is appropriate.

While a few of the illustrations referred to are here introduced, a perusal of the literature and a study of the entire series will prove most beneficial to the prosthetist in the selection of teeth of suitable forms for individual cases.

The accompanying half-tones of noted statues in the various galleries and museums of Europe and the United States illustrate quite plainly the types of faces to which Madame Schimmelpennick called attention a century ago.

"Admiral Farragut," "Saphira" and "Vulcan" represent the square type and would require the parallel-sided tooth of Class I.

Fig. 217.—"Admiral Farragut"

Fig. 218.—" Saphira "

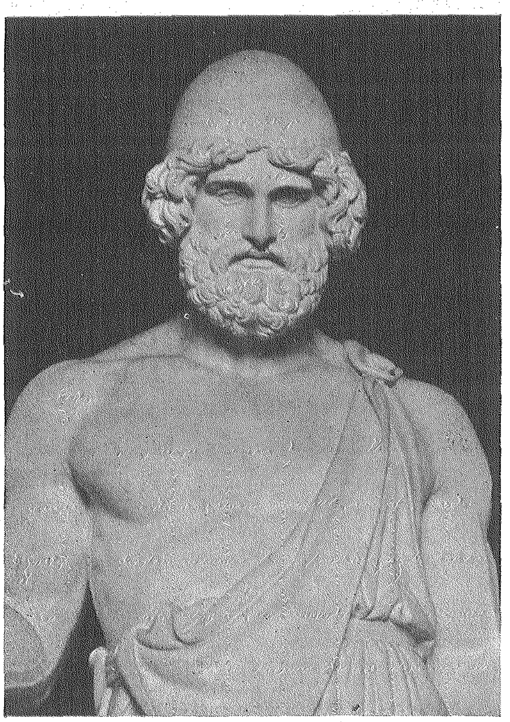


Fig. 219.—" Vulcan "

"Cicero," the "Vestal Virgin" and the statue of "A Young Woman" represent the tapering face and would require tapering teeth were dentures to be supplied them. Class II.

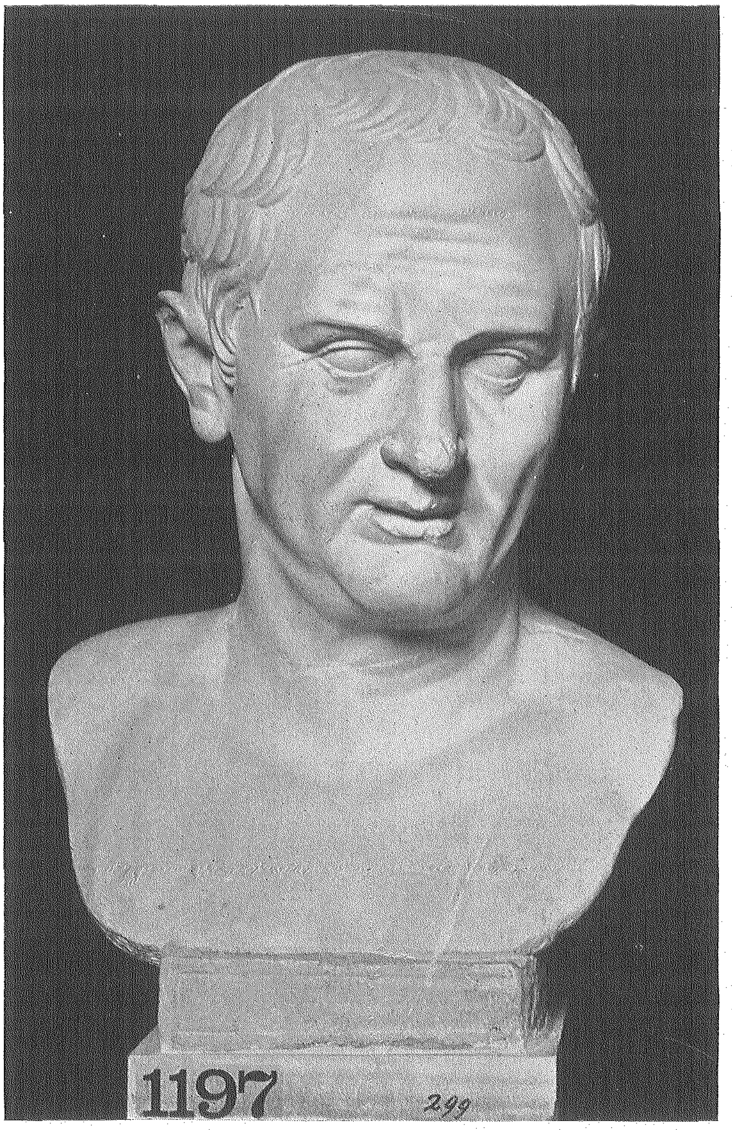


Fig. 220.—"Cicero"

Fig. 221.—"A Vestal Virgin"

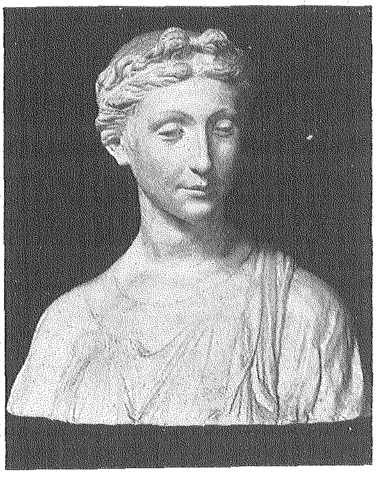


Fig. 222.—"Statue of a Young Woman"

"Juno," "Aphrodite" and "David" represent the oval type and would require the ovoid tooth of Class III.

Fig. 223.—" Juno "

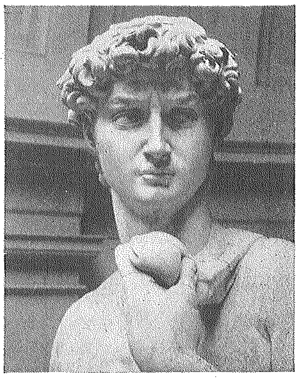


Fig. 223½.—" David "

Fig. 224.—"Aphrodite "

"Nero" represents a circle, very nearly, and could be supplied with a short, wide tooth of Class III.

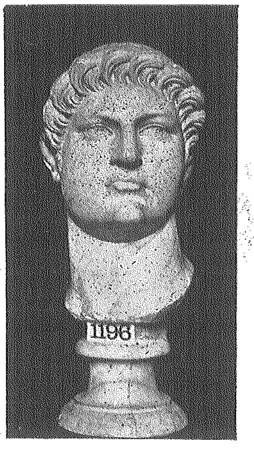


Fig. 225.—" Nero "

The head of "A Roman Lady" shows a severely straight though harmonious facial line.

Fig. 226.—"A Roman Lady "

The Color Problem in Tooth Selection

The problem of selection of artificial teeth that will harmonize with the general color scheme of the individual's complexion is a vital factor in the production of dentures of esthetic value.

That this subject is given too little consideration is apparent from observing the prosthetic restorations seen in the mouths of persons in all conditions of life. Many of these substitutes are out of harmony in color. The reason for this can only be found in the prosthetist's lack of knowledge of color principles.

The most logical means of avoiding such inharmony in this line as is daily apparent is by a study of the rules of harmony relating to colors, their complements and contrasts.

In Vanderpoel's "Color Problems" we find the following:

"The relation of color to light is much the same as that of music to sound. Color has its many hues, its long scales of tints and shades, its true and false chords. Mere sound gives us but little pleasure; when developed, however, into its highest form, music, we are thrilled, as by the song of a bird, a favorite ballad, or a Beethoven symphony. So in light, our enjoyment culminates at the glories of color in a flower or a sunset, at the shadows that play over the hills, or at the varied hues of a salt marsh. Hence, we may aptly term color *the music of light;* and when we think of the wonderful ways in which it has been used and combined by painters and designers for hundreds of years, it must seem strange to us that its harmonies have not been as thoroughly studied and classified as those of sound."

It must not be inferred, however, from the above quotation that a classified system of color science, capable of being utilized by anyone who so desires, is not available. As a matter of fact, many valuable scientific works have been written, some in the simplest language possible, in which the fundamental principles of color harmony are fully explained.

That these works have not been extensively recognized and more generally utilized in the past, particularly in specialized lines, as in prosthetic esthetics, is largely due to prevailing educational methods.

A brief outline of some of the principles of color harmony will now be given in the hope that it may not only be beneficial in a practical way, but prove an incentive to further study in this most interesting field.

A Synopsis of Color Principles

DEFINITIONS

"*Color* is the immaterial result of the decomposition of light. A ray of light in passing through a triangular prism is decomposed into a series of colors the same as a rainbow.

"*Paint or Pigment* is the material basis which decomposes light so as to reflect only some of its constituent colors.

"*Shade* refers to the chromatic composition of a color. Cobalt and cerulium offer us different shades of blue.

"*Tint* is the condition of a shade of color which arises from its admixture with water or white. It becomes, thereby, more or less intense without any change in its chromatic composition.

"*Tone* is the condition of a color in which it *appears* other than it *is*. A light blue under the effect of a bright or dull light will appear a light blue, yet, in the representation of these different conditions, different shades must be used; different tints would fail to convey a just idea of the color.

"*Harmony* is the effect of a proper arrangement of colors in a picture.

"*Contrast* is the effect arising from different colors being adjacent to one another, as red beside blue or yellow, etc." —(Bacon).

Color

The principal source of terrestrial light is the sun. Under ordinary conditions, light emanating from this source is white, or colorless.

By a process called *dispersion*, sunlight, as well as that derived from artificial sources, can be resolved into a series of different colors, known as *spectrum colors*.

Dispersion of light is accomplished by directing a ray of sun or artificial light through a shutter, into a darkened room, passing it through a horizontally fixed prism, or over a diffraction grating, and allowing it to fall upon a white screen.

By fixing the prism in such position that the light enters it at a slant, the beam will be bent twice in its course, first on entering, and second, on leaving the crystal. As a result, instead of showing as a spot on the screen it shows as a perpendicular band, or line, presenting a series of juxtaposed colors.

This indicates that certain colors, of which white light is composed, have different refractive indices, that is, the rays of one color will be bent at a different angle from those of another.

The colors and their order from above downward, as they appear on the screen, are as follows:

Purple.
*Blue.
Green.
*Yellow.
Orange.
*Red.
Purple.

Formerly the top color was rated as two colors, violet and indigo, but in 1890 the discovery was made that indigo was composed solely of blue and black, and as black is not a component of sunlight, indigo is not a possible prismatic color.

Each pair of juxtaposed colors blend almost imperceptibly into each other so as to present different shades and varying tints, just as they appear in the rainbow, yet the center of each color is clear, distinct and unmixed.

A distinction must be made between white light, which is immaterial or intangible, including the colors resulting from its dispersion, and pigment colors, which are composed of material substances.

Since we cannot distinguish the color of an object in the dark it naturally follows that either sun or artificial light must fall upon it to disclose its tint.

The reason why one object appears one color and another object a different color in the same light and under similar conditions is due to some inherent quality of the substances themselves for absorbing certain spectral colors and reflecting others.

For example, a red substance absorbs all the other colors of the spectrum but red, which is reflected. A green substance absorbs all the spectrum colors but blue and yellow, which, when mixed, produce green.

PRIMARY COLORS (PIGMENTS)

A primary color is one which cannot be formed by combining other colors. Blue, yellow and red are considered as pri-

* Primary colors.

maries, in both prismatic and pigment colors. From these, by their admixture in proper proportions, practically all other colors except white and black can be produced, and a very close approximation to these is possible.

SECONDARY COLORS

A secondary color is made by combining two primary colors in equal parts. There are three secondary colors: Green, orange and purple, which are formed as follows:

Green — from blue and yellow.
Orange — from yellow and red.
Purple — from blue and red.

TERTIARY COLORS

A tertiary color is made by mixing two secondary colors in equal parts. There are three secondary colors: Citrine, russet and olive, which are formed as follows:

Citrine — from orange and green.
Russet — from orange and purple.
Olive — from purple and green.

The formation of a tertiary color, by mixing two secondaries in equal parts, is equivalent to mixing two parts of one primary to one each of the other two primaries. For example, olive is formed from purple and green. Since purple contains one part of blue and one of red, and green is composed of one part of blue and one of yellow, it naturally follows that olive is composed of two parts of blue to one each of red and yellow.

INTERMEDIATE COLORS

When a primary and a secondary color are combined in equal parts they form what is known as an intermediate color. These are named and formed as follows:

Sulphur (yellow-green), three parts yellow to one of blue.

Saffron (yellow-orange), three parts yellow to one of red.

Nasturtium (red-orange), three parts red to one of yellow.

Garnet (red-purple), three parts red to one of blue.

Campanula (blue-purple), three parts blue to one of red.

Turquoise (blue-green), three parts blue to one of yellow.

By varying the proportions of the constituent pigments, it is possible to produce an almost endless variety of colors.

COMPLEMENTARY COLORS

Certain colors are pleasing to the eye, or *harmonize,* when placed alongside each other, while others are displeasing, or *inharmonious.* Those which are most pleasing are termed *complementary colors.* Now, why is this so?

As has been shown, the most satisfactory light to the visual organs is sunlight, subdued or diminished in its intensity to such degree as the optic nerve can tolerate with comfort. The same holds true of the more brilliant white varieties of artificial light.

Both natural and artificial light, as has been shown, when passed through a prism or over a diffraction grating are dispersed into the primary and secondary spectral colors.

It therefore follows that harmony in colors results from so mixing them or placing them in juxtaposition that all are represented, as in white light, though not necessarily in balanced proportions.

A complementary color is defined as one which supplies those colors that are lacking in another color. There are various ways of producing complementary effects, some complicated, and others quite simple. It is to the simplest of these that attention will now be directed.

The complement of red is green, because green is composed of blue and yellow, and, therefore, it supplies these two colors, which are lacking in red. Likewise the rule works both ways, for red is the complement of green.

The complement of blue is orange, and of orange, blue.

The complement of yellow is purple, and of purple, yellow.

As a general rule more harmonious results are produced when the complementary color is less pronounced than the principal color. When too conspicuous it lessens the prominence of the main color.

COLOR FUNCTIONS OF THE VISUAL ORGANS

These statements in regard to colors and their complements are not arbitrary rules, promulgated for convenience, but are based upon physiologic functions of the visual organs, and can be demonstrated by anyone to his own satisfaction.

For example, when one gazes intently at a red object for two or three minutes, until the eyes become saturated with that color, and then closes the eyes an image of the object will still be seen, not in red, however, but in green.

If, instead of closing the eyes, one continues to gaze at the same or other red objects, a greater or less sense of monotony and visual fatigue is experienced, which is immediately relieved on looking at something green. The same holds true of the other colors and their complements.

The tiring of the visual organs, when compelled to gaze continuously at incomplete spectral colors, together with the automatic formation of complementary colors within the eyes, clearly indicates that white light, which contains all of the prismatic colors, is normally and naturally demanded by the organs of vision.

When the principal color viewed is not intense, but represents a more or less dilute tint of a primary, secondary or intermediate color, the corresponding complement will be proportionately reduced.

Whatever the color scheme may be, the strength or *tone* of the various colors should accord. "The note struck may be high or low, but should be maintained throughout the color scheme. A crude, strong color, though otherwise harmonious, will clash discordantly among delicate tints of a notably lighter tone." (Sanford.)

The question may arise in the reader's mind, "Of what value is this discourse on the physics of light, and the harmony of colors, to the prosthetist?" Simply this: Without a rudimentary knowledge of the physics of light, and the natural laws of the harmony of crude colors and their complements, the selection of teeth of appropriate shade, or tint, becomes a difficult, and in some cases, an impossible task.

The artist, or artisan, can lighten or strengthen the principals or complementaries of the color scheme he is creating, and arrive at a just balance of harmony between the two.

The color scheme which presents to the prosthetist, which he works with, and he cannot change, is the patient's face. Here the flesh tints of the complexion display themselves in the integument according to the general characteristics, habits of life and health of the individual.

The prevailing tones are gray and yellow, tinged with red and brown. Now since gray consists of white and black, the degree of grayness determines the tone of the complexion, whether light or dark. The reds and browns always appear in more or less attenuated form, and usually are modified by admixture with other colors to suggest secondaries or intermediates.

The hair, to a marked degree, contributes to the general color scheme of the individual. In color it may range from white to black, including intermediate shades of yellow, red and brown. As a rule, light hair and light complexions are associated, while dark or black hair usually implies a more strongly pigmented integument in which perceptible tints of reds and browns more or less diluted, yet plainly apparent, are noticeable.

The lips range in color from a gray, which at times is scarcely distinguishable from the integument, through varying shades of pink, red, brown to purple, depending largely on the vitality and age of the individual. They form the immediate setting, or frame work, for the teeth.

In addition to the usually pronounced color of the lips in which the teeth are framed, the shadows of the lips and oral cavity must also be considered. These shadows tend to soften the lighter teeth and blend them with the more darkly shaded integument.

Dr. G. W. Clapp, who, with the aid of a color expert, examined many individuals, in an effort to determine the percentage of various colors present in natural teeth, gives the data of one case as follows:

Miss D. A.	Age 19 Wt. 119 lbs. Ht. 5.6 in.	Red	Yellow	Blue	Black	Orange	Color Developed	
	Eyes	17.5	43.0	16.0	16.0	1.5	25.5	yel.
	Hair	Dead	Black					
UPPERS	Skin	4.1	3.0	.88	.88	2.12	1.1	red
U. R. Central........	Cervical	1.1	1.4	.20	.20	.90	.3	yel.
	Incisal	1.1	1.35	.34	.34	.76	.25	yel.

COLORS FOUND IN NATURAL TEETH

According to Dr. Clapp's analyses, many colors are to be found in the natural teeth. With gray as a foundation, the predominance of some one of the primary or secondary colors gives the tooth its color individuality. He says: "Natural teeth exhibit every color of the rainbow. The primary colors, red, blue and yellow, are found in every human tooth. At least one of the secondary colors, orange, green or violet, is found in every tooth, generally with an excess of some primary color which gives to the tooth its recognized color as a blue, a yellow or a pink. Gray teeth occur when there is no excess of primary color."

SUGGESTIONS

In the selection of teeth for a given case no specific rules can be laid down, because of the wide variation in color schemes of different individuals. Persons with complexions showing pronouneed reds or browns, and with dark hair, require comparatively dark teeth, in which orange or pink tints predominate.

Persons are frequently seen whose general color scheme is neutral, no pronounced primary or secondary colors apparent. Either a very dark or a light tooth for such a case would be inappropriate, by attracting too much attention to the mouth. Teeth of gray shade or neutral tint should be selected and of such depth of tint as will coincide with the complexion.

Fair or light complected persons require correspondingly light teeth, tinged with yellow or blue, sometimes almost neutral as to primaries and secondaries.

White teeth are inappropriate in all cases, although patients frequently demand them. Natural teeth are never white, the nearest approach being a light shade of gray. The harmony and esthetic appearance of many otherwise good dentures is frequently spoiled by the use of teeth of too light shade.

As has been shown, the color scheme of an individual may range from pronounced primaries or secondaries, through imperceptibly attenuating gradations to neutral grays, in which none of the prismatic colors are discernible.

This color scheme, painted by nature's hand, is the prosthetist's canvas, in which he must place a central setting, the teeth. How, then, can he hope to attain esthetic results without a knowledge of the laws of harmony of colors?

The physiologic color function of the eye, previously referred to, which automatically creates the complementary of a pronounced color, is an aid, in the selection of teeth, to those deficient in a knowledge of the laws of harmony.

In some individuals this *intuition,* if it might be so called, is an efficient, though unrecognized, guide in choosing teeth that will "look well," while the results attained through this means are at times pleasing and harmonious.

More often, however, when the physiologic function is imperfectly developed or totally lacking, as in the color blind, most inharmonious selections result, a fact plainly apparent to anyone in whom this faculty is not deficient.

The selection of teeth for edentulous cases is not a problem of matching shades, but of harmonizing colors by gradations and complementaries, the general color scheme of the patient affording the basis for such selection.

It is hoped that this discourse on color and form, brief and imperfect as it is, has disclosed its importance in the field of dental prosthetics, and that it will create in the mind of the reader an interest in and a desire for more extended knowledge in the esthetic field.

CHAPTER XX

ARRANGING AND OCCLUDING THE TEETH

Upper Arch

ARRANGING THE SIX ANTERIOR TEETH

The full upper set of fourteen teeth should be first arranged, beginning with the central incisors. A section of wax is removed from the upper occlusion rim of sufficient width, length and depth to receive a central incisor. Into the space so formed a central incisor is set, its mesio-labial angle in line with the median line previously marked on the wax rim.

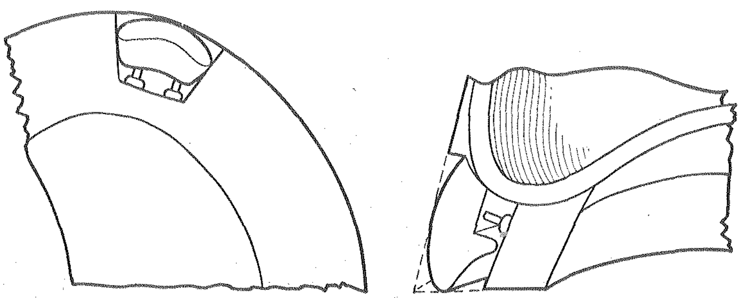


Fig. 227.— Diagrammatic Cut Showing Section of Wax Removed with Tooth in Correct Labial and Incisal Position

The labial contour of the tooth should coincide with the general labial contour of the rim, the two undisturbed margins of wax on either side of the space serving as guides in securing correct alignment. Its incisal edge is brought even with the incisal rim of wax. When set, the tooth should occupy the space of and restore the disturbed contour occasioned by the removal of the section of wax. In nearly all cases the long axes of the centrals, when viewed labially, should diverge slightly from incisal to gingival, away from the median line, the horizontal alignment mesio-distally of the incisal edge serving as a guide, or at least strongly indicating the amount of such divergence. When in proper position, a hot spatula is passed in back of the tooth so as to melt the wax, not only around the pins, but against the entire lingual surface as well, and thus firmly fix it in place.

In like manner a section of wax is removed and the lateral incisor is set in position, the central just placed on its mesial side, and the undisturbed wax in the cuspid area on the distal serving as guides for its correct labial alignment. The cuspid is then set and fixed in similar manner.

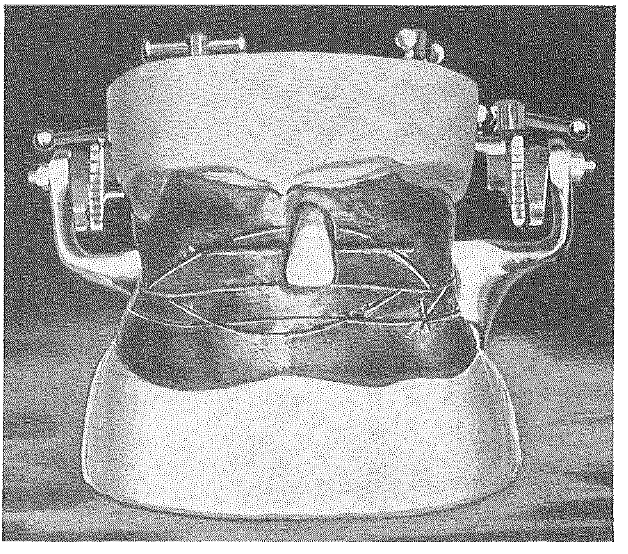


Fig. 228.— View of Upper Left Central Incisor Adjusted in Occlusion Rim

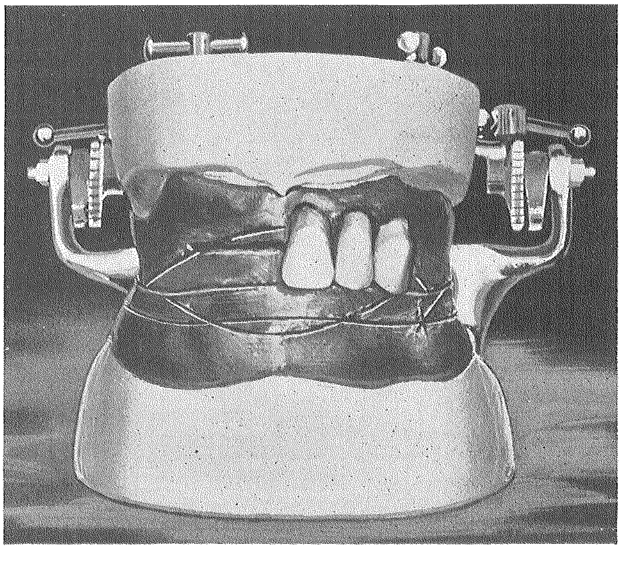


Fig. 229.— Upper Central Lateral and Cuspid Arranged

It will usually be best to return to the median line and place the other three anterior teeth in the order mentioned, so that should rearrangement for esthetic reasons be necessary, it can be more readily accomplished now than after any of the posterior teeth are placed.

Arranging the Posterior Teeth

The first and second bicuspids and first and second molars on one side are set in a similar manner in the order named, followed by the arrangement of the teeth on the opposite side.

After removing the section of wax for each posterior

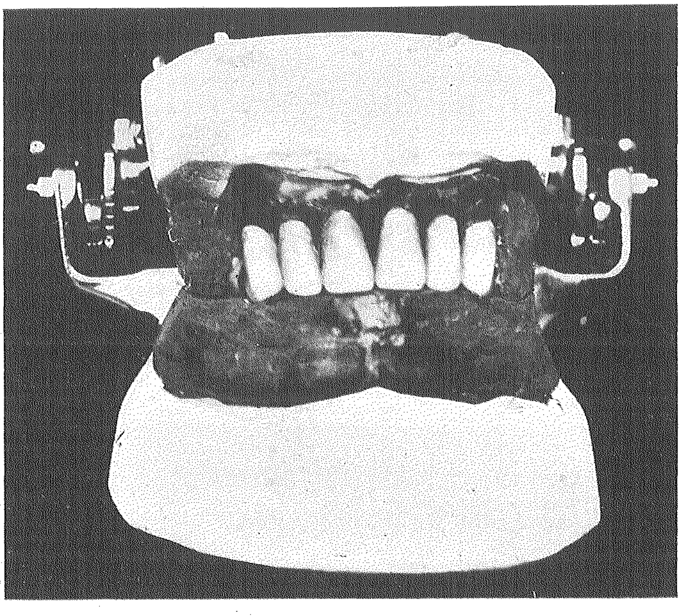


Fig. 230.— Six Anteriors Arranged and Waxed in Position

tooth, the walls of the matrix so formed should be thoroughly softened with a hot spatula, the tooth pressed into buccal alignment, and the frame closed. This brings the occlusal rim of the lower occlusion model up in contact with the tooth, which, if longer than normal, establishes its correct incisal or occlusal length.

If shorter than required, it must be brought down in close contact with the lower wax rim when closed. In fact, the tips of the cusps of all of the upper bicuspids and molars should be sunk one-half their depth in the lower occlusion rim. This may readily be done by softening the wax slightly where the cusps strike, as each tooth is placed. The reason for this is that when the tips of the upper bicuspids and molars are not imbedded as described, but are allowed to rest on the undisturbed lower wax rim, in arranging the corresponding lower teeth they must be raised the full depth of their cusps, and even higher, in order to bring them into occlusion with the upper teeth. This raises the occlusal plane of the denture in the bicuspid and molar region from one-sixteenth to one-eighth of an inch above the line established by trial of the wax occlusion models.

By following the plan outlined, the cusps of the upper teeth pass slightly below, and those of the lower slightly

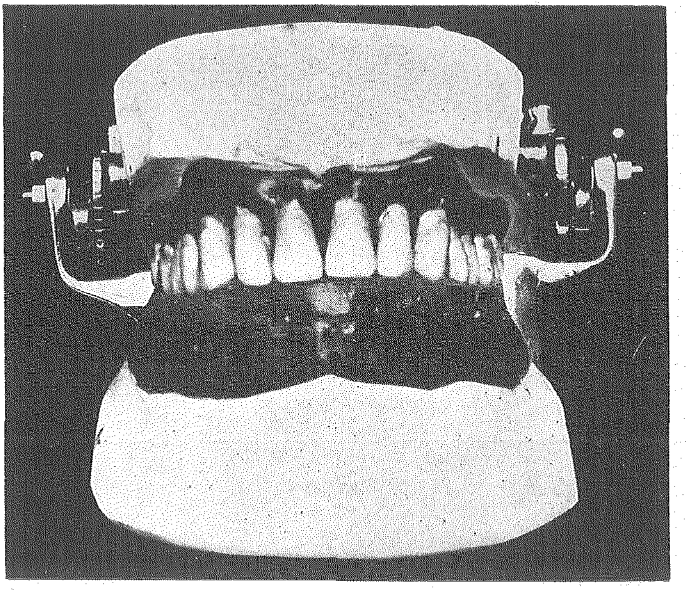


Fig. 231.— Full Upper Denture Occluded

above, the wax occlusal plane, thus maintaining the normal position of the plane as previously determined.

ARRANGING THE LOWER TEETH IN OCCLUSION WITH UPPER TEETH

The arrangement of the teeth in the lower arch should begin with the lower second bicuspid because better interlocking of the various planes and cusps can be secured with the occluding teeth than when the same order of arrangement is followed as in the upper arch, viz., centrals, laterals, cuspids, etc.

A section of wax is removed from the lower occlusion rim directly opposite the distal one-half of the upper first and mesial one-half of the upper second bicuspids. A heated spatula is thrust deeply into the floor of the space, and the side walls, particularly toward the lingual, are thoroughly softened.

The lower second bicuspid is set in this softened matrix, its occlusal surface considerably above normal position. The

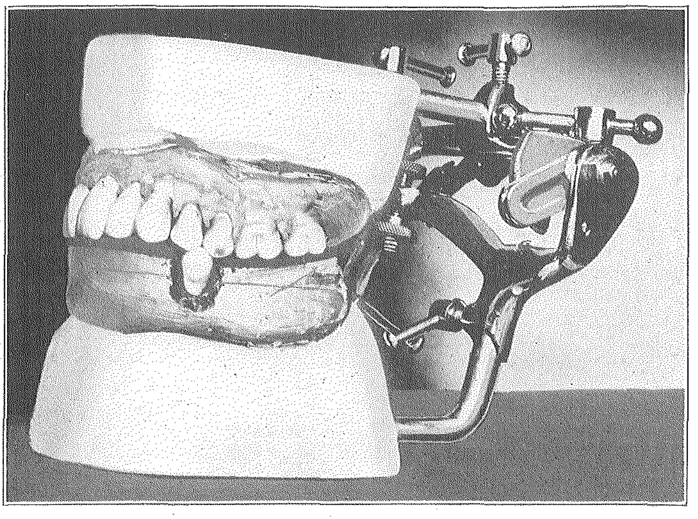


Fig. 232.— Lower Second Bicuspid Set in Softened Wax, but Slightly Above Position. By Closure of the Frame It Is Forced Downward and in Approximately Correct Occlusion

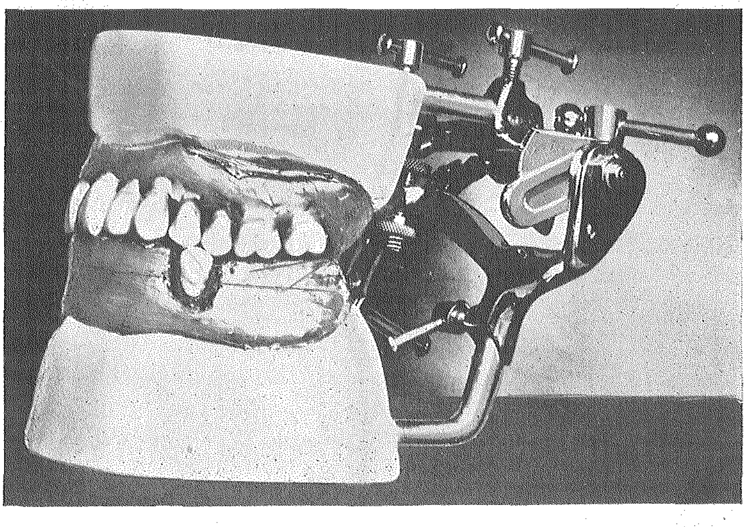


Fig. 233.— Cut Showing Proper Contact Developed between the Marginal Ridges

frame is then carefully and slowly closed, using reasonable force if necessary to bring the upper teeth in contact with the lower occlusion rim. The wax in which the upper teeth are imbedded should be thoroughly chilled, previous to and during this step, to prevent their displacement under the applied pressure.

The closing of the frame brings the upper bicuspids in contact with the elongated lower second bicuspid, and forces it down to place. If carefully carried out and the wax is sufficiently plastic, the various planes of the teeth will become closely interlocked, as in normally occluded natural teeth.

Care should be taken to see that in closing the frame the lower bicuspid is not forced outward gingivally. This will most certainly occur on account of the slope of the ridge lap

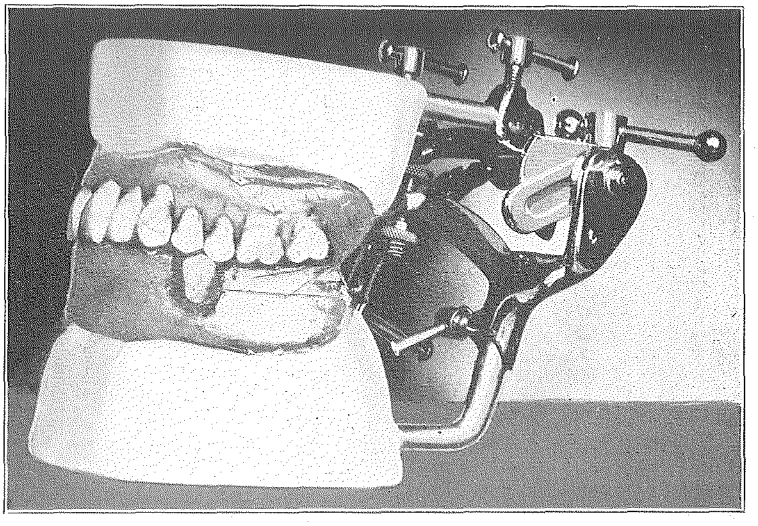


Fig. 234.—Frame Thrown to Left to Test Contact of Buccal Marginal Ridges. In This Case There Is Imperfect Contact between Mesial Ridge of Lower Second, and Distal Ridge of Upper First Bicuspid

acting as an inclined plane, thus directing the tooth outward as it settles into the wax, unless counter-pressure is applied gingivally to keep it in proper alignment.

TESTING THE OCCLUSAL SURFACES FOR WORKING EFFICIENCY

Before placing the next tooth the relation of the lower second to the upper first and second bicuspids should be tested as to its *working efficiency.* This is done by drawing the lower portion of the frame outward on the side being tested, so as to bring the buccal marginal ridge of the lower second bicuspid outward and directly under the corresponding ridges of the occluding teeth.

Usually, although in full occlusion the tooth may have interlocked well with the opposite teeth, it will be found that while the mesial or distal slope of the buccal marginal ridge finds contact with the opposite tooth, the other slope does not strike, a space of greater or less width being apparent (see Fig. 234, page 387).

This defect may be remedied by holding the frame in lateral position, and moving the lower bicuspid bodily forward or backward, as required, until the planes are brought in close contact and the wax surrounding the tooth chilled, when the frame is allowed to spring back to position.

A piece of carbon paper inserted between the occlusal surfaces will, under pressure, disclose the points of interference in normal occlusion, which can be ground away with a small

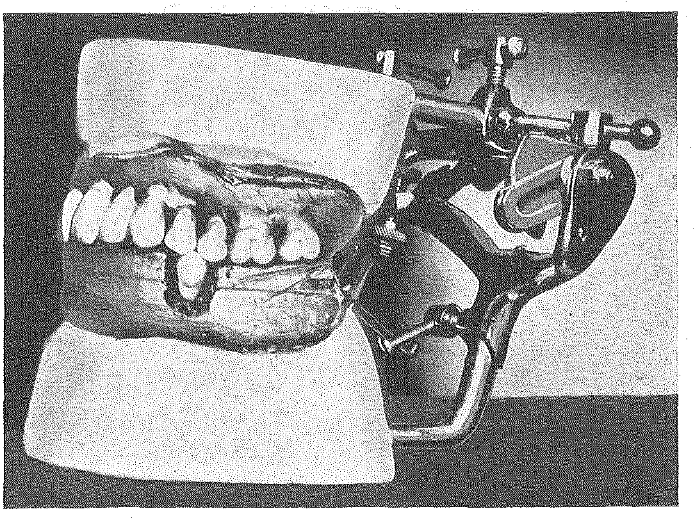


Fig. 235.— Lower First Bicuspid in Occlusion. Brought in Occlusion by Moving It Forward

engine-stone. The mesial and distal marginal ridges of the opposing teeth are usually the points needing correction.

Another method quite as efficient in some cases, particularly where but little correction is required, is to soften the wax in which the three teeth are imbedded so that with slight pressure they may change their position. By carefully subjecting the frame to lateral movements, at the same time exerting slight pressure to keep the teeth in occlusion, the position of both upper and lower teeth may be modified so as to correct the defects mentioned, without much, if any, grinding.

SECURING CONTACT OF THE LINGUAL MARGINAL RIDGES

Now, while occlusal requirements may be perfectly developed and contact of the mesial and distal slopes of the buccal marginal ridges may be secured, it is frequently the case that contact of the lingual marginal ridges between the lower and upper teeth is defective or entirely lacking. Since the efficiency of the masticatory apparatus depends upon close contact of both buccal and lingual marginal ridges quite as much as upon good occlusal contact, it is necessary to work out the required contact of the lingual marginal ridges also.

Failure to develop contact lingually in the first steps of arrangement is usually the result of too long buccal cusps of the lower, or too short lingual cusps of the upper teeth. When, however, the teeth are well proportioned, lack of contact may

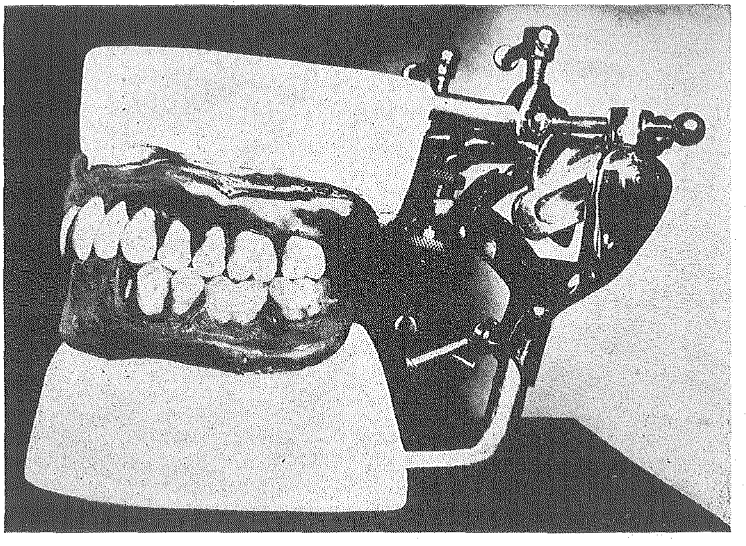


Fig. 236.— The Left Lower Bicuspids and Molars Occluded

be due to inclining or tipping the teeth in one or both arches too far lingually, that is to say, while their cervical position may be correct, their occlusal ends may incline too much to the lingual. Correction may be made in the former case by reducing the length of the cusps by grinding, and in the latter by changing the inclination of the teeth in the wax. The time required for effecting such changes as noted is very slight, and when corrected as soon as discovered, and as each tooth is set, usually obviates more general or extensive modifications later on.

A section of wax is now removed for the reception of the lower first molar, the matrix walls softened, the tooth set in a slightly elevated position, pressure exerted on its cervix, and the occluding frame closed to force it into position as previously described. In like manner similar tests are applied, and corrections made to improve occlusion and contact between the buccal and lingual marginal ridges. Similar steps are carried out in adjusting the second molar and first bicuspid in the order named, after which the bicuspids and molars on the opposite side are arranged in similar order and manner.

ARRANGING THE SIX LOWER ANTERIOR TEETH

The six anterior teeth can now be set in position. These are placed in the wax rim in the following order: cuspids, laterals and centrals.

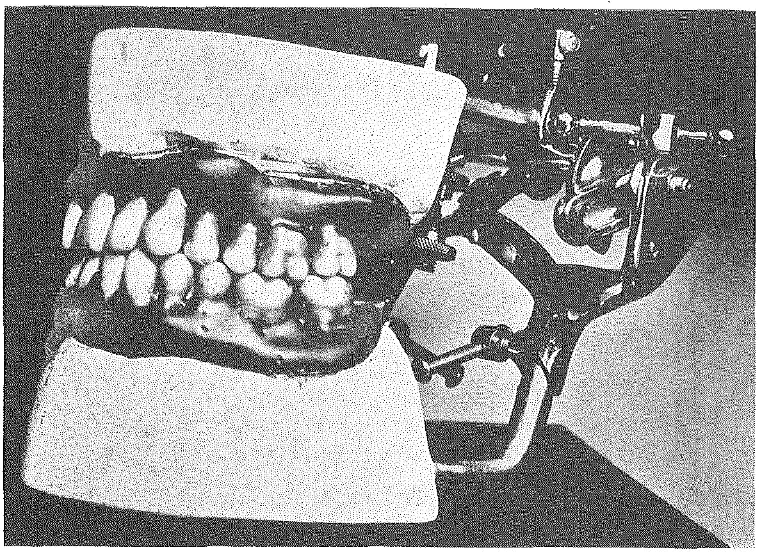


Fig. 237.— Buccal View of Full Denture Occluded. Gums Not Carved

Should the teeth prove too narrow to fill the space when aligned in proper curvature, a wider set of sixes should be substituted, or if too wide, a narrow set can be used. When only slightly excessive in width, correction may be made by grinding the distal surfaces of the cuspids and the mesial surfaces of the first bicuspids at their points of contact. This procedure reduces the length of the arc described by the six anterior teeth, and increases the distance between the first bicuspids, so that teeth which at first glance appear too wide to be practicable, can be utilized with very little effort.

As each tooth is set, the frame should be subjected to lateral movements to test the incisal relationship of the several teeth. Frequently by grinding the incisal edges of the lower teeth at the expense of the labio-incisal angle, clearance space may be developed without shortening the teeth or placing them to the lingual of their former position.

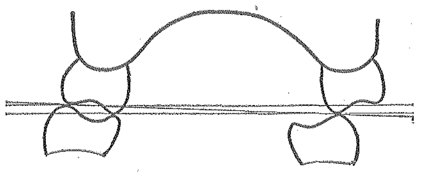


Fig. 237½.—Diagram Showing the Relation of Lower to Upper Molars in the Initial Act of Mastication. Balancing Side on Right. Working Side on Left

Where much overbite of the upper over the lower teeth is deemed necessary, the arc described by the latter must be correspondingly reduced, in order to secure clearance space in lateral movements. In ordinary cases an overbite of one-sixteenth of an inch will prove sufficient for practical purposes, and produce satisfactory esthetic results as well.

DEVELOPING BALANCING CONTACT

In the arrangement of the teeth, so far nothing has been said of the balancing contact. This has purposely been left

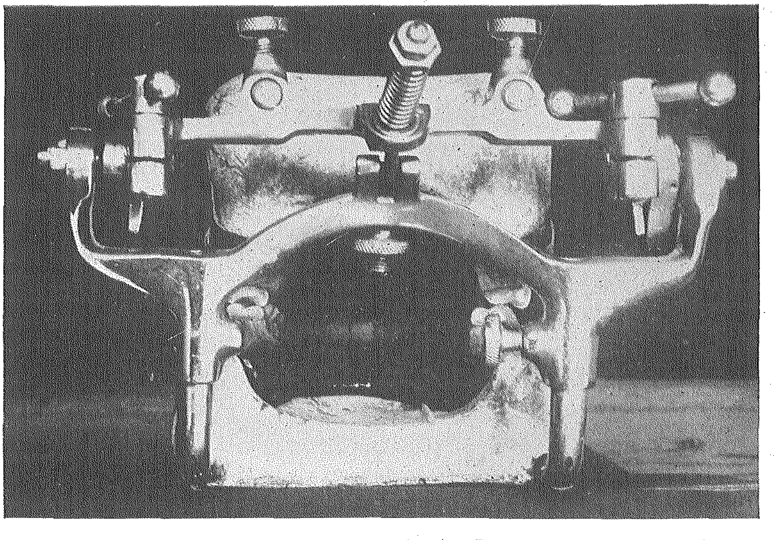


Fig. 238.—Distal View of a Full Denture, Showing Relation of Teeth on Working Side, Left, and Balancing Side, Right

until the teeth have been occluded, since balancing adjustment must always be carefully developed in all cases as a final step. Test is now made as follows:

The frame is drawn to one side until the teeth on the working side are carried to their differential limit, i. e., the buccal and lingual marginal ridges of the upper and lower teeth are in contact. While in this position the relation of the upper and lower second molars on the opposite side should be observed. The disto-buccal cusp of the lower second molar should rest against the mesio-lingual cusp of the upper second molar, or in the case of disproportion in the mesio-distal diameters of the molar teeth, it sometimes finds contact with the disto-lingual cusp of the upper first molar.

If on throwing the frame sidewise as described, the second molars do not meet, an instrument should be inserted under

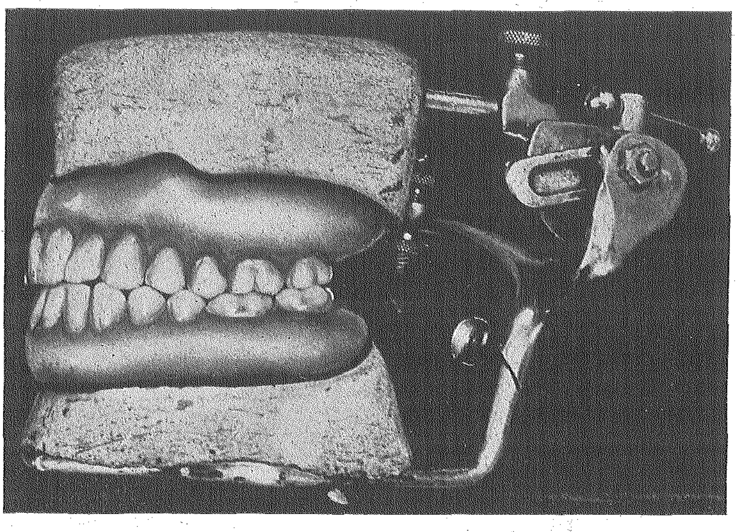


Fig. 239.—Left Buccal View of Case. Teeth in Working Relation

the distal end of the lower second molar and the latter raised until contact is established. The frame should now be opened without disturbing the molar in its raised position, a heated spatula passed under it to melt the wax and form a new base on which to rest, and the wax allowed to cool.

The lower are now brought into occlusion with the upper teeth by closing the occluding frame, if this can be done without disturbing the lower second molar in its corrected position, and the position of the upper molar changed to occlude with the lower. When on testing, the lower and upper teeth do not occlude, being held apart by the modified position of the second molars, the wax under the upper molar should be softened and the teeth brought together under pressure. The use of carbon paper will also disclose points of interference.

It should be kept in mind that *balancing contact* is developed between the upper and lower second molars in almost every instance, and when developed no other contact is required on that side between that point and the opposite lateral incisor or cuspid tooth. The teeth on the balancing side are not in such relation to each other as to form a masticatory mill or to hold food, the actual work being accomplished on the opposite or working side, therefore any considerable contact is unnecessary.

It will be found by reference to the diagram that the general contact between the teeth in the two arches, in the initial

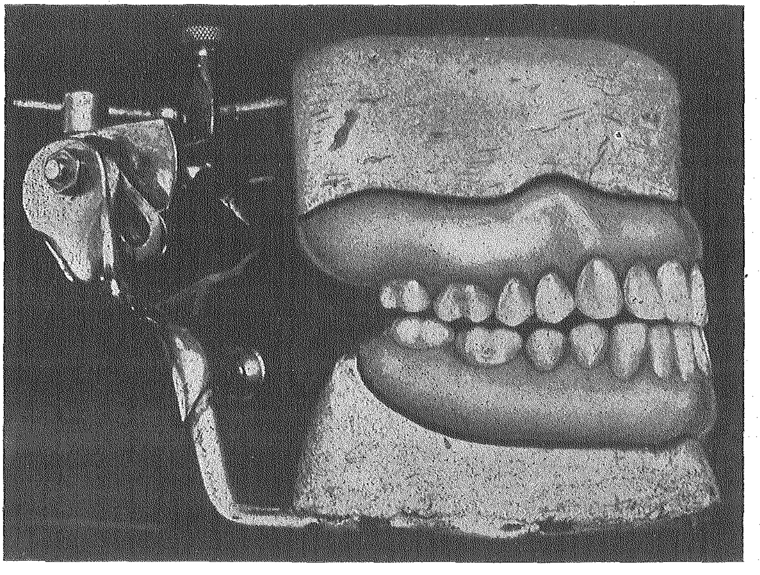


Fig. 240.—Right Buccal View of Case. Second Molars in Balancing Contact

act of masticatory effort, i. e., the position where the teeth begin their return to normal occlusion, is as follows:

The buccal and lingual marginal ridges of the lower and upper teeth on the working side from the cuspid to the second molars inclusive, are in contact. On the opposite side contact exists between the second molars. These points, if connected by imaginary lines, represent a triangle, the teeth along the working side occupying the base, the second molars on the opposite the apex of the figure.

The fact that contact is thus ranged along the sides and at the angles of a three-sided figure no doubt gave rise to the term *three-point contact*. This term is misleading because, as a matter of fact, there are, or should be, many points of con-

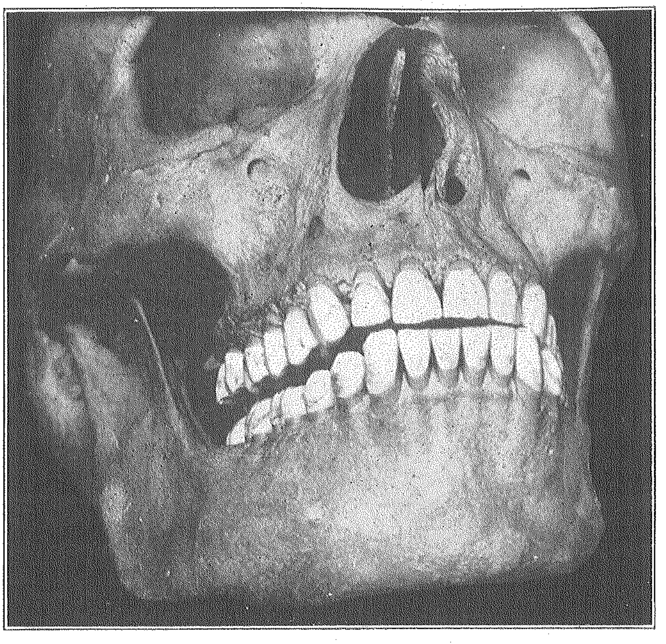


Fig. 241.—Human Denture Showing Broken Contact of Lower with Upper Teeth from First Molars to Cuspids of Opposite Side

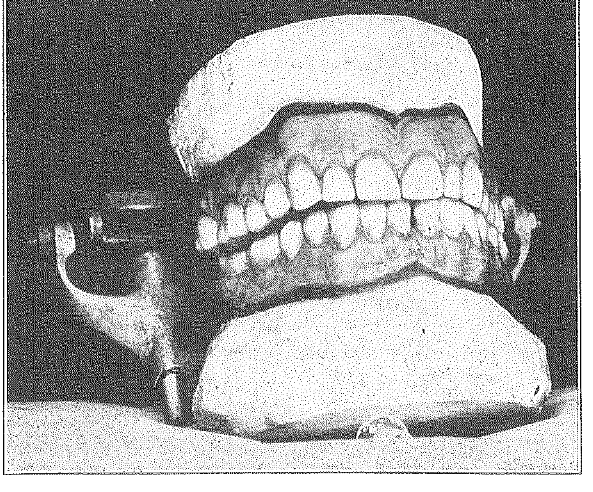


Fig. 242.—Artificial Denture Showing Broken Contact from Mesial of Second Molars to Centrals of Opposite Side

tact between the teeth on the working side of the mouth, but not necessarily more than one on the balancing side.

This is Nature's plan, as can be seen by examining the natural teeth in a normally arranged denture. Stress, therefore, is laid upon this fact because many in attempting to occlude teeth anatomically, endeavor to secure close-locking contact between the upper and lower bicuspids and molars on the entire balancing, as well as working, side in lateral movements.

FINAL TEST WITH CARBON PAPER

When the arrangement of the teeth has been concluded and balancing contact has been secured, a final test of all surfaces with carbon paper is made, and the high points thus disclosed removed with engine-stones. This test should be

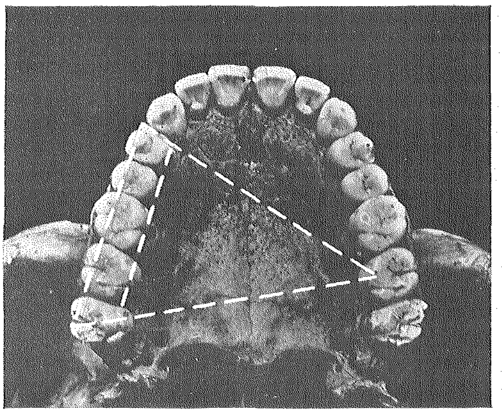


Fig. 243.—Diagram Showing How Contact on Working and Balancing Sides Occurs Along Base and at Apex of a Triangle

repeated until smooth-gliding contact in lateral and protrusive movements is developed.

DEVELOPING THE CONTOUR OF THE DENTURES IN WAX

Strips of wax are now placed on the labial and buccal surfaces of the denture, one strip against and parallel with the periphery, and another overlaying the cervices of the teeth. The round end of the heavy burnishing spatula is heated and passed rapidly back and forth along the strips to soften and burnish them into close contact with, and cause them to adhere to, the outer surfaces of the wax denture. The wax should overlay the cervices of the teeth about one-twentieth of an inch in depth and cover the gingival thirds at this time, the idea being to apply a slight surplus everywhere, from which, by carving, the gum festoons and general contours are developed to proper curvature and thickness.

It has been previously shown by the presentation of Dr. Williams' work that there are three typal forms of human teeth, each type presenting certain modifications.

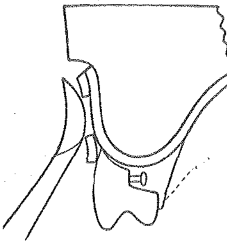


Fig. 244.— Sectional Cut Showing Detail of Applying Wax Strip for Gum Contouring

To one who has given this subject any consideration, it is a comparatively simple matter, according to the data, to select teeth of appropriate form for any individual case, since the manufacturers are supplying artificial teeth closely resembling the typal forms of the natural organs.

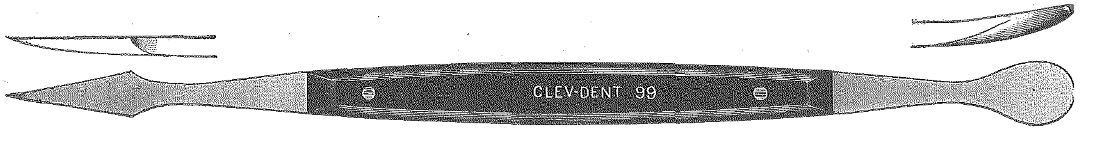


Fig. 245.— Wax Carving and Burnishing Spatula

Now, granting that teeth of correct form and size have been selected and occluded, it does not follow that esthetic results will inevitably follow their use. In fact, in the carving and festooning of the gums one class may be easily made to resemble another, or any form may be so distorted as to

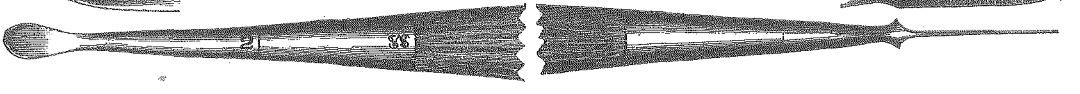


Fig. 246.— Carving Tool Suitable for Use in Wax, Vulcanite or Porcelain

be unrecognizable. Clearly, then, it is the prosthetist and not the manufacturer who finally determines the type of tooth the finished denture presents.

As an artist, the prosthetist should recognize the type of tooth required. As a sculptor, he should be able to so mold the pliant materials around the rigid porcelain teeth as to frame them, as it were, to meet the esthetic requirements of the case.

It requires quite as much judgment to fashion the artificial gums around teeth of appropriate form in order not to distort their type, as to develop reasonably appropriate forms from types of teeth that do not strictly conform to the requirements of a given case. In either case the prosthetist must possess a well-developed esthetic sense to produce harmonious results.

The advantage in using teeth of suitable typal forms is that, although the prosthetist's esthetic judgment must be none the less well developed, the teeth themselves indicate the form of the gum festoons, and therefore serve as patterns in the carving of the case. When teeth are used which do not strictly conform in typal outline to the case, the prosthetist must be able to see a mental picture of the requirements of the case, and develop those forms by the disposition of his wax around the teeth.

As an artisan, the prosthetist must reproduce in permanent materials the modeled wax form of the denture and maintain in clearness and purity during the finishing stages the outlines of the typal forms of teeth he set out to develop.

The dentures at this stage are in the rough, as it were, as slight surplus allowance of wax should be made for loss in final finishing. They should, however, represent in general detail, though roughly blocked, the typical outline forms of the finished dentures, just as the work of a sculptor, as, for example, the statue of Tolstoi, by Mucha, represents the characteristic features of the man. (See page 398.)

The attainment of esthetic results along these lines, as well as in the arrangement of the teeth, is of the utmost importance. The denture which the prosthetist produces, and which is fitted in the patient's mouth, is not like a garment which can be worn at pleasure or put off for something more attractive. It literally becomes a part of that patient's body, to be worn for years, or until further tissue loss or accident requires renewal. It corrects impaired phonation, disturbed facial contour, and by its use, when properly constructed, the patient is enabled to masticate and assimilate food, thereby enabling normal bodily functions to be carried on. The health of the patient, his well-being, comfort and good looks depend upon the efficiency of the prosthetist's efforts.

He, therefore, who undertakes this specialty should have the ambition, or be required, to develop more than *average skill,* since conditions of such vital importance depend upon the results of his efforts.

DEVELOPING THE GUM FESTOONS

When teeth of approximately the right form have been selected and arranged, and the wax has been applied and burnished against the labial and buccal surfaces of the denture

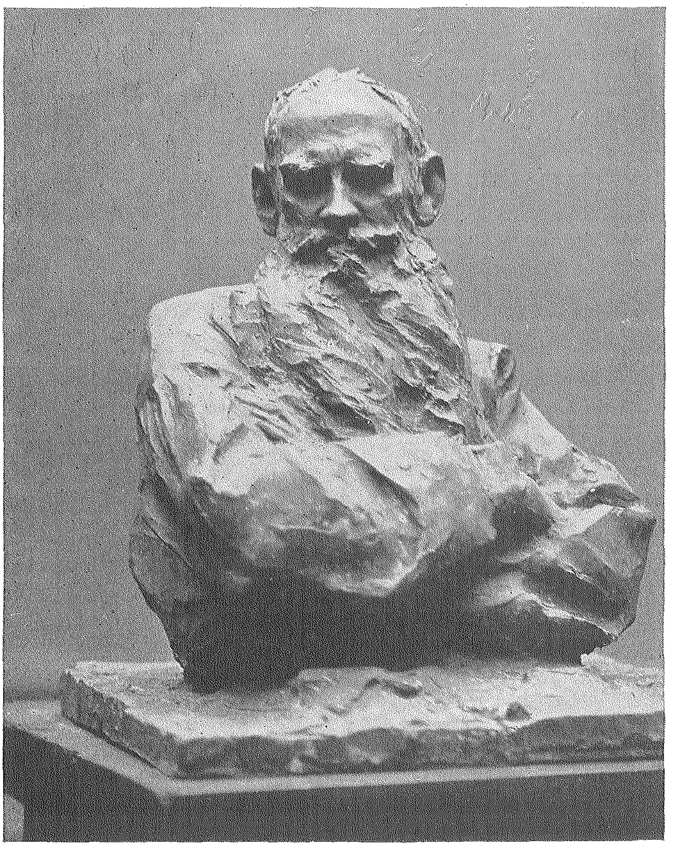


Fig. 247.—Statue of Tolstoi (by Mucha), Showing Characteristic Lines without Fully Developed Details (See Page 397)

slightly thicker than required, the gum festoons are developed as follows:

With a sharp carving tool, or the pointed blade end of the burnishing spatula, the surplus wax is removed from the labial face of each tooth. The instrument, applied at right angles to the surfaces of the tooth, should be held with the pen grasp — thumb, index and middle fingers — the fourth and little fingers resting at some convenient point on the case so as to control the movements of the blade.

The gingiva of each tooth is then carefully outlined with the blade, the surplus wax removed, and the correctness of form noted. It is usually better to remove too little than too much wax in the first outlining, since more time is lost in making additions than is required in going over the case a second time after inspection. The wax should be allowed to fill the embrasures to as great an extent as is consistent with the development of correct typal forms, to avoid the formation of unnecessary food pockets.

This fact, however, should be kept in mind: When teeth are selected for a given case which conform in length to the distance between the incisal rim of wax and the high lip line, and in typal form to the requirements of the case, they must

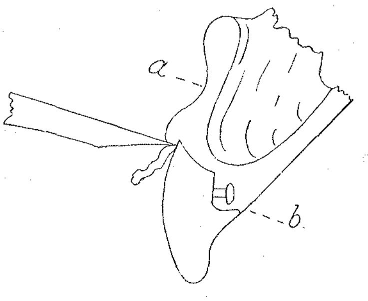


Fig. 248.—Detail of Carving Tool as Applied in Developing Gingival Outlines

not be distorted and their esthetic value impaired by the excessive use of wax in gum festooning.

The round end of the spatula, or a similar carving tool, is now used to develop the varying surfaces of the gum festoons above the embrasures and between the gingivæ and periphery of the denture.

It is not possible to describe accurately the outline of these uniform, yet plainly marked, undulating surfaces swelling out over the rounded labial and buccal curves of the teeth and sinking into the embrasures and areas as between the roots of the natural teeth, were they present. Many in the attempt to reproduce the gum festoons and surfaces extend grooves from the embrasures toward the periphery. While these are decidedly better from an esthetic standpoint than mechanically rounded, convex ridges, they lack that indescribable and delicate variation — the imperceptible fading of one surface into another so often seen in normal, healthy gum tissue.

One who is really interested in this work can find no better ideals than can be gained by taking impressions of the labial and buccal surfaces of the teeth and gums of normal mouths, securing casts of the same, and studying the forms and variations there represented.

TRIMMING THE PERIPHERAL OUTLINE OF THE DENTURES

When the festooning of the gums has been completed, and frequently before, the excess peripheral wax should be removed so as to disclose the general outlines of the dentures. The attention should be directed to the form of the denture as a whole, as well as to specific details, and by early outlining them the proportion of the parts to the whole can be more easily determined.

FINISHING TOUCHES IN CARVING

Attention has previously been called to certain prominent points in the development of the wax contour and occlusion models. These will bear brief repetition, since the final touches are given them at this time before trial in the mouth.

The central notch providing for the unrestricted action of the frenum is cleared of excess wax, and the margins smoothly rounded.

The incisive fossæ or depressions should be developed above the lateral incisors. In most cases, in order to develop these depressions, it will be necessary to set the cervices of the laterals inward so that a straight edge applied to the cervices of the central and cuspid on either side will clear those of the laterals. This does not require that the incisal edge of the lateral shall be set within the anterior curve of the arch, but merely necessitates the slating inward or backward of the long axis of the lateral.

When set directly upright the incisive fossæ, if developed, will form an abrupt, and usually an unsightly, depression, while the monotonous curvature of the labial surfaces and parallel arrangement of the central, lateral and cuspid, do not produce as fine esthetic effects as where the alignment is varied. The cuspid eminence is usually plainly developed, sometimes strongly marked, as conditions demand. It is usually most prominent, though not always so, at the peripheral margin, slightly concave from above downward, and again prominent as the gum festoon will permit at the cervix of the tooth.

Usually back of the cuspid eminence the periphery of the denture drops down, frequently sufficient to form a decided notch, to permit the free play of the buccal muscles. The periphery of the baseplate in the region of the tuberosities should extend as high as tissue attachment will permit, to give stability to the denture in masticatory effort.

It is best in all cases to so form the baseplate as to embrace practically all of the tuberosities, not only on the buccal surfaces, but distally as well. When rounded or somewhat spherical, as the tuberosities frequently are, the baseplate, when enclosing them, is prevented from sliding forward in masticatory stress.

FINISHING THE LINGUAL SURFACES OF THE WAX MODEL DENTURES

The excess wax should be removed from the lingual surfaces of the dentures and any depressions filled in to effect the desired contour.

In many cases it is advisable to develop in wax the lingual forms of the incomplete porcelain teeth so as to represent the forms of natural teeth. By applying tinfoil to the palatine area and burnishing it carefully against the lingual wax contours of the various teeth, the work of final finishing in vulcanite is reduced to the minimum.

Care should be taken to see that the baseplate is not excessively thick at any point, and that the border portion is not bulky or over-developed. Special care should be bestowed on the correct development of the surfaces to the lingual of the incisors. If unnecessarily thick, the patient's speech will be thickened to a marked degree, while if deficient a whistling tone is apt to be produced. This is because in phonation the tongue does not find normal contact with the denture, or, in those cases where, in the production of certain tones, the tongue does not touch the teeth or the baseplate, the space through which the air passes is of abnormal outline.

Tests should be made as to the efficiency of the denture in phonation during trial in the mouth. Frequently the removal or addition of a little wax will correct what otherwise might prove a serious defect. Such changes are usually required to be made back of the incisor, and occasionally along the lingual, surfaces of the bicuspids.

THE DEVELOPMENT OF THE RUGÆ

When the rugæ are plainly marked in the palate they are easily reproduced in the denture by carefully adapting the softened baseplate to the case in such manner as to force it into the depression between the folds, and yet not thin it on the ridges.

In preparing an impression for the production of a cast, the rugæ should in most cases be slightly exaggerated by scraping the bottom of the grooves impressed by the high ridges with a discoid excavator. This not only allows the denture to become more firmly seated on the vault tissues, but clearly indicates the position and form of these folds so that they may be easily reproduced in the baseplate when desired.

Just what the function of the rugæ may be is not known. In the lower animals they aid in prehension. In man their

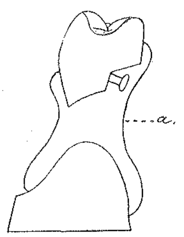


Fig. 249.— Section of Lower Denture, Showing Lingual Surface, A, Concaved to Increase Tongue Space.

roughened surfaces may assist in separating triturated from imperfectly masticated food, and may result in a keener appreciation of taste as well.

When rugæ are developed in a denture special care must be taken to have the baseplate of the exact thickness required in the finished substitute, to cover the cast with thin tinfoil before vulcanizing, and the lingual surface of the wax model also before flasking, the tin lining remaining in the matrix side of the flask. This procedure forms an improvised metal matrix between which the rubber is vulcanized, and when carefully carried out, the surfaces of the vulcanite in contact with the foil are practically finished when removed from the flask.

The lower wax model denture is finished in much the same manner as the upper, the prominent points of the latter, however, being developed to a lesser degree because the surface markings of the lower natural denture are not strongly marked. Special care should be observed to avoid unnecessary bulk of wax on the lingual of lower cases, for unless removed in finishing the vulcanite, tongue movements are liable to be impeded. When finished in the manner described, the wax model dentures are ready for trial in the mouth.

TRIAL OF THE DENTURES IN THE MOUTH

The following points should be observed in the trial of the wax model dentures in the mouth:

First, *occlusion.* The patient is instructed to open and close the mouth a number of times, and in doing so to avoid the application of excessive masticatory force, which tends to displace the teeth in the wax.

Observe the following:

Whether or not the teeth rest against each other, as in normal occlusion.

See that they intercuspate properly.

That the overhang of the buccal marginal ridges of the upper bicuspids and molars over the lower teeth is the same on both sides.

Note whether the median lines of the upper and lower dentures coincide.

Observe the pose of the lips when at rest and in smiling, and finally, the profile and fullness of the face, to see whether addition or reduction of wax in any area is required.

Second, *lateral movements.* The patient is instructed to move the mandible from side to side to test the clearance paths of the teeth.

Usually it is best at the beginning of this test to introduce carbon paper between the occlusal surfaces of the two dentures, and by this means under lateral movements the high points are disclosed. These should be ground away with engine stones. Repeated trials, followed by grinding, first on one side and then on the other, should be made until the cusps of the lower denture glide smoothly between those of the upper teeth without interference.

When there is much variation of the lateral mandibular rotation centers from those of the occluding frame, considerable grinding will be required. When the rotation centers are approximately four inches apart, but few, if any, corrections will be necessary.

In carrying out the lateral movements the patient should be cautioned against exerting much force upon the teeth, since by these side movements they are much more readily displaced than under direct stress.

The necessity for using hard wax that will not soften readily at oral temperature, for the rims in which to imbed the teeth, becomes apparent at this stage of construction.

Third, *balancing contact* may be tested by placing carbon paper between the upper and lower second molars on the protruded side. If the porcelain is not discolored by the carbon, there is lack of proper contact. Correction is made by removing the lower denture, raising the second molar distally, higher than the actual required position, melting wax in the space underneath to serve as a foundation, returning the denture to the mouth while the wax is still plastic, and having the patient throw the dentures into balancing relation and close. The elongated tooth will thus be forced down into correct relation, the plastic wax underneath preventing the tooth from settling to its former shortened position.

One other test still remains to be carried out. The change of position of the lower second molar, particularly when elevated as described, in order to develop balancing contact, usually requires that the central groove and sloping planes leading to it, of the upper second molar be deepened correspondingly to receive the buccal marginal ridge of the lower second molar when the teeth are in normal occlusion. This test and the correction is made with carbon paper and stones, or the wax under the upper second molar is softened, the lower baseplate removed, chilled and returned to place, and the patient instructed to close with sufficient effort to force the upper molar into the softened wax a sufficient depth to bring the remaining teeth into full occlusion.

The latter method, although practicable at times, frequently results in loss of balancing contact, because the point of contact previously established by elevating the lower molar is moved upward in gaining normal occlusion. Correction by grinding, therefore, is preferable.

When satisfied that the various important requirements of the dentures have been developed as outlined, tests of the patient's ability to phonate correctly should be made, as previously mentioned.

It is difficult to correctly estimate the exact amount and general form of contour in a denture required for the correct articulation of sounds in all cases, except by careful trial.

In fact, in certain cases, as where the patient has never before worn artificial dentures, the use of any appliance having a baseplate in excess of bulk of normal lost tissue will cause a thickening of speech for some time after its introduction.

In all cases an effort should be made to develop as nearly as possible the normal surfaces seen in natural dentures by avoiding either excessive bulk or deficient contour.

FINAL FINISHING OF THE WAX MODEL DENTURES

After the various tests and corrections have been carried out as outlined until satisfactory results have been secured, the dentures are removed from the mouth and returned to the casts on the occluding frame.

If during trial in the mouth the position of any of the teeth has been purposely changed, care should be taken to avoid closing the frame with any degree of force or the corrections made in the mouth are liable to be disturbed.

Each denture is now carefully inspected to see that the gum festoons and general contour are as desired, or, if not, corrected.

The surfaces of wax are carefully smoothed with a burnisher and all minute fissures or holes obliterated, since in subsequent flasking the plaster will enter them and show as rough points on the matrix walls.

The surfaces of wax may be rendered very smooth by carefully rubbing them with a pellet of cotton moistened with chloroform. Since chloroform is a slow solvent of wax, care should be taken to avoid covering the teeth with the dissolved wax carried by the cotton. When this occurs the teeth will readily loosen in the matrix in the removal of the wax.

The case is sometimes passed quickly through a Bunsen flame to smooth the surfaces, but this method should not be generally adopted, since the flame affects high points more readily than depressions and finely-carved surfaces and delicate festoons are quickly obliterated.

Before removing the casts from the occluding frame care should be taken to see that each wax model denture is firmly attached to its cast.

This is done by placing a little extra wax at various points around the periphery of the baseplate and with a hot spatula melting it along the junction of the baseplate with the cast.

REMOVING THE CASTS FROM THE OCCLUDING FRAME

With a sharp knife, the plaster which was built around the bows and against the base of the cast in mounting, is pared away so as to expose and undermine the bows, after which the cast is easily detached. The adherent plaster is then removed so as to reduce the cast to its original form before attachment to the occluding frame.

CHAPTER XXI

REPRODUCTION OF THE WAX MODEL DENTURES IN PERMANENT MATERIALS

The duplication of the wax model dentures in permanent materials may be roughly divided into five stages, as follows:

Flasking the wax model denture.
Packing the matrix with rubber.
Closing the flask.
Vulcanizing.
Finishing.

A wax model denture usually presents a very irregular outline and many varying surfaces. It is also composed of some of the permanent factors of the denture, viz., the teeth, and sometimes the baseplate. The wax portion of the model denture must be replaced with rubber applied in a plastic condition and afterward hardened. The problem is how to replace the wax with vulcanite without losing the relation between the teeth and cast of the mouth.

Sectional Molds

The reproduction of a pattern or model in metal or other materials capable of being rendered plastic is usually accomplished by surrounding the object it is desired to reproduce with a sectional mold, so formed as to part from irregular surfaces without breaking, removing the model from the mold, replacing the various sections, and filling the space formed by the removal of the model, with the plastic material.

To carry out such work accurately some means must be provided for holding the several parts of the sectional mold in exact relation to each other after removal of the pattern or model, and while filling the matrix.

Iron and brass founders use what is termed a flask or *molding box,* consisting of two or more sections, in each of which a portion of the mold is formed. These various sections of the molding box are held in position by means of accurately fitted guides, so that when separated and the model is removed, the several parts of the mold can be reassembled and held in the same relation they occupied when the pattern was enclosed within.

When a pattern composed entirely of wax is used, and the object is to be reproduced in metal, as an inlay, crown, bridge or denture, the mold can be made in a single piece and the wax model dissipated by heat, thus clearing the matrix and obviating the necessity for forming the mold in sections.

In prosthetic operations the reproduction of a wax model denture is usually accomplished by forming of plaster a two-piece sectional mold in a metal box termed a *flask*. Sometimes in complicated cases, as in the construction of obturators and artificial velæ, a three or four section mold is required, involving the use of flasks of special forms.

Flasks

Vulcanite flasks used for dental purposes are made of brass or cast iron. They usually consist of a lower section in which the base of the cast is invested, and an upper section in which the mold containing the teeth and representing

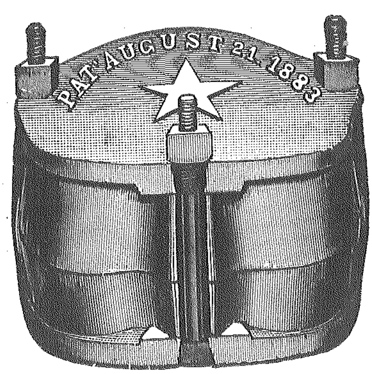


Fig. 250.—A Flask of the Usual Type Used for Vulcanization of Dentures

in reverse the gum and lingual areas of the denture is formed. The lower section may or may not have a removable bottom, while the top of the upper section is always removable, to facilitate the *flasking* of the case.

These various parts of the flask are provided with pins, or lugs, which fit into holes or slots in the corresponding opposite parts, for accurately guiding and holding them in correct relation to one another while flasking, and during the final closing of the packed case.

Two general styles of flasks are in common use:

First — Flasks to which screw bolts are fitted, for closing and holding the packed case together during vulcanization.

Second — Flasks which are closed and held together by means of a spring clamp or press.

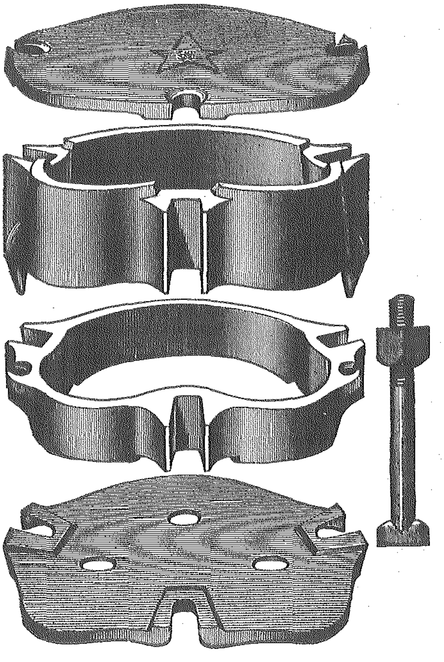


Fig. 251.— Cut Showing the Flask Separated

An appliance called a flask press is frequently employed for closing packed cases, the bolts or clamps being used for holding the flask together.

The usual methods followed in closing flasks and holding them together during vulcanization will yield satisfactory results if reasonable care is observed in carrying out the several steps. If carelessly performed, errors are liable to occur during this operation which may result in destroying denture adaptation. Attention will be called to these sources of error, and means for obviating the same, under the heading, *Closing the Packed Flask.*

Most of the flasks offered by the supply houses are too small to receive average and large sized casts. Since no advantage is gained in the use of small flasks, the larger sizes should be used.

FITTING THE CAST AND WAX MODEL DENTURE IN THE FLASK

In upper cases the cast with wax model denture attached is now set in the lower, or shallow, section of the flask. If too large peripherally to rest upon the bottom of the flask, the margins of the cast should be pared away at points of interference until it drops into position. Usually reducing the distal end of a cast, when trimming in this location is permissible, will be all that is required.

The upper section of the flask is now set in position to test the depth of cast and denture as compared to the depth of the entire flask. Should the incisal ends or occlusal sur-

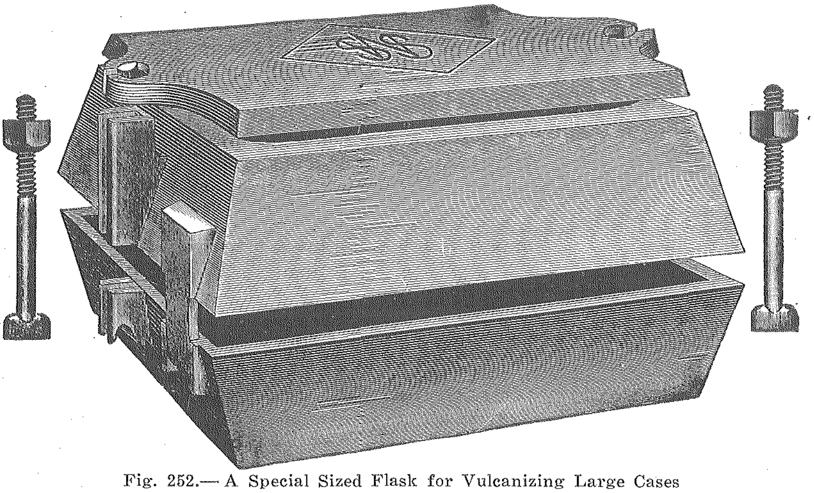


Fig. 252.— A Special Sized Flask for Vulcanizing Large Cases

faces of the teeth project above the upper plane of the second section, they will interfere with the top plate going to place, and the teeth are liable to become displaced. This is obviated by reducing the base of the cast sufficiently to lower the teeth below the upper plane.

FLASKING THE WAX MODEL DENTURE

The upper portion of the flask is now set aside and the cast and denture removed from the lower section. A mix of plaster of medium consistency and containing no accelerator is applied over the bottom and around the inside periphery of the first section of the flask.

The cast should be set in water for a short time just previous to investment to partially fill the pores, then set in position in the flask and pressed down into the soft plaster to the position previously determined. With a short, stiff blade spatula the plaster between the sides of the flask and the peripheral line of the wax model denture is smoothed down where high, and built in where deficient, so as to form a continuous surface from the denture margin to the upper plane of this first section. This surface of plaster forms the dividing line between the two halves of the invested case.

Care should be taken to see that none of the gum portion of the denture is imbedded in the plaster investment of the first section, or the packing of the case becomes difficult. Under no circumstances should the line of separation of the two halves of the flask occur near the cervices of the teeth or the basic rubber will most certainly find its way through to, and mix with, the gum material.

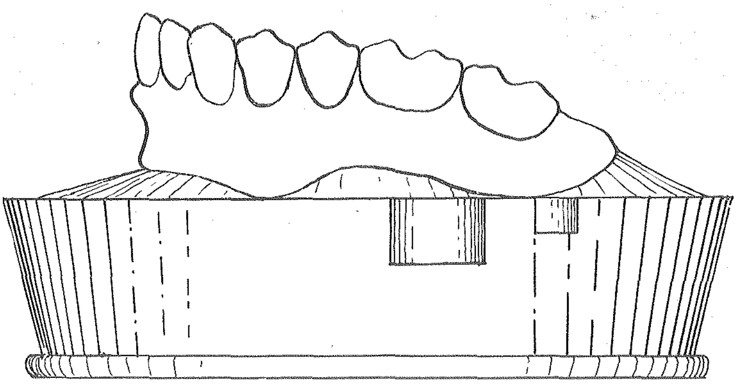


Fig. 253.—Diagram of Upper Wax Model Denture Invested in First or Lower Section of Flask

The plaster is built against the distal margin of the baseplate, but not so as to overlay it at any point. When set, the surplus plaster is trimmed off and the surfaces surrounding the cast smoothed up with a piece of sandpaper. Particular attention should be given to removing all plaster from the flask margins and from the holes or grooves which receive the lugs of the second section. This is necessary in order that the metal edges of the two sections may come together without interference. When smoothed up and the loose debris is removed, the plaster surfaces are varnished with a good separating medium and allowed to dry.

The second section of the flask is now set in position, into which plaster of medium consistency, too thick to pour, is introduced with a spatula, placing it on the incisal and occlusal surfaces of the teeth. By jarring the flask on the bench, the plaster is vibrated down between the labial and buccal surfaces of the denture and flask and over the lingual areas as well.

Special care should be taken in filling the upper half of the flask to avoid confining the air in the embrasures, or anywhere throughout the plaster investment. When air spaces are present, pressure of the surplus rubber in the matrix is liable to force the teeth into these spaces in closing the flask, or result in uncontrolled loss of rubber from the matrix. Elongation of the teeth from this cause is of frequent occurrence, particularly when the matrix contains much surplus rubber.

To obviate this difficulty, a *metal occlusion retainer* suggested by Dr. Greene, is bent to lie in contact with the occlu-

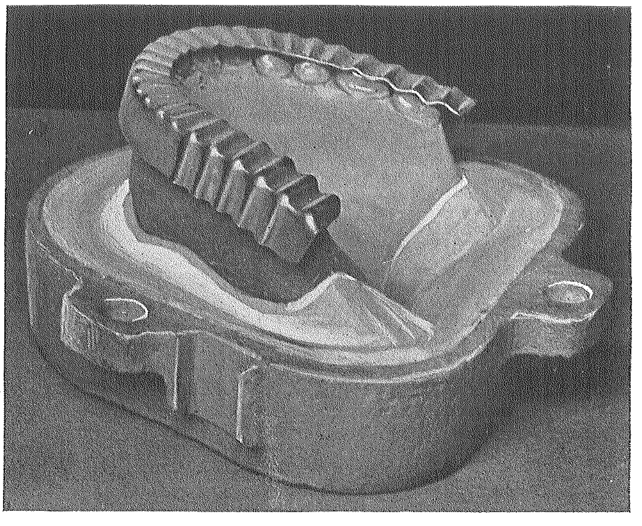


Fig. 254.—A Metal Occlusion Retainer Fitted to a Half Flasked Upper Denture

sal surfaces of the teeth and extend over the labial and buccal surfaces as well. In the second stage of flasking when the plaster has assumed a level even with the occlusal surfaces of the teeth, the occlusion retainer previously conformed to the arch is quickly filled with plaster, inverted and pressed down until in contact with the teeth at many points. The remaining space in the flask is now filled with plaster slightly above its upper margin.

The top of the flask is now adjusted and pressure applied to force out the excess plaster while it is still plastic. Care should be taken to see that the projections of the top enter their respective guides of the flask.

Since rubber is easily soiled from dirty fingers, and since the flask as well as the rubber must be handled more or less in packing the matrix, to obviate discoloration of the rubber, the outer surfaces of the flask should be cleaned with a scrub-brush and water. The holes and grooves which receive the bolts should also be cleared at this time, for if deferred until the case is packed, some of the debris is liable to become intermixed with the contents of the matrix. This scrubbing and cleaning of the flask can be carried on while the plaster is hardening.

From fifteen to twenty minutes' time should be given the plaster in the upper portion of the flask to set, or a longer time if necessary when slow-setting material is used. The plaster must be thoroughly hardened before separating the flask, to prevent displacement of the teeth.

Separating the Flask

The flask and contents should be warmed to render the wax soft, but not sufficiently heated to melt it. This is necessary so that the wax may part readily from the teeth without dislodging them from the matrix. Heating is best accomplished in a warming oven, the temperature of which does not exceed 120 degrees Fahrenheit. This method requires but a short time, while the danger of melting the wax is entirely obviated. In case the warming oven is not available, the flask may be heated over a Bunsen stove. When so done, it should not be allowed to rest in one position for any length of time, particularly when the case is invested in a closed-bottom flask. With a pair of flask tongs it may be turned so that its various surfaces can all be heated without overheating any part.

The principal advantage of using dry heat in softening the wax is that the plaster of both cast and matrix as well is rendered harder and more resistant to stress than when saturated, as it is by the usual method of placing in hot water.

Since plaster is low in conductivity, sufficient time should be allowed for the heat to penetrate the interior. When overheated and the wax is melted, it soaks into the plaster matrix and cannot well be removed by the usual means. Its presence impairs the quality of the vulcanite, frequently preventing it from fully hardening, as well as modifying its color.

Opening the Flask

The heated flask resting upon the bench it set edgewise and with a folded towel steadied with one hand. The point of a knife is inserted between the line of junction of the two sections just sufficiently to gain a hold. A slight rotary or prying motion is applied until the sections show a slight line of separation. The flask is then turned and the knife applied to the opposite side. The sides of the flask by the guides, especially when the latter fit closely, are the logical points to apply the wedging pressure.

The force at the start should be very light and gradual, to permit the wax to yield without endangering any overhang that may be present, either on the cast or matrix walls.

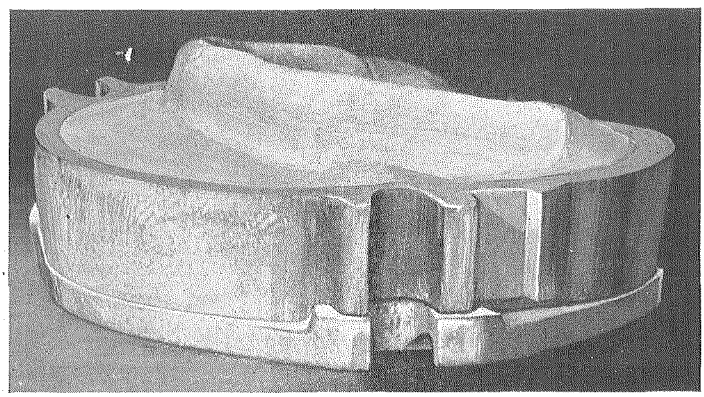


Fig. 255.— First Section of Flask Containing Cast. After Separation

When the two sections show a line of separation around their entire peripheries, with a folded towel in each hand the flask is picked up, and with a steady, rocking, manual force, the lower and upper halves are gradually parted.

Insufficient warming of the wax within the matrix, or undue force exerted in separating the flask, frequently results in fracturing the matrix, or the cast, or in dislodging some of the teeth.

When separated, the cast will be found enclosed within the lower section of the flask, and the teeth covered by the wax in the upper section.

CLEARING THE MATRIX OF WAX AND BASEPLATE MATERIAL

When Ideal Baseplate, or any hard special material is used as a baseplate, it can best be removed by inserting the point of a knife at the back under the central vault portion, when by prying upward it may be readily fractured and the broken pieces removed.

With a spoon-shaped instrument, such as a medium-sized Kingsley Scraper, the wax enclosing the teeth can be started at one tuberosity, and if of sufficient cohesiveness, can be gradually released from the teeth and matrix, en masse.

When somewhat hardened, it should again be rendered plastic or removed in sections; otherwise the teeth will be displaced. When overheated, but not actually melted, a dash of cold water will restore its cohesiveness without entirely destroying its plasticity. When melted and partially absorbed by the matrix, the entire elimination of the wax is not possible without the application of dry heat sufficient to lower the resistance of the plaster to stress; therefore such means should not be used.

The bulk of wax having been removed, such smaller portions as are adherent to the pins of the teeth and in the embrasures should be picked out with a delicate instrument, care being taken not to mar the matrix or dislodge the teeth.

The flask is now set, tuberosities up, at an angle of about 45 degrees, in the sink, and a small stream of boiling water allowed to fall from a height of ten or twelve inches against the molar and bicuspid teeth on each side. A small teakettle is very convenient for this purpose, the spout producing a small stream which is easily directed where desired. A pan with handle and having a sharp lip will answer the same purpose.

To rid the matrix quickly of wax, and prevent excessive absorption of water by the latter, the water must be boiling hot, must fall from a considerable height, must be directed where needed, the flask inclined so that the water will readily flow from the matrix and carry the melted wax with it, and the process carried out as quickly as possible and stopped as soon as all wax is removed. The plan adopted by some of placing the flask section in a pan of water and bringing to a boil, is an incorrect and careless procedure, resulting in full saturation of the plaster with water and frequently of a film of wax adhering to the flask, matrix surfaces and teeth.

The matrix section is now emptied of the water in its deeper parts, a thorough examination made to see that the pins and embrasures are clear of debris and that the plaster has not found its way into interproximate spaces through crevices in the wax model denture while filling the second section. Should any be present, it is picked out with a delicate instrument, and the defective parts carved to correct form.

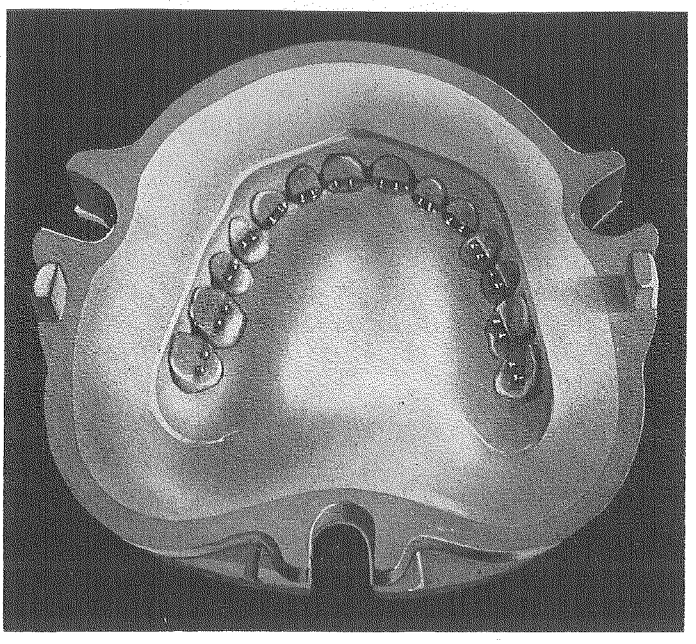


Fig. 256.— Top View of Prepared Matrix Ready for Packing

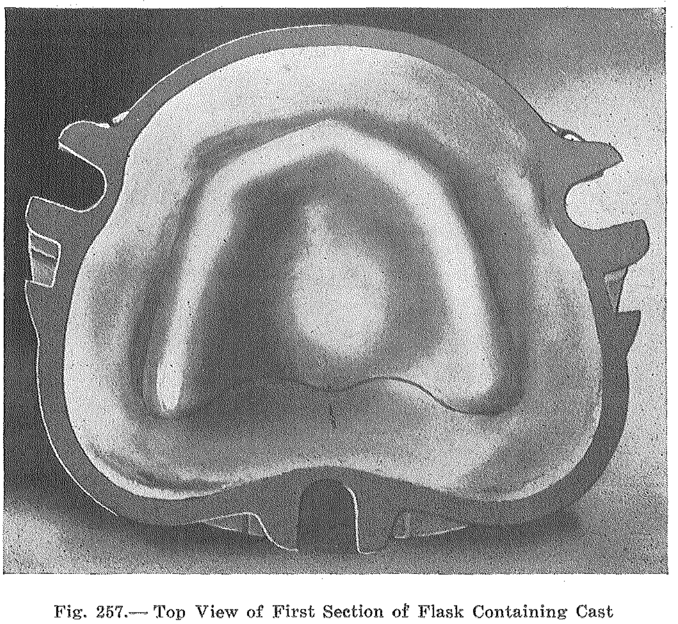


Fig. 257.— Top View of First Section of Flask Containing Cast

Any delicate overhanging margins of the matrix should be trimmed away to prevent fracture while closing the packed case. Its removal only slightly increases the bulk of excess peripheral vulcanite subsequently, while if allowed to remain, and fracture does not occur, the broken pieces are liable to become intermixed with the rubber. The correct order of procedure is to remove the peripheral overhang of the matrix margin before washing out the wax, since the latter step will thus clear the matrix of the cuttings.

Should any teeth become dislodged, they may be cemented in place by varnishing those surfaces which rest in the matrix with liquid silex, and returning them to place under pressure.

Should the case have become overheated before opening the flask and the wax melted, the order of procedure just outlined should be carried out. In addition and at this stage the use of chloroform applied with tweezers and cotton pellets will remove some of the superficial wax.

Treatment of First Section of the Mold Containing the Cast

Since plaster when dry is much more resistant to stress than when moist, the application of water to the cast for the removal of adherent wax should be avoided if possible. When rigid baseplate material has been employed and the case is not overheated, the cast is free from wax on all areas except around the margins where the periphery of the baseplate has been luted to it. A slight amount of wax in this location can usually be removed by careful scraping, followed by washing of the areas so covered with chloroform.

PROVIDING FOR THE ESCAPE OF SURPLUS RUBBER

Since no two bodies can occupy the same space at the same time, some means must be provided for the reception of the surplus rubber during the closing of the flask. When no provision is made for the purpose stated, and any excess of rubber is present in the matrix, then when the two sections of the flask are brought together under pressure, compression of some portion of the matrix will occur. The amount of space so formed will be in direct proportion to the excess of rubber retained within the flask.

To overcome danger of distortion of the cast or matrix a shallow depression extending from the inner wall of the flask inward to within one-sixteenth of an inch of the cast margin should be made around the entire periphery in the first section of the flask. This depression should not be connected at any point with the matrix, the idea being to leave a narrow line of contact at the peripheral margin of the denture between the surfaces of plaster in the two sections when the flask is closed.

This line of contact retards the ready escape of the rubber during the closing of the flask, and subsequently during vulcanization. Furthermore, should much excess be present, this peripheral line of contact being so much more limited in area than the cast or matrix walls, will yield slightly and permit the surplus to escape into the groove, thus relieving undue pressure within the matrix.

The cutting of waste gates leading from the periphery of the matrix to the outer groove is unnecessary, and, in fact, detrimental, as when present they permit the too ready escape of surplus rubber.

The groove having been formed, the debris is brushed off and this section is set aside until the matrix is packed with rubber.

Steps Preparatory to Packing the Matrix

Dental rubber, while more or less plastic and adhesive, is not sufficiently so to be formed into a homogeneous mass as it is introduced into the matrix. In adding one piece of pink rubber to another, or in introducing the basic material, spaces are liable to result from the overlapping of one piece on another. Unless these spaces are eliminated while packing, an intermixture of the pink and basic rubber will often occur. Such mishaps always detract from the esthetic appearance of the finished denture.

There are two methods in vogue for rendering the rubber more plastic preparatory to packing, viz., first heating the rubber before introduction, and second, heating the matrix, by which means the rubber, although cold, is immediately rendered plastic when carried to place.

HEATING THE RUBBER BEFORE INTRODUCING IT IN THE MATRIX

This is usually accomplished by placing the pink and basic rubber on a plate, as it is cut in pieces of suitable size for packing. The plate is placed over a pan of water and the latter heated over a burner. The greatest amount of heat possible to develop by this method will not exceed 212 degrees Fahrenheit, not sufficient to injure the rubber, yet ample to render it plastic and workable. The objection to this method lies in the fact that the rubber, although heated, is carried to a cold matrix where it immediately becomes chilled, and is almost as difficult to condense as though it had not been so treated.

HEATING THE MATRIX PREPARATORY TO PACKING THE RUBBER

The second and much more practical method, when one becomes accustomed to it, consists in heating the matrix side of the flask to about 212 degrees Fahrenheit, or until steam begins to escape from the plaster. A matrix so heated will usually retain sufficient heat to permit the rubber to be condensed, but should the packing of the case prove tedious, it may be reheated without injury to the rubber already packed.

The advantages of this method are twofold, viz., first, drying and hardening of the plaster matrix, rendering it more resistant to stress, thus reducing its liability to distortion in closing the flask; and second, the absorbed heat of the matrix not only softens the rubber as soon as placed, but keeps it plastic so that it may be united into a homogeneous mass entirely free from spaces, thus obviating the danger of intermixture of the basic and gum material.

The disadvantages of this method consist in danger of overheating the flask, thus injuring the plaster, and the necessity for exercise of greater care in manipulation to avoid burning the fingers. In all other respects this method of rendering the rubber plastic is preferable to the former, and by observing reasonable care the objections mentioned can be obviated.

To prepare the matrix for packing by the second method, the flask should be placed on a metal plate or sheet of gauze, over a Bunsen flame, and heat applied gradually so as not to disintegrate the plaster in the bottom of the flask. Since plaster is a poor conductor of thermal changes, the process should be continued a sufficient time to heat the entire matrix throughout. Care should be taken not to force the heating too strongly, or the rapid accumulation of steam next the bottom and walls of the flask may disturb the plaster contents. In the meantime, while the flask is heating, the rubber may be prepared for packing.

PREPARING THE RUBBER FOR PACKING THE MATRIX

A good-sized sheet of clean paper is laid on the bench; the packing instruments, a pair of ball pointed pliers, a thin-blade burnisher, a sharp-pointed instrument and the heavy wax burnishing spatula are laid conveniently at hand.

The muslin, covering both sides of a sheet of granular gum facing or pink rubber, is stripped back so as to expose

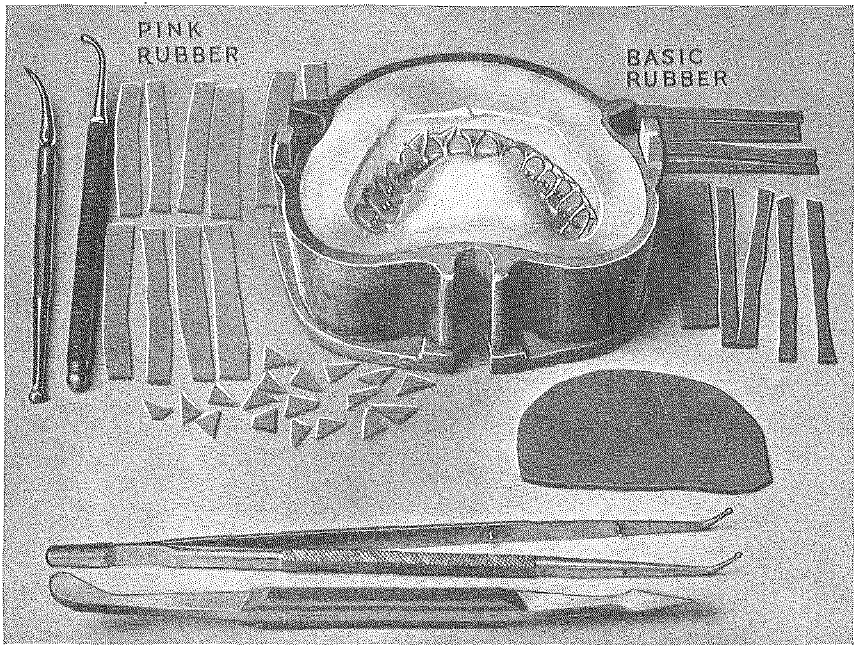


Fig. 258.—This Cut Shows the Essentials for Packing a Case. To the Left and Bottom Are the Instruments Required. To the Left, Strips and Triangular Pieces of Pink or Granular Gum Rubber. On the Right Side, Strips of Basic Rubber. Lower Right, a Single Piece of Basic Rubber for Overlaying the Vault Portion of Matrix

from one-half to two-thirds of the sheet. Eight or ten strips three-sixteenths of an inch wide are cut from across the sheet and allowed to fall on the paper, but should not touch each

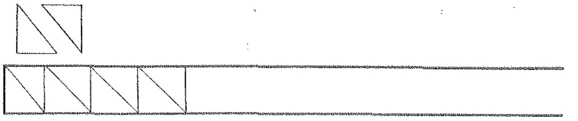


Fig. 259.—Diagrammatic Cut Showing Method of Cutting Triangular Pieces of Pink Rubber

other because of their tendency to adhere. From one or more of these strips are cut about twenty-eight triangular pieces for filling the embrasures between the teeth. These also should be kept separate.

BASIC RUBBER

Several strips of the red, maroon or black rubber, which is to constitute the base, are cut and laid to one side of the pink. As the packing proceeds, wider strips will be required, but they can be cut as needed and of a width suitable to the requirements of the case. The rubber being cut as described, and the matrix side of the flask heated, the case is now ready for packing.

PACKING THE MATRIX

Since the outer matrix wall of a vulcanite case, being perpendicular or nearly so, is most difficult to adapt the rubber to and hold in position until the flask is finally closed, this portion of the matrix is packed first because more accessible before the introduction of the basic material.

The one essential point to keep in mind during the packing of the rubber is to so place it as to avoid intermixture of the gum material and the basic portion. The gum facing must be applied piece by piece and formed into a solid homogeneous mass free from spaces. It must lay in close contact with the matrix walls and show no tendency to draw away from them. It must entirely fill the embrasures between the teeth from the deepest portions represented by the interproximate spaces in the bottom to the extreme upper periphery of the matrix.

PACKING THE GUM FACING

With the sharp packing instrument, or a pair of ball pointed pliers, a triangular piece of granular gum or pink rubber is carried, pointed end down, into the embrasure between two teeth, and with a suitable thin-bladed burnisher is forced into the deepest and narrowest portion. Another piece is carried to the adjoining embrasure and adapted in a similar manner. The adjacent angles of the two are pressed between the matrix walls and the labial cervix of the tooth, and if sufficiently long to meet, are united together by pressure. If too short, a third piece can be laid above the cervix of the tooth and the three united.

The other embrasures are similarly filled, each triangular piece of rubber as it is added being closely conformed to the walls and its upper end united with the adjoining piece already placed. The embrasures, interproximate spaces and the space between the cervix of each tooth and the matrix wall for an eighth of an inch above the teeth should be filled solidly with triangular pieces of gum, and all well condensed so as to eliminate all openings.

A strip of pink or granular facing rubber is now applied against the lingual surfaces of the teeth, and pressed against that which already fills the embrasures. Its lower margin should not approach the pins of the teeth closer than one-sixteenth of an inch, nor should it ever enclose them, since teeth anchored in pink vulcanite are gradually dislodged under stress.

The strips of rubber, when cut crosswise of the sheet, are not of sufficient length to pass around the matrix wall from

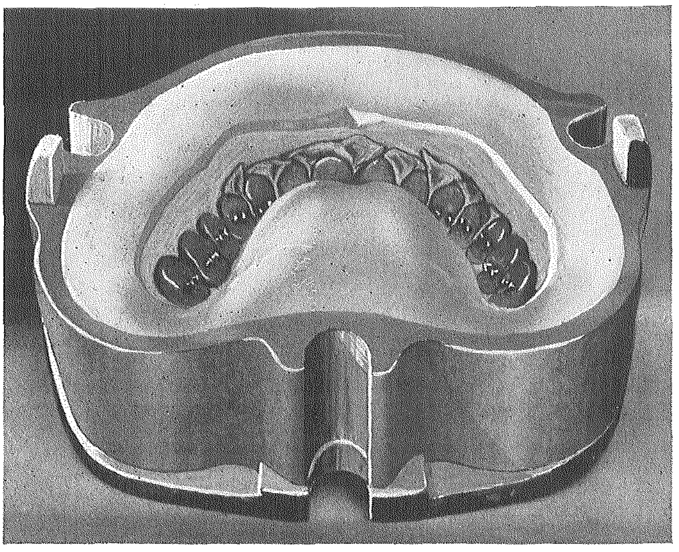


Fig. 260.—Some of the Triangular Pieces of Pink Rubber Packed in the Embrasures

one tuberosity to the other; therefore to complete the first layer, a second strip is abutted or allowed to slightly overlap the end of the first piece, after which it is adapted to the corresponding unfinished part of the matrix above the tooth pins on the opposite side. In placing these and all other strips of the gum material, care should be taken to avoid stretching them, as the tendency of the mass of gum facing to leave the matrix wall is very noticeable if the strips are stretched as applied.

Another strip of facing is placed above that already packed, its lower slightly overlapping the upper margin of the first. When by pressure — usually with the round end of the burnishing spatula, slightly heated — it is adapted to the matrix wall and underlying rubber, other strips are added and pressed to place in like manner, one layer overlapping another, until the entire wall of the matrix is covered. When

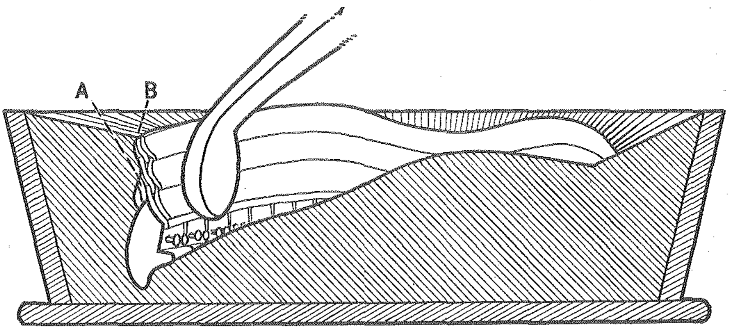


Fig. 261.— Diagrammatic Cut Showing How the Strips of Pink Rubber Should Overlap Each Other, Similar to the "Breaking of Joints" in a Brick Wall

care has been exercised in carving the wax gums to correct contour, two layers of pink rubber will furnish ample thickness to obviate exposure of the basic material on the gum surfaces in the final finishing of the case.

As a final step in the condensation of the gum portion, a folded towel should be placed against the outer surface of

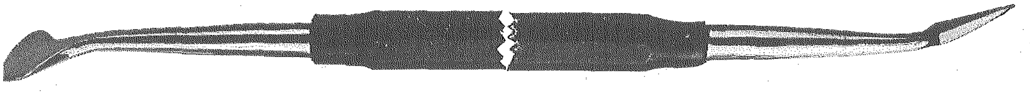


Fig. 262.— A Convenient Rubber Packing Instrument (Ivory)

the flask to protect the thumbs from the heated metal, and finger pressure should be applied to the rubber built against the matrix wall, the force exerted being outward and slightly downward.

Some prosthetists, before introducing the gum material, paint the matrix wall with a solution of pink chloro-rubber, which serves to cement the layers of gum material closely to the walls. When applied in a thin layer, and the chloroform is allowed to evaporate before packing, it serves a useful purpose, but is more often harmful than beneficial, as at times it seems to retard the hardening of the pink rubber in vulcanizing. It is also liable to change the color of the outer surfaces of the gum facing to a slight extent.

PACKING THE BASIC RUBBER

The entire outer wall of the matrix having been packed and condensed as described, the next step is to introduce the basic rubber.

A narrow strip is laid in the bottom of the matrix and pressed under the pins of the teeth, care being taken not to displace the gum facing which fills the deepest portions of the interproximate spaces. This strip of basic material, although placed under the pins, should lay to the lingual of the gum facing.

A wider strip is now laid over the first one and pressed solidly against it, so as to eliminate any spaces that may be present. The bottom of the matrix is filled in this manner so as to represent in bulk the amount of wax and baseplate material that formed the bulk of the wax contour model.

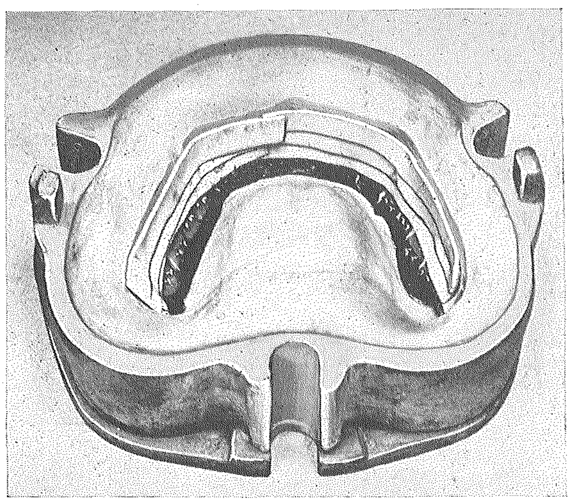


Fig. 263.— The Gum Facing Packed. First Strip of Basic Rubber Packed Under the Pins

In upper cases the palatine portion is covered with one, sometimes, though seldom, two, thicknesses of rubber cut so as to overlay this area and extend on and attach to that filling the deeper part of the matrix.

A pattern can quickly be cut from the muslin removed from the sheet rubber, and its size tested by placing in the matrix. When properly formed, it is laid on the sheet of rubber, a piece cut according to outline, the muslin removed, and the rubber placed in position and firmly condensed at its margins to that already packed around and to the lingual of the pins in the bottom of the matrix. A strip of basic material wide enough to line the gum portion of the matrix is cut and stretched to reduce its thickness. This is then laid

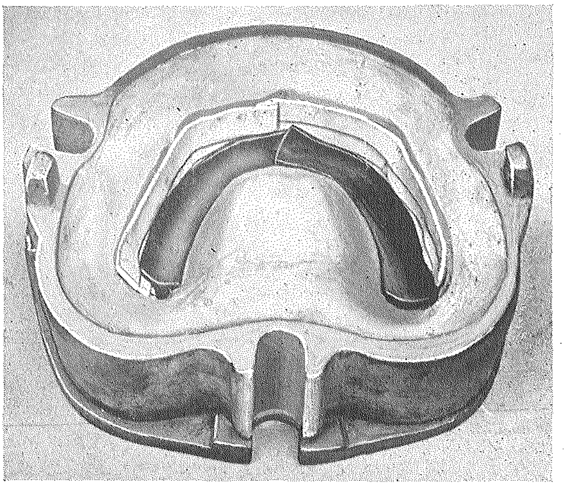


Fig. 264.— The Pins Entirely Covered with Basic Rubber

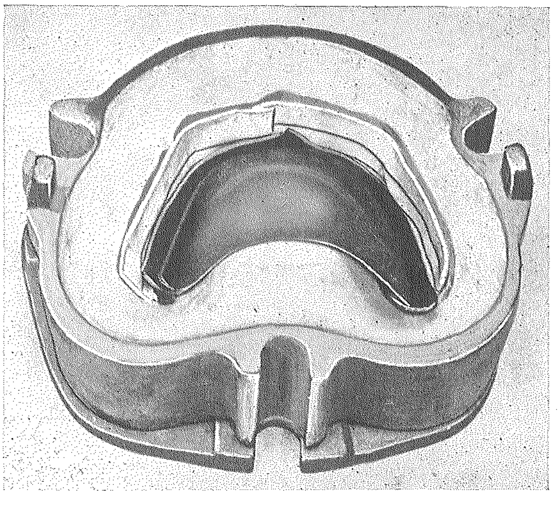


Fig. 265.— Vault Area Covered with a Single Layer of Basic Rubber

against the gum facing and firmly pressed against it. This lining of basic material strengthens the gum portion, and further insures the entire palatine and border surfaces of the denture, being composed of the same colored vulcanite, a point of considerable esthetic importance.

A second layer of rubber, usually a strip about one-half inch wide and long enough to extend from anterior to posterior limits of the matrix, is laid in the central palatine area, to insure slight surplus in this region on closing the flask.

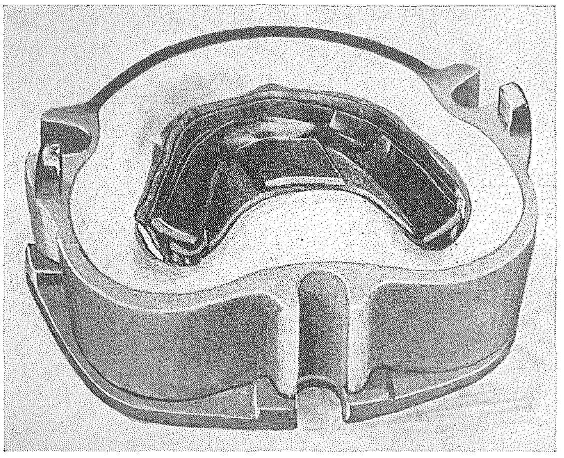


Fig. 266.— Matrix Packed Ready for Closing the Flask

When both basic rubber and gum facing have been introduced and thoroughly condensed, the case is ready for the final steps preparatory to closing the flask.

When diatoric teeth are used it is necessary, in packing the matrix, to fill the central depressions of the bicuspids and

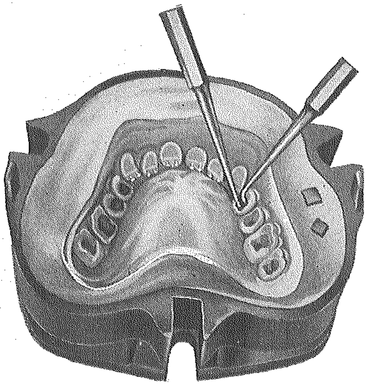


Fig. 267.— Cut Showing Method of Packing Depressions in Diatoric Teeth

molars with small pieces of basic rubber. This is an essential part of the packing process and is necessary in order that the anchorage spaces within the teeth for the rubber may be perfectly filled in the final closing of the flask.

GAUGING THE AMOUNT OF RUBBER REQUIRED

The amount of basic material required is entirely dependent on the extent to which absorption of the *residual ridge* has progressed. When extensive, more rubber will be required than when the ridge is prominent.

A simple method of testing approximately the proper amount of rubber required to fill the matrix, is to collect all of the wax and baseplate material removed from the matrix,

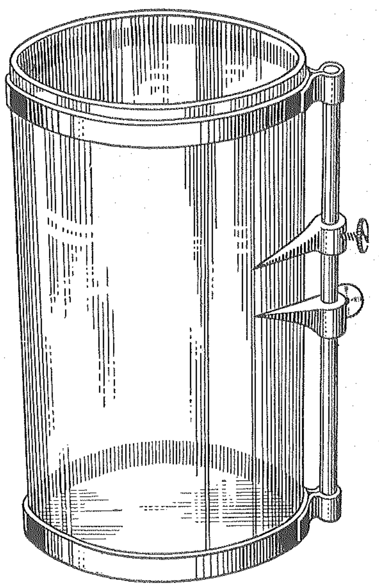


Fig. 268.— Water Gauge for Determining the Volume of Water Required to Fill the Matrix

work it up into a solid, compact mass and test its bulk by displacement of water as follows:

A glass is filled to overflowing with cold water. Into this the wax, held on the point of a small instrument, is immersed, which, of course, displaces an equal bulk of water. The wax is then removed, the required amount of gum facing — usually about one-half sheet — is placed in the glass, and sufficient basic material is added to again bring the water to the point of overflow of the glass. A slight addition should be made to compensate for the wax that adhered to the pins and was lost by washing the matrix with hot water.

Dr. E. T. Starr suggested the use of a glass vessel having two adjustable pointers attached to a perpendicular post held by means of top and bottom bands. The top pointer was set at high-water mark, as established by the introduction of the wax. The lower pointer was set at low-water mark, determined by removal of the wax. Sufficient rubber, both facing and basic material, was added to raise the water to the upper pointer. The use of this appliance obviated the overflow of the water.

Flask Closing

PRELIMINARY CONSIDERATIONS RELATIVE TO FLASK CLOSING

Previous mention has been made of the crystalline character of plaster, its tendency to crush under pressure when the modulus of resistance to stress of the crystals has been reached, and of its greater resistance to stress when in a dry condition than when saturated, or even slightly moistened with water.

These facts are of vital importance in vulcanite denture construction, for when disregarded, distortion of the cast, of the matrix side of the flask, or of both, is very liable to occur. When so occurring, the result is frequently a partial or total loss of adaptation of the denture to the tissues.

ESTIMATING THE FORCE EXERTED BY THE SCREW

Few prosthetists realize the enormous pressure capable of being exerted on both the cast face and the opposite matrix walls when the latter contain a considerable quantity of excess rubber, the flask being completely closed at a rapid rate and under direct screw pressure. The rule for estimating the force exerted by a screw is stated as follows:

$$P : W :: \text{distance between contiguous threads} = \pi \times \text{twice the length of lever.}$$

Explanation

P = power, indicates the amount of force exerted on the end of the lever or wrench handle.

W = weight, indicates the load moved by the screw in advancing through the nut, or the force applied against the excess rubber.

Distance between contiguous threads of screw refers to pitch of screw.

π = pi, is the Greek letter used to indicate that number — 3.1416 — which, when multiplied by the diameter of a circle = the circumference.

The lever or wrench represents the radius of the circle described by the end of the handle in revolving the nut around the screw. To find the diameter of the circle, the radius must be doubled.

In applying this rule to determine the force exerted by the flask screws, the principal factors concerned are as follows:

First. The power delivered on the end of the wrench handle by the hand.

The record of over two hundred tests made by prosthetists under the writer's observation, with a specially designed

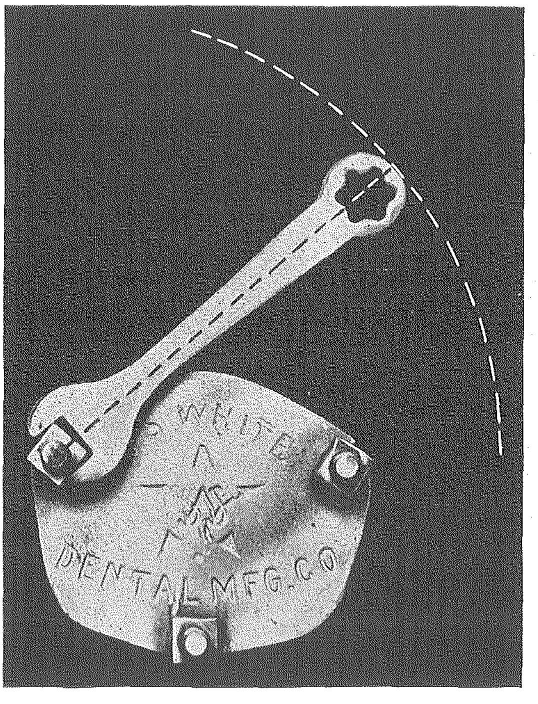


Fig. 269.—Diagram Showing Arc Described by Flask Wrench

wrench capable of registering the pounds pressure applied, showed a range of from 15 to 80 pounds exerted on the end of the four-inch handle. The low average of the total was 50 pounds.

Second. The *weight*, or second factor, represents the force exerted by the surplus rubber against the cast in one side, and the matrix walls and teeth in the opposite side of the flask, as the screw pressure forces out the excess material. This, of course, is an unknown quantity, but is determined by the rules of proportion in the usual manner.

Third. *The distance between two continuous threads* represents the approach of the two halves of the flask to each other in revolving the nut once around by means of the wrench. The threads on the average flask bolts are 1-20 of an inch apart, or, as ordinarily spoken of, the *pitch* of the screw is 1-20.

Fourth. The fourth term of the proportion is determined as follows: Multiply the length of the wrench by 2, which gives the diameter of the circle, in inches, traversed by its outer end. This multiplied by 3.1416 will give the circumference of the circle in inches.

With three factors known, the fourth can easily be found. The following example will serve to illustrate the enormous force commonly delivered against the cast face in flask closing:

Number of pounds applied to the end of the wrench handle 4 inches long..............50
Force exerted against cast face by excess rubber under pressure X
Distance between two contiguous threads.......................................1-20 of an inch
Circumference of circle described by end of wrench ....$3.1416 \times 2 \times 4 = 25+$.

Formula, 50 : X :: 1-20 : 25 +.

Multiplying the two extremes = 1250.
Dividing 1250 by 1-20 to determine the other mean = 25000.
Deducting 2-3 for friction, gives 8333 pounds exerted on cast face.

Accompanying tests made by the writer in a specially designed compression dynamometer revealed the fact that a face plate with one inch superficial area could be forced from 1-16 to 1/8 inch into hardened and comparatively dry plaster at 2,000 pounds pressure, and 1/4 to 3/8 inch in well hardened plaster, set four hours. It will thus be seen that distortion of both cast and matrix may readily occur under the pressure of over four tons as ordinarily applied.

The only redemption from failure in denture construction in every case is due to the fact that the rubber is plastic and does not resist the force of the screw, as would a hard, unyielding material. When the closing of the flask is forced too rapidly, however, with a large amount of excess rubber present, the effect is practically equivalent to that produced with a hard, unyielding material interposed. This is often seen in fractured casts and distorted surfaces in the final opening of the flask.

Five pounds of power on the end of the wrench handle represents the maximum force that should be applied in flask closing. Even this amount, limited as it is, yields a pressure of over 800 pounds on the cast face.

TEST CLOSING OF THE FLASK

To insure a sufficient quantity of rubber in the matrix and yet obviate distortion of the cast face and matrix walls,

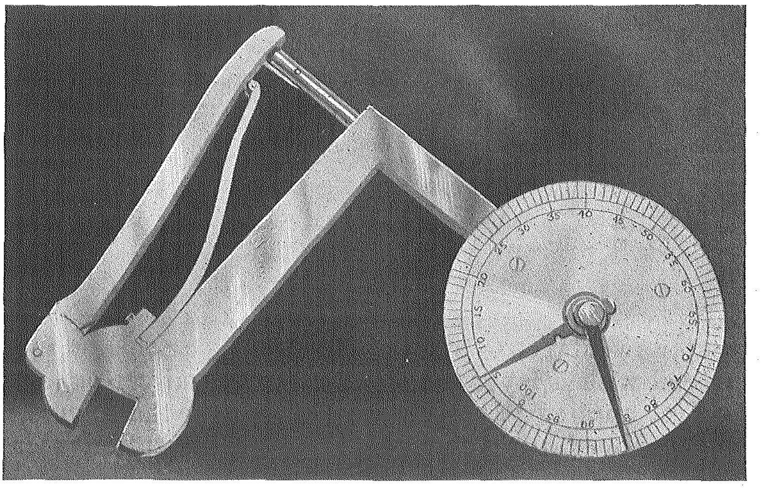


Fig. 270.—Dynamometer Flask Wrench for Registering the Force Applied in Closing Flasks

as a result of undue force, the following method will be found satisfactory:

The matrix should contain very little excess rubber. The proper amount may be determined with comparative accuracy by means of the water glass test previously described.

The flask should be gradually raised in temperature to 212 deg. F., dry heat, the two halves brought together by tightening the bolt nuts slowly, being careful not to exceed five pounds force on the wrench handle, and when closed the bolts are removed and the flask separated.

To prevent adhesion of the rubber to the cast surfaces a square of muslin slightly larger than the area of the matrix should be interposed between the two halves of the flask. A piece of the cloth removed from the sheet rubber, when freed from the sizing or starch, will answer this purpose. On opening the closed flask the muslin can readily be removed from the condensed rubber within the matrix without distorting the latter by moistening it with a pellet of wet cotton.

Close examination should be made to see that the matrix contains sufficient rubber, usually determined by observing the peripheral surplus and by applying pressure interiorly. If deficient, additional rubber should be placed where required and the flask closed without reheating.

TREATMENT OF THE CAST SURFACES FOR VULCANIZATION

Just before the final closing of the flask the surfaces of the plaster cast should be well saturated with liquid silex, a thick coating being applied and allowed to remain undisturbed for two or three minutes, when the surplus may be removed with a cloth or pellets of cotton. This film of silex penetrates the surface of the plaster to a slight extent, fills the minute openings between the crystals as well as the smaller air spaces and gives a smooth, hard finish to the cast. As a result the vulcanite will present a much smoother surface than when pressed and hardened against an untreated plaster surface.

Casts formed from Spence's plaster, which on account of its greater resistance to stress is preferable to plaster, should be covered with a layer of thin tin foil, usually No. 4. The foil is first applied to the cast surfaces with the fingers, the surplus removed with shears and final adaptation secured with a soft napkin or pellets of cotton and pressure.

When adapted the foil is removed, the surface of the cast is coated with a film of LePage's glue, the foil returned to place and by pressure and burnishing conformed closely to all surfaces of the cast. Sandarac or shellac varnish may also be employed. Whatever adhesive agent is used it should be applied in a thin coat and allowed to become somewhat sticky before returning the foil to the cast.

To aid in the removal of the tin foil from the vulcanized case the former should be covered with a film of soap, either lather or liquid, the surplus being removed with pellets of cotton and the film allowed to dry before closing the flask.

In case the tin foil cannot be readily stripped from the denture after vulcanization it can be removed by the application of mercury, rubbing it into the tinned surfaces with chamois leather.

Casts formed from magnesium oxy-chloride require no coating or preliminary treatment, the surfaces being sufficiently smooth to impart a dense and polished surface to the vulcanite.

The steps having been carried out as described, the plaster contents of the flask are now in a comparatively dry and hardened condition, the matrix filled without distortion of its walls or the cast face.

To prevent the rapid saturation of the now dry plaster investment in the flask during vulcanization, the latter should be placed above the water in the vulcanizer, and hardened in steam instead of under water, as is the usual method. Cases so manipulated often come from the vulcanizer with the plaster almost as hard and capable of resisting stress as when first introduced.

SCREW PRESSES

Screw presses are frequently employed for closing flasks. These appliances have screws of different pitches, ranging from 1-10 to 1-16, which with a short handle yield less force

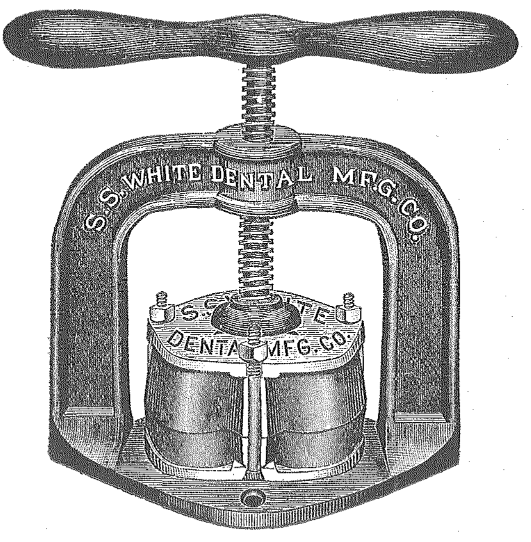


Fig. 271.— Double Handle Flask Closing Press. Screw 1/12 Pitch

than a screw of less pitch, as 1-20. The handles of most flask presses, however, are double, permitting the use of both hands in closing, so that an equal, or greater, amount of force can be developed by means of the press with double handle than with the flask wrench.

Spring devices, as the Donham or Wilson flask presses, are designed for maintaining the partially closed over-packed

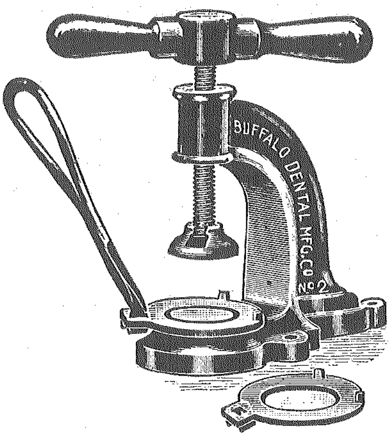


Fig. 272.— Double Handle Flask Closing Press. Screw 1/16 Pitch

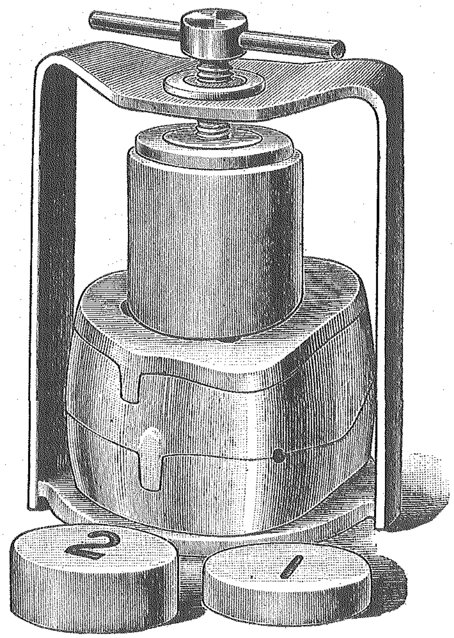


Fig. 273.— The Donham Automatic Flask Closing Spring Press for Two Flasks

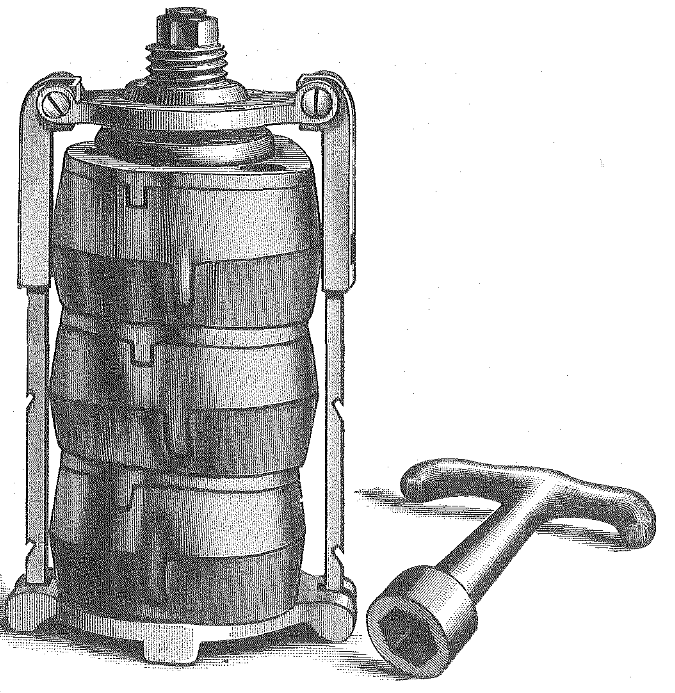


Fig. 274.— Adjustable Automatic Flask Closing Spring Press for One, Two or Three Flasks

flask under continuous pressure until the elevation of temperature within the vulcanizer renders the rubber sufficiently plastic to escape into the space provided, without subjecting cast or matrix to excessive pressure or crushing strain.

In the vulcanization of thick, bulky masses of rubber, spring closing devices are of decided advantage, for the reason that when excessive expansion of the mass occurs, the spring yields, allowing the flask to open slightly, thus relieving the matrix walls and cast face from undue stress. Later on when contraction sets in, the resiliency of the spring will again force the flask together.

CHAPTER XXII

VULCANITE

In prosthetic operations, *vulcanization* is the process by which rubber as prepared for dental purposes is changed from a plastic state to a hardened condition capable of retaining its molded form and of resisting stress.

Rubber so treated is termed *vulcanite,* and the apparatus by means of which the process is carried out is called a *vulcanizer*.

In order to have a clear understanding of the process of vulcanization it will be necessary to learn something of the origin and physical properties of both crude and manufactured rubber, and of the chemical changes which occur during the hardening process.

Rubber

Rubber is a colloidal substance obtained by evaporating the juice derived from various species of tropical trees, shrubs, vines and creepers. The first importations of importance of this material into Europe, in the form of bags and bottles, occurred in the early part of the eighteenth century, but its real origin was apparently unknown. From the fact that it was found very useful in rubbing out lead-pencil marks it was called *rubber*. The name *India* was applied to it because the early shipments came from the West as well as the East Indies.

Brantt states that "In 1735 La Condamine first discovered that the substance was the dried milky juice of a tree which the Indians on the coast of the Amazon River called *Caout-Chouc* and from which, from time immemorial, they had been making waterproof fabrics, shoes, vessels, etc."

Caoutchouc

It is a long story — the history of investigation concerning the physical and chemical properties of caoutchouc. More than one hundred and seventy-five years have elapsed since La Condamine first discovered that it was of vegetable origin. Many eminent chemists have devoted a great deal of time to investigating this natural product, and yet to-day there are some problems arising from the necessary mixture of caoutchouc with other substances for commercial purposes, but partially solved.

Carl O. Webber, Ph. D., Crumpsall, Eng., whose work is perhaps the most logical and up-to-date, in "The Chemistry of India Rubber" (1909), says in regard to the difficulties attending investigations of this material:

"No class of bodies offers such formidable manipulative difficulties to the investigating chemist as the remarkable group of colloids comprised under the collective name of India rubber. These difficulties are physical rather than chemical — that is to say, they do not so much consist in the functional complexity of the molecules of India rubber as in the circumstance that these molecules are, at any rate at present, known only with the colloidal state superimposed upon them. Matter in this state does not exhibit the abrupt changes of physical condition which, in crystalloids, take the form of melting points, boiling points and solution. The physical changes induced in colloids by heat, or by solvents, are perfectly continuous changes as long as the underlying chemical molecule or configuration remains intact. As a consequence the characterization and identification of the colloids and their derivatives and their isolation and purification from mixtures of them, offers frequently almost insuperable difficulties."

Crude caoutchouc as it comes to market is of varying and uncertain composition. A lot produced in a given locality will oftentimes differ slightly in composition from another lot from the same species of trees in a nearby locality.

The juice when it first issues from the tree is milklike in appearance and is termed *latex*. It consists of more than 50 per cent water. On exposure to the air it loses most of the moisture, is reduced in bulk, turns brown and becomes more or less elastic.

The rubber gatherer in the native forests dips a clay-covered paddle in the collected latex, gives it a few turns and subjects the adhering film to the heat and smoke of an open fire to evaporate the moisture rapidly, repeating the process many times until a good-sized oval mass, termed a "biscuit," is formed.

In this as well as various other crude methods of preparation, sand, dirt and other foreign matter become incorporated, while covering an imperfectly evaporated layer with a fresh one causes the retention of excess moisture.

Recent methods whereby the latex, when freshly collected, is subjected to the action of chemicals for the extraction of undesirable constituents, have resulted in the production of rubber of a superior quality.

One formula for Para latex and another for the rubber after evaporation of the moisture are given below:

Latex		*Evaporated Juice*	
Water	55.15	Caoutchouc	94.6
Caoutchouc	41.29	Resin	2.66
Proteids	2.28	Proteids	1.75
Sugar	0.36	Ash	0.14
Ash (Salts)	0.41	Moisture	0.85
Loss	0.51		
	100.00		100.00

Caoutchouc of commerce is prepared for manufacturing purposes by first shredding it and washing to remove the contained soluble constituents and foreign matter. It is then thoroughly dried and passed through heated rolls to render it again homogeneous. Caoutchouc prepared in this manner, although comparatively pure, is adaptable to but few purposes because of its tendency to stick to objects it comes in contact with, or when folded on itself. It also deteriorates, and in time loses its elasticity and becomes hard.

The discovery of a method of rendering soft rubber less adhesive and more permanent was made by Charles Goodyear of Boston in 1839, and Thomas Hancock of England in 1842. Goodyear patented his process in 1843. While the methods of these men eliminated the stickiness and improved the quality, the rubber was not hardened appreciably. Nelson Goodyear discovered a process of hardening rubber in 1849, which process was, and is still, termed *vulcanization.*

The hardening of all varieties of rubber is rendered possible by the addition of sulphur. In the actual process of hardening, the rubber may be subjected to the action of heat and usually moisture, in a specially designed boiler termed a *vulcanizer.* "Thin articles may be vulcanized cold by dipping them in a cold mixture of 100 parts carbon disulphide and 2½ parts of bichloride of sulphur for from 1½ to 3 minutes, according to the thickness of the articles." (Braunt.)

The first experiments with rubber in denture construction were made by Mr. Bevan of the Goodyear Rubber Company, in conjunction with Dr. Putnam of New York, and Dr. Mallett of New Haven in 1853. Their vulcanizer weighed 1,200 pounds. (Harris, 1871.)

Formulas for Dental Rubbers

The following formulæ for various colored rubbers used for dental purposes are those furnished by Dr. Wildman:

	Dark Brown	Red	Dark Pink	Grayish White	Black	Jet Black	Maroon
Caoutchouc	48	48	48	48	48	48	48
Sulphur	24	24	24	24	24	24	24
Vermilion		36	10	..	..	..	30
White Oxide of Zinc		..	30	96	..	..	..
Ivory or Drop Black		..	..	..	24	48	6
Per cent of Caoutchouc in mass	66	44	43	22.6	50	40	44

Various shades of red and pink rubber are produced by modifying the percentage of vermilion; maroon, by increasing or decreasing the black pigment.

Vulcanizable Rubber Employed for Denture Bases

Red, maroon and black varieties of rubber of the best quality, in addition to sulphur, contain a comparatively small percentage of inert material usually represented by the coloring pigments employed. Because of their greater strength and elasticity, the better grades of rubber should, as a rule, be employed for baseplate purposes.

Cheap grades of basic rubber are heavily loaded with foreign material to reduce the cost. When present in any considerable quantity they reduce the elasticity of the finished product and render it brittle as well.

The cheaper grades of rubber, however, show less tendency to become porous in vulcanizing than do the better grades because of the comparatively low percentage of caoutchouc present, grayish white in the table of formulas, showing only 22 per cent of rubber.

PINK RUBBER EMPLOYED FOR GUM FACING

Since the basis of all vulcanized rubbers is a combination of sulphur and caoutchouc, and the color of this mixture is brown, it follows that in order to produce a pink the base must be lightened by the addition of a white pigment. White oxide of zinc, and sometimes kaolin are used for this purpose, to which vermilion is usually added for producing a pink tint. Varying shades of this color may be produced by modifying the proportions of the pigments. The best products, however, are but poor imitations of the natural gum tissues, being dense, opaque and flat.

In full cases where the gum tissues are not visible the dissimilarity is not so striking as in partial cases where the natural gums are exposed to view. When possible to avoid it, pink vulcanite should not be applied when the line of junction of the artificial gum with the natural tissues will be plainly apparent.

To overcome the objection of the flat, lifeless appearance of pink vulcanite, various substitutes have been offered, one of the most satisfactory of which is that known as Granular Gum Facing.

PINK GRANULAR GUM FACING

This gum facing consists of many minute particles of various colored rubbers, pink, white, red and possibly a little yellow, the pink largely predominating, so united as to form a homogeneous mass, yet not so blended that the particles lose their individual tints.

As prepared for use it is lighter than the natural tissues but darkens slightly during vulcanization. Although opaque it does not appear as flat as the ordinary pink vulcanite, on account of the variegated colors of which it is composed.

When this material is used for artificial gum facing, the carving and polishing having been properly accomplished, it presents the very best appearance of any of the pink varieties of vulcanite and should be used in preference to the latter.

If on vulcanizing it presents a darker appearance than desired, it may be lightened or *solarized* by placing in a glass vessel, covering with alcohol and bleaching in the sun for one-half to three-fourths of an hour. Pink vulcanite can also be lightened in the same manner. The tint so imparted will in time disappear, but the favorable impression produced on the mind of the patient is well worth the time expended.

The Chemical Constituents of Rubber

Caoutchouc is classed as a colloidal hydrocarbon. When subjected to the action of the best-known solvents the greater portion, about ninety-five per cent, is brought into solution, while about five per cent remains insoluble. The chemical formula of the soluble portion is $C_{10}H_{16}$, while that of the insoluble constituent is $C_{30}H_{68}O_{10}$. The percentage of carbon and hydrogen in the insoluble portion is the same as in the soluble portion, as is seen in the following: $C_{30}H_{68}O_{10} = (C_{10}H_{16})_3 + 10\ H_2O$.

Webber, whose researches in this field are perhaps the most elaborate of any, refers to the insoluble constituent of rubber as follows:

"In brief I suggest that this insoluble compound is a link between India rubber and the complex carbohydrates, the celluloses in particular, which I am inclined to consider the raw material from which the plant produces all the terpenes, including India rubber."

There is, on the other hand, no doubt that India rubber absorbs oxygen when exposed to the atmosphere, and this oxygen absorption finally always results in the conversion of the India rubber into a brittle resinous body, generally described as Spiller's resin. Spiller has published an analysis of this body and gives the following figures:

C — 64
H — 8.46
O — 27.54

"It is interesting to note that these figures very exactly agree with the composition of a body of the formula $C_{30}H_{48}O_{10}$, the relation of which to our insoluble constituent, $C_{30}H_{66}O_{10}$, is obviously significant. Equally interesting to observe is the fact immediately deducible from the above given percentage composition of Spiller's resin, that this oxidation of India rubber consists purely and simply in the addition of oxygen to the unsaturated India rubber molecule, and that consequently the carbon-hydrogen ratio of India rubber — 10:16 — remains unaffected in this process." * * * "From this we may infer that the oxygen percentage of India rubber in its free resin state of purity is due to two factors, one of which is the presence of the insoluble constituent, $C_{30}H_{66}O_{10}$, the other to the formation of oxygen addition products of India rubber."

He further states that the insoluble constituent does not seem to be present in all varieties of rubber, and when present it occurs in very small quantities.

Chemistry of Vulcanization

Webber further sums up the observations and results of many experiments in the vulcanization of rubber as follows:

"From these facts we are justified in drawing the following conclusions:

"First — The India-rubber hydrocarbon, polyprene $C_{10}H_{16}$ combines with sulphur without evolution of hydrogen sulphide. The vulcanization process of India rubber is, therefore, an addition process.

"Second — The insoluble constituent of India rubber, which forms only an insignificant proportion of the chemical product, not exceeding five per cent of the total, combines with sulphur under vulcanizing conditions at a very slow rate, with the evolution of hydrogen sulphide and with the formation of a substitution product.

"The process of vulcanization consists in the formation of a continuous series of addition products — of polyprene and sulphur, with probably a polyprene sulphide $C_{100}H_{160}S$ as the lower and $C_{100}H_{160}S_{20}$ as the upper limit of series. Physically this series is characterized by the decrease in distensibility, and increase in rigidity from the lower to the upper limit. Which term of the above series, i. e., which degree of vulcanization, is produced is in every case only a function of temperature, time, and proportion of sulphur present."

"There arises now, of course, at once the question as to the nature of the process by which sulphur enters into combination with the polyprene, whether the polyprene sulphide or sulphides formed are addition or substitution products. Certainly what we already know respecting the chemical nature of India rubber leads us to infer that the vulcanization process consists essentially in the formation of an addition product of sulphur and polyprene. This assumption, however, requires further support in view of the fact that quite a number of writers, from Payen to most of the recent authors, declare that vulcanization is accompanied by the evolution of sulphuretted hydrogen, thereby implying that the process is a substitution and not an addition process. Indeed, most of the recent authors on this subject state this in so many words. We shall therefore have to subject this point to a careful examination.

"Assuming the compound of polyprene and sulphur, which indisputably forms in the vulcanization process, to be a substitution product, it follows with absolute necessity that for each 32 parts of sulphur combining with the polyprene we must obtain 34 parts of hydrogen sulphide. Now in the process of vulcanization as practically carried out, we obtain on an average, say, 2.5 per cent of combined sulphur. Consequently, the vulcanization of one ton of India rubber, on the above assumption, would be bound to yield very nearly 60 pounds of hydrogen sulphide, or approximately 18,000 litres. Considering that in a number of factories the amount of India rubber vulcanized daily largely exceeds one ton weight, we should expect to find the vulcanizing rooms of these factories reeking with this gas. As a matter of fact, however, there is scarcely ever a trace of this gas to be discovered in the rubber works atmosphere, and the very rare cases in which its presence becomes noticeable may always be considered as an indication of something 'having gone wrong.' "

Webber's work may be briefly summed up as follows:

That the hardening of rubber by vulcanization is brought about by a chemical union of $C_{10}H_{16}$ or polyprene with sulphur, resulting in the formation of a series of polyprene sulphides, not by the breaking up of the $C_{10}H_{16}$ molecules, but by the addition to them of sulphur; that the formation of hydrogen sulphide during the process of vulcanization is not an essential chemical reaction, necessary to the hardening of rubber; that when formed it is due to the presence of the insoluble constituent — $C_{30}H_{68}O_{10}$ — in the rubber; that when the process of vulcanization is properly conducted, such slight amount of hydrogen sulphide as is formed does not seriously interfere with the quality of the hardened product; and, finally, that when hydrogen sulphide is formed in excessive quantity it is an indication that something "has gone wrong," and the quality of the vulcanite is impaired.

While Webber's observations seem generally logical, there are some peculiarities occurring in the vulcanization of certain classes of cases that require further study. For example, thick cases in which there is a large bulk of rubber present, frequently come from the vulcanizer in a porous condition and with a strong odor of hydrogen sulphide, an indication of something having gone wrong. The same grade of rubber may be employed in thin or even medium thick cases, vulcanized under the same conditions of temperature, time, and moisture, or at the same time in the same apparatus, yet show no porosity, nor will the odor of hydrogen sulphide be perceptible.

The cause of this is not clear. If Webber's observations are correct that the development of hydrogen sulphide is due to the presence of the insoluble constituent in the rubber, and the same grade of rubber is used in both cases, why should not the case containing less bulk show at least a proportionate amount of porosity, accompanied by an appreciable amount of hydrogen sulphide?

Two hundred blocks of vulcanite, $\frac{5}{8}$x$\frac{5}{8}$x$\frac{5}{8}$ inches, in all of which practically the same grade of rubber was used, when sawed through the center showed the following results:

125 blocks, very porous.
25 blocks, slightly porous.
50 blocks, non-porous.

These cases were all vulcanized in the same apparatus, and under as nearly the same conditions of time and temperature as possible, yet seventy-five per cent were porous, while twenty-five per cent were solid. The most porous blocks were bulged out slightly, while some of the semi-porous and all of the solid blocks showed some contraction. The above tests were made for the purpose of illustrating the variation in porosity of the different blocks and were not tested for dimensional change.

Wilson suggests that the expansion of the rubber in the matrix, which occurs before and possibly continues for a short time after the vulcanization point is reached, depletes the matrix of some of the solid material. This having escaped beyond the bounds of the matrix cannot return when contraction later occurs, being prevented from doing so, first, by the natural sluggishness of the rubber, and, second, because as soon as vulcanization sets in the rubber next the outer surfaces of the matrix forms a constantly hardening crust, which effectually prevents its return, and, third, the surplus itself being usually disposed in thin layers is quickly hardened by the vulcanizing process.

Now, as vulcanizing proceeds, the interior of the bulky mass not yet hardened continually contracts, usually toward the hardened outer shell, resulting in the development of many internal spherical spaces, the formation of a partial vacuum, and on account of the heat attained, the hydro-carbon be decomposed and unite with the sulphur to form sufficient H_2S gas to fill the space.

Whatever the cause, the fact remains that porous conditions frequently develop during vulcanization, oftentimes to such an extent as to require reconstruction of the denture.

Porosity of Vucanite and How to Overcome It

Any means, therefore, that can be employed for reducing the excessive bulk of rubber without materially increasing the weight or disturbing the required contour of the case might be advantageously used for overcoming porosity.

Several methods, having this end in view, will here be mentioned:

First — The baseplate itself may be formed in wax so as to represent one-half or more of the required bulk of the finished denture. This may then be vulcanized, after which the teeth are occluded upon it, the deficient contour developed in wax and the case revulcanized.

This method is specially applicable to lower cases where the alveolar border is almost completely absorbed and where the establishment of normal profile and bite requires that the teeth shall be set high above the border crest. It may also be used to advantage in badly absorbed ridges in upper cases. While this method does not reduce the bulk of rubber, the process of vulcanization is divided into two stages, which in practically every case will avert porosity.

Second — When for any reason the double vulcanization method is not considered advisable, these and similar cases may be carried out as follows:

The wax model denture is flasked in the usual manner. Ping gum facing is applied to the labial and buccal walls of the matrix. The lingual wall of the matrix is lined with basic material which should be carefully applied so as to leave no open spaces in the lining. This leaves the central portion or body of the matrix still unfilled. Into this space blocks of old vulcanite, cut in such manner as to fit into the opening without disturbing the packed rubber, are placed. The blocks should not extend so high as to interfere with the alveolar ridge of the cast when the two halves of the flask are closed.

Additional basic rubber is now laid over the blocks, extending from the inner to outer periphery of the matrix, thus entirely covering or sealing them in, so that none of the old rubber will be exposed to view when the case is finally finished. Sufficient excess should be present to insure all spaces between the blocks and matrix walls being filled on closure of the flask.

Third — Blocks of aluminum or tin may be employed instead of vulcanite, the technic of application being similar to that just described. When a considerable space is to be filled, aluminum is preferable to the tin on account of its lighter specific gravity. When either of these or similar metals are inclosed, the weight of the denture will be increased.

Fourth — The interior of the matrix may be filled in with pink or white rubber, each of which is heavily loaded with inert foreign material, as the oxide of zinc or white kaolin.

These rubbers, even in excessive bulk, seldom ever become porous in vulcanization.

Closing Flasks With Spring Pressure

To compensate, in part at least, for the excessive contraction which occurs in bulky cases during vulcanization, the closing of the flask with spring pressure is advised.

The matrix is packed in the usual manner, slightly in excess of the amount actually required to fill the space. The flask is set in a spring press of the Wilson or Donham type, and the screw turned to develop sufficient tension in the spring to force the flask together, as the rubber becomes semi-liquid with rise of temperature.

Since closure of the flask is not accomplished immediately but is extended over a considerable period of time, in many cases not until the hardening process begins, it is argued that the expansion in the mass of rubber, due to heating, is over before all of the excess is removed from the matrix. Space is thus provided for some of the last excess by the contraction of the mass of rubber which begins with the hardening process.

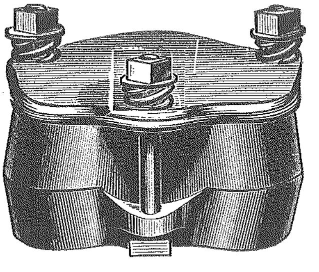


Fig. 275.—Flask with Bolt Springs in Position

Stated differently, some of the excess rubber is thus fed into the constantly contracting mass until the hardening process is well under way. The resulting vulcanite shows greater density with less contraction than when the flask is completely closed before introduction into the vulcanizer.

All forms of spring-flask closing devices are designed, primarily, to partially compensate for excessive contraction in the mass of rubber by prolonging the closing process throughout the greater portion of the contractile period. Secondarily, the use of springs obviates excessive stress on the matrix walls and thus reduces the tendency toward distortion.

Dr. Geo. B. Snow suggests the use of small spiral springs interposed between the nuts and flask top. When applied, the flask need not be fully closed, but the springs must be compressed so that as the rubber becomes plastic with rise in temperature, the resiliency in the springs will effect complete closure. (See cut, page 446.)

Dimensional Changes Occurring in Rubber During Vulcanization

EXPANSION

Two distinct changes occur in rubber during the vulcanizing process, viz., first, *expansion,* followed by *contraction.*

The expansive movement, which is very decided, begins with the first application of heat and continues until shortly after the hardening process sets in. The lowest point at which rubber begins to vulcanize or harden is approximately around 240 degs. F., while the highest point at which it may safely be conducted, without causing detrimental chemical change, is 320 degs. F.

During the initial heating of a packed and closed flask, up to the lowest point of vulcanization, the matrix having been full and waste gates formed as described, the rubber flows outward into the spaces so provided as a result of expansion due to rise in temperature of the mass.

In case no waste gates are present and the flask, fully packed, is closed before introducing into the vulcanizer, distortion of the matrix will usually occur, the amount depending, first, upon the excess of rubber present, and second, upon the tendency of the matrix walls to yield under stress or compressive force, and third, upon the temperature of the applied heat.

That the expansive force of rubber is very positive and powerful as well is frequently seen in the distortion of matrix walls and cast surfaces, which distortion if wrought directly would require the application of heavy mechanical force.

CONTRACTION OF RUBBER

The contractile movement sets in shortly after the rubber begins to harden and continues throughout the vulcanizing process in a moderately definite ratio, the amount depending upon the functions of time and temperature of applied heat.

Since no appreciable amount of excess rubber, which from any cause has been expelled, can return to the matrix, it naturally follows that as contraction of the essential body of material occurs, there being no means of replenishing it as it becomes reduced in bulk, warpage of the baseplate is very liable to occur since the mass no longer completely fills the matrix space.

At times contraction of the rubber is so marked that spaces develop between the vulcanite and the teeth, while that enclosing the pins contracts in such manner as to almost release the latter. When such a condition arises the teeth will frequently be found loose, can readily be moved in their mat-

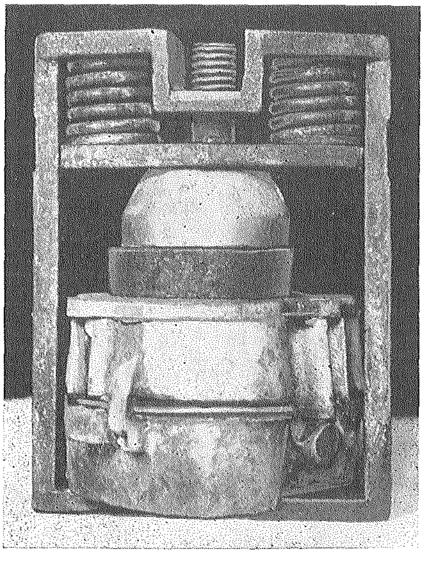


Fig. 276.—This Cut Shows a Flask Forced and Held Apart One-eighth Inch by the Expansion of Rubber During Vulcanization. The Spring Exerted a Pressure of Over 500 Lbs.

rices, and will be easily displaced under stress. When the denture is subjected to use, the spaces become filled with food, which, as it decomposes, gives rise to disagreeable odors. Cases in which marked contraction occurs usually require reconstruction.

Vulcanizers

The apparatus in which the flasks containing the packed rubber are placed while hardening is called a vulcanizer. It consists of a boiler usually large enough to hold two or three flasks, and is commonly made of seamless hammered copper, the walls of which are about one-eighth of an inch thick.

The top margin of the boiler is turned true and polished and to this a cap or cover is fitted for confining the steam. The cap is usually grooved to receive a packing of graphite, steam-proof fiber or metallic lead, to seal the boiler tightly and prevent the escape of steam during vulcanization.

Various methods are employed for fastening the top to the boiler, the most convenient of which is by means of a cross-bar hinged to one side of the boiler. When the cover is adjusted, the bar rests upon it and is bolted to the opposite side with a single bolt.

As before stated, the boiler is usually made of hammered or pressed copper, without brazed or soldered joints, so as to resist the expansive force of steam to which it is subjected during vulcanization. Cast boilers of copper, brass or iron, unless made specially heavy, are liable to prove defective and leak or burst with use. Explosions are by no means rare, and such accidents are always dangerous. Every precaution, therefore, should be taken to obviate them, first, in the selection and use of the most trustworthy and well-constructed appliance it is possible to secure, and second, in bestowing the proper care upon it while in use.

SAFETY DEVICES

To the lid of the vulcanizer is usually attached various devices for registering temperature or indicating pressure within the appliance, those most commonly employed being the thermometer and the steam gauge.

THE THERMOMETER

An attached thermometer enclosed within a metal case indicates the temperature. The base of the thermometer case screws over a projection on the vulcanizer cover.

The center of the projection is bored out to make a reservoir for containing mercury. In this mercury bath the thermomter bulb rests and by this means the thermometer has a direct metallic connection with the interior of the vulcanizer through the mercury and the metal cover. The metal casing of the thermometer should be removed from the vulcanizer cap from time to time to see that the depression contains the required quantity of mercury, i. e., sufficient to surround the thermometer bulb. When the bulb does not rest in the mercury bath the temperature reading will be much lower than the temperature of the steam within the vulcanizer. The result in such cases is that if the temperature is raised to the vulcanizing point as indicated by the thermometer, the contents of the flask will in all probability be ruined by overheating. Deficient mercury in the depression oftentimes accounts for the safety valve of the vulcanizer blowing off before the thermometer registers the vulcanization point.

THE STEAM GAUGE

Since a definite ratio exists between steam pressure and temperature, a steam gauge of ordinary type and connected to the vulcanizer cover in the usual way may be used in conjunction with or independent of other registering devices.

TABLE OF STEAM PRESSURE

The following table, showing the relation of temperature to pressure of heated or unconfined, and superheated or confined steam, is furnished by the Buffalo Dental Manufacturing Co.:

Degrees Fahrenheit	Steam pressure per square inch
212	0
220	2
230	6
240	10
250	15
260	21
270	27
280	34
290	43
300	52
310	63
320	75
330	89
340	104
350	120
360	140
370	160
380	180
390	205
400	234
410	264
420	296
430	335

Degrees Fahrenheit	Steam pressure per square inch
440	375
450	410
460	455
470	515
480	565
490	603
500	663
510	721
520	798
530	864
540	937
550	1015

It will be noted that the elastic force of steam increases at a rapid rate and not in direct proportion to rise of temperature. For example:

At 220° F. the pressure is 2 lbs. By steps of 50 degrees the increase is very marked.

270° F. the pressure is 27 lbs., an increase of 25 lbs.
320° F. the pressure is 75 lbs., an increase of 48 lbs.
370° F. the pressure is 160 lbs., an increase of 85 lbs.
420° F. the pressure is 296 lbs., an increase of 136 lbs.
470° F. the pressure is 515 lbs., an increase of 219 lbs.
520° F. the pressure is 798 lbs., an increase of 283 lbs.

Without suitable means for controlling the temperature, or without almost constant watching of the vulcanizer, overheating or burning of the rubber during the hardening process is very liable to occur.

GAS REGULATORS

To avoid the necessity of constant supervision of the vulcanizer when in use and still maintain a uniform and effective working temperature, an appliance called a *gas regulator* can be used for controlling the amount of gas supplied to the burner. By proper adjustment of the regulator the gas supply to the burner will be reduced when the temperature rises above the point of vulcanization determined upon and at which the pointer of the regulator was previously set.

TIME REGULATORS

To further reduce the responsibility of the prosthetist, a *time regulator* can be attached to the gas supply pipes, which will automatically cut off the fuel at whatever time the clock is set. By combining the gas regulator with the time regulator, the prosthetist introduces the flask, closes the vulcanizer, turns on and lights the gas and leaves the apparatus to itself, when, without further attention, the case is vulcanized and the gas automatically shut off. Before lighting the gas the lever arm of the clock which controls the gas valve should

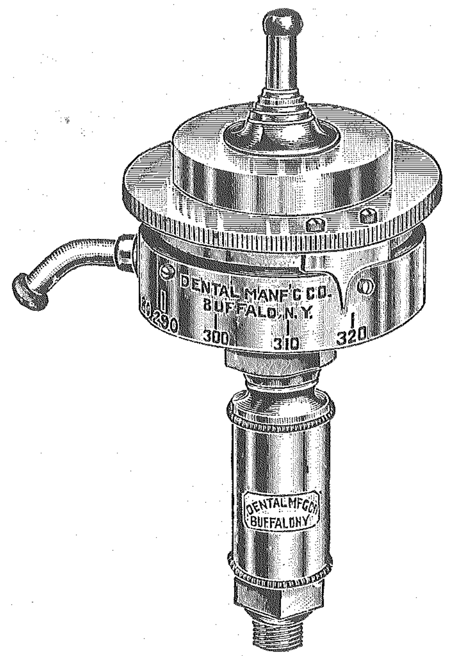


Fig. 277.— Automatic Gas Regulator

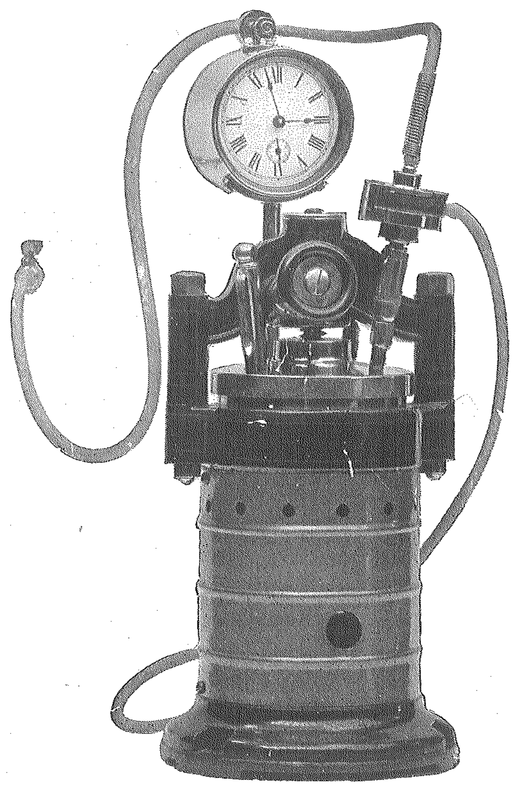


Fig. 278.— Vulcanizer with Gas and Time Regulator Attachments

be set on the threaded spindle of the hour hand at such point as to allow time for the temperature to rise to vulcanizing point and further to allow time for vulcanization to occur as well.

Appliances of this type are not a luxury but a necessity in every well equipped dental laboratory.

THE SAFETY VALVE

Every vulcanizer should have attached to it a device called a *safety valve,* which, when the pressure within the boiler exceeds somewhat the high vulcanizing pressure, will automatically open and release the steam.

The simplest device of this type consists of a tube screwed into the top of the vulcanizer. The outer end of the tube is fitted with a screw cap having a hole in the center. The opening through the cap and tube leads directly into the vulcanizer. By removing the cap, placing a disc of thin copper foil over the end of the tube and replacing the cap tightly, the

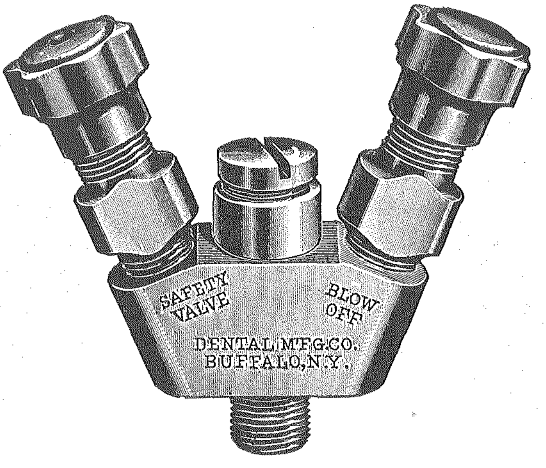


Fig. 279.—Safety Valve and Blow-Off Attachment for Vulcanizer

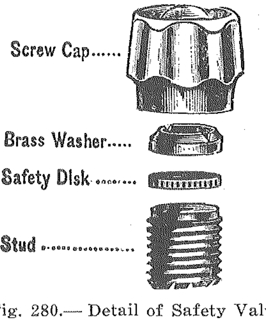


Fig. 280.—Detail of Safety Valve

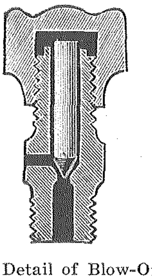


Fig. 281.—Detail of Blow-Off Valve

vulcanizer chamber is thus sealed. The copper foil disc usually breaks when the pressure exceeds 350° F., considerably above vulcanizing temperature, but well below the tensile limits of the boiler, thus avoiding danger of explosion. This safety valve is independent of thermometer, gas or time regulator or steam gauge and will work when other means fail, providing, however, that reasonable attention is given it to see that the tube, both internally as well as externally, of the disc does not become clogged.

Vulcanization of Cases in Which Automatic Flask Closing Devices Are Used

Practically all dental rubbers are so compounded that when heated to 320° F. and maintained at that temperature for one hour they will vulcanize. From twenty-five to forty minutes are usually required to raise the temperature within the apparatus to the vulcanizing point so that the actual time consumed in the process of hardening the rubber ranges from eighty-five to one hundred minutes. Bulky cases should be vulcanized at the same temperature, but for a somewhat longer period, since large masses of rubber naturally require more time to harden than do those of less bulk.

It is the opinion of the writer, based upon many experiments in the vulcanization of all classes of cases, bulky and otherwise, that the use of automatic springs for closing the flask in the preliminary stages of vulcanization will result, first, in less dimensional change of the matrix; second, in a thicker external shell being formed, and third, in a denser quality of vulcanite when hardened.

These observations coincide very closely with extensive experimental work carried on by Dr. G. H. Wilson, and which is described in detail in his work, Dental Prosthetics. (1914, Lea & Febiger.)

When automatic closing devices are used, space should be provided for the escape of surplus rubber. This should be in the form of a groove of ample size, close to and extending entirely around the periphery of the matrix, but with no gateway connections leading from the matrix to the space.

Vulcanization of Cases in Which the Flasks Are Closed and Bolted Before Placing Them in the Vulcanizer

To avoid excessive dimensional change in the matrix during vulcanization, in those cases in which the flask is closed and bolted before placing in the vulcanizer, the following conditions must be observed:

The case should be treated as described under the heading, "Test Closing of the Flask." (See page 431.)

In this, as in all methods of vulcanization, the case should be placed above water and the process conducted in an atmosphere of steam.

From thirty to forty minutes' time should be allotted in raising the case to vulcanizing temperature, which, in this instance, is lower than by the method just described.

Vulcanization should be conducted at a temperature ranging from 290° F. to 300° F. and for a period varying from two to two and one-half hours.

It is the belief of the writer that, although the rubber is, in all probability, in the most liquid condition at the highest temperature, it also exerts the greatest expansive force between 300° F. and 320° F.

If this assumption is true, it will thus be seen that by this method the matrix is relieved of considerable expansive force, which, if permitted to develop, would result in distortion.

Summary of Facts of Importance in Regard to Vulcanization

The important facts in regard to vulcanization may be summed up as follows:

When automatic flask-closing devices are used, cases may be satisfactorily vulcanized at 320° F. for a period of one hour, or, when bulky, at the same temperature for a longer period.

When flasks are closed and locked before introducing in the vulcanizer the process should be conducted at a temperature not exceeding 300° F., preferably slightly lower, and for a sufficient length of time to induce the proper degree of hardness in the vulcanite. The time may range from two to three hours, depending on the bulk of material and the quality of the rubber employed. The actual time can only be determined by suitable tests for any particular rubber. Such tests, when once made and recorded, serve as a basis for subsequent operations.

Removal of the Flask from the Vulcanizer

From ten to fifteen minutes should elapse, after vulcanizing a case, before opening the blow-off valve for the release of the steam. It should then be opened but slightly so that the pressure may be gradually reduced. When opened widely, so that the steam pressure within the vulcanizer is lowered suddenly, before that within the flask, the contents of the latter will frequently become distorted.

Removal of the Denture from the Flask

On removal of the flask from the vulcanizer, and before opening, it should be placed in cold water for another ten or fifteen minutes, or until the plaster and denture are thoroughly chilled, otherwise warpage of the case will occur at this stage.

When chilled, the bolts are removed and the flask carefully pried apart. Sometimes it is advisable, when the plaster contents of the flask have not become softened to any extent in vulcanizing, to remove the top of the flask and with a knife, carefully remove the plaster from the outer surfaces of the denture, being careful while doing so not to mar the denture base or fracture the teeth.

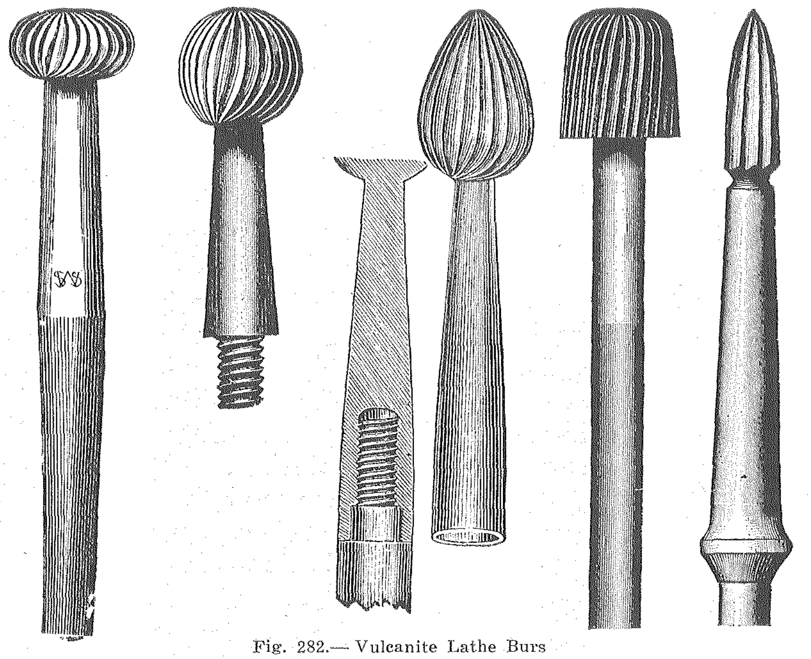


Fig. 282.—Vulcanite Lathe Burs

The flask is then separated, the plaster beneath the denture undermined and the cast and denture pried out. Removal of the surrounding plaster is a simple matter. The case should then be thoroughly scrubbed with a stiff brush to remove all remaining portions of plaster when it is ready for final finishing.

POLISHING THE DENTURE

With a coarse saw the surplus vulcanite is trimmed from the periphery of the baseplate. Further shaping of the margins to correct peripheral outline can be done with the double end vulcanite file and vulcanite lathe bars. The final smoothing of the margin and general surfaces can be quickly accomplished with emery bands on the lathe arbor.

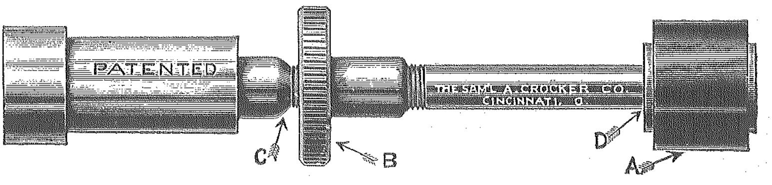


Fig. 283.— Emery Band Lathe Mandrel

When, in the final waxing of a denture, the correct gingival outline is given the gums, so that they represent the type of teeth required for that particular case, but little effort will be required in finishing the vulcanite.

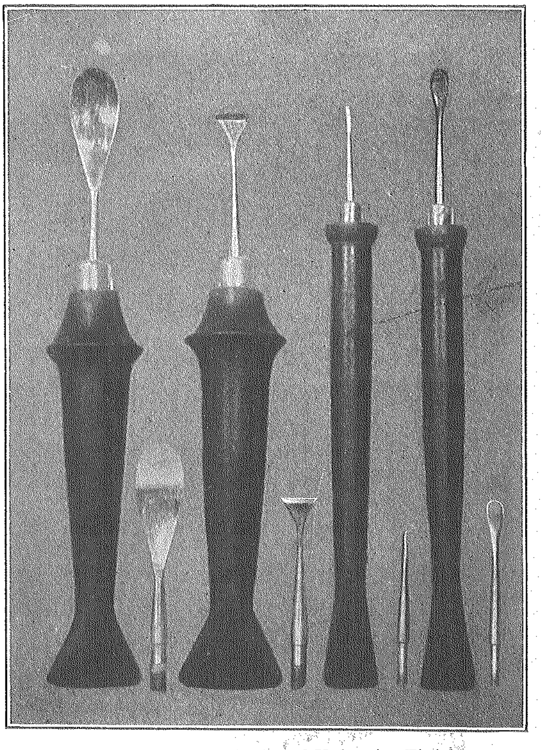


Fig. 284.— Dr. Wilson's Set of Vulcanite Finishers

The right and left bevel chisels are used to true up the gum festoons and develop clean, symmetrical, lingual margins of vulcanite against these surfaces of the teeth. The set of chisels and scrapers suggested by Dr. G. H. Wilson are excel-

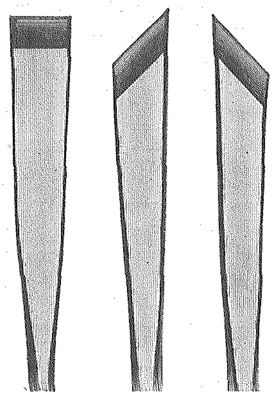


Fig. 285.— Right and Left Bevel and Square Chisels

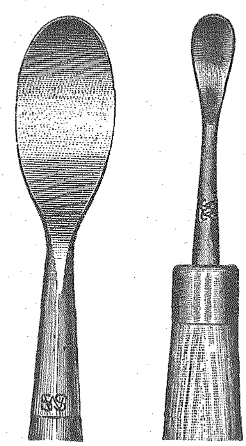


Fig. 286.— Large and Medium Scrapers of the Kingsley Type

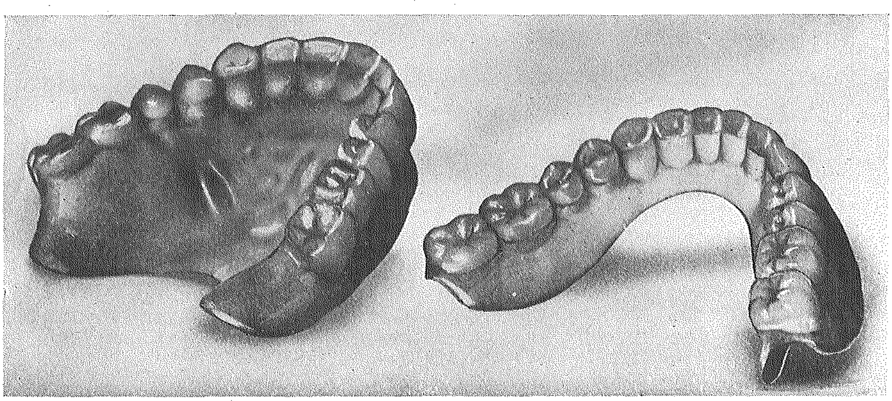


Fig. 287.— View of Upper and Lower Denture, Showing Lingual Surfaces of Teeth Developed in Vulcanite. Constructed for Dr. John Rawlingson, a Noted English Surgeon, by Dr. Genese in 1864. Loaned by Mr. Sykes of C. Ash & Sons

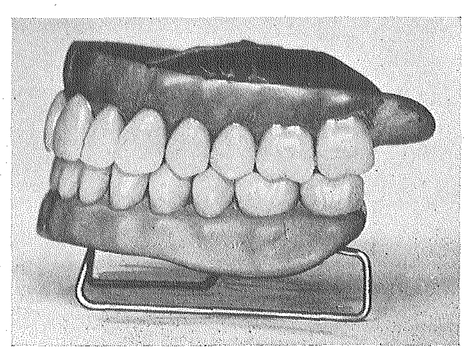


Fig. 288— Buccal View of the Rawlingson Case. This Shows Well-Proportioned Upper and Lower Teeth and Fine Occlusal Relations

lent for this purpose. This set contains a small pointed instrument for removing vulcanite from constricted spaces in the embrasures and interproximate spaces.

It is frequently advisable to develop in vulcanite, the lingual forms of the natural teeth, after the method introduced by Dr. Genese, in 1860, and later described by Dr. Fine, in 1906. Three advantages are gained by this manner of contour development: First, the bulk of vulcanite is materially reduced without impairing the strength of the baseplate; second, the teeth are given approximately their true lingual forms and consequently feel natural and comfortable to the

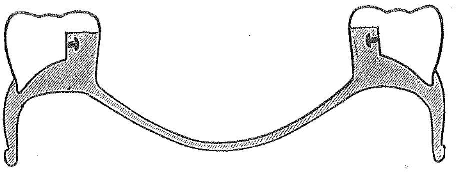


Fig. 289.— Sectional View of an Upper Denture. Lingual Surfaces of the Teeth Developed in Vulcanite (Fine)

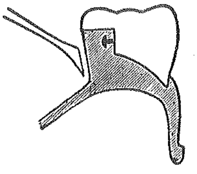


Fig. 290.— Sectional View of Upper Denture, Showing Form of Instrument Used in Carving the Wax

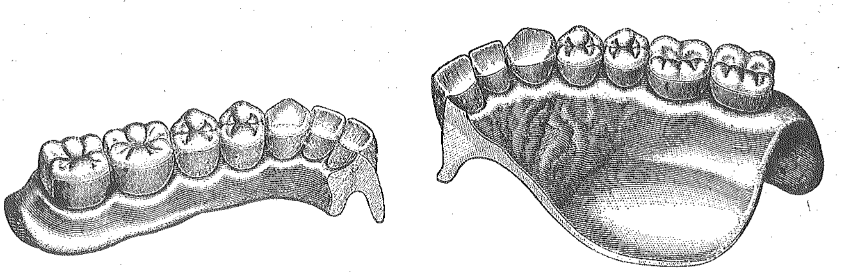


Fig. 291.— Lower and Upper Dentures in Section, with Lingual Surfaces of Teeth Developed in Vulcanite

wearer; third, such a form of denture aids materially in correct phonation. The only objections are the time required in the carving and the difficulty encountered in finishing the vulcanite in the linguo-gingival angles and embrasures.

By developing the lingual forms of the teeth in the final carving of the wax and lining the vault portion of the wax model denture with tinfoil before flasking the case, the finishing steps are comparatively simple. The tinfoil margins next the teeth should be turned away from the latter so as to be caught in the plaster investment in the upper half of the flask. When No. 30 foil or heavier is used it can readily be stripped from the vulcanite or the thinner gauges can be quickly removed by rubbing with mercury.

Rubber vulcanized against tinfoil comes from the flask clean, polished and more dense than when vulcanized against plaster, and when care is used in waxing a case but little final polishing is required.

REPRODUCTION OF THE RUGÆ

When reproduction of the rugæ has been carried out, small scrapers of the Kingsley type are most useful for freshening the depressions between these irregular ridges. If properly developed in wax, however, and the tinfoil is applied as described, care being taken to burnish it into the depressions, the polishing wheels will complete the finish without resorting to other means.

USE OF THE CALIPERS

To avoid undue thinning and consequent weakening of the baseplate, the calipers should be applied at various times dur-

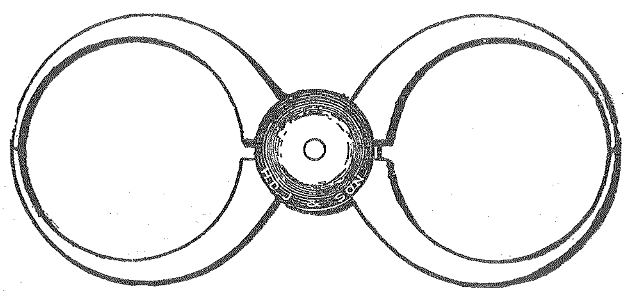


Fig. 292.— Registering Calipers

ing the finishing process. The instrument shown in the illustration is the type most commonly used.

FINAL POLISHING OF THE DENTURE

The general finish is given the vulcanite with various grits of abrasive powders and water, in the form of a medium paste, and applied with brush, felt and muslin wheels of various sizes, on the lathe. For rapid cutting, a rather coarse grit, pumice stone, followed by a finer to remove the slight scratches left by the former, is the usual method of reducing the irregular surfaces and slight angles left by the chisels, scrapers and emery bands.

The scratches left by the pumice powder are removed with whiting and water. A still higher polish may be given the vulcanite by coating it with vaseline or heavy lubricating oil, dipping it in dry plaster, and applying lightly to a soft bristle

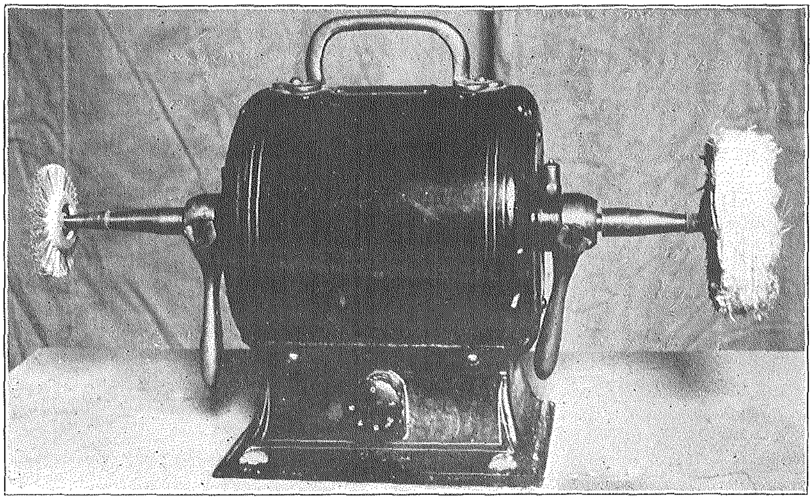


Fig. 293. — Polishing Lathe. On Left Spindle Is a Two-Row, Converging Bristle Stiff Brush Wheel. On Right, a 3½-inch Stitched Muslin Polishing Wheel

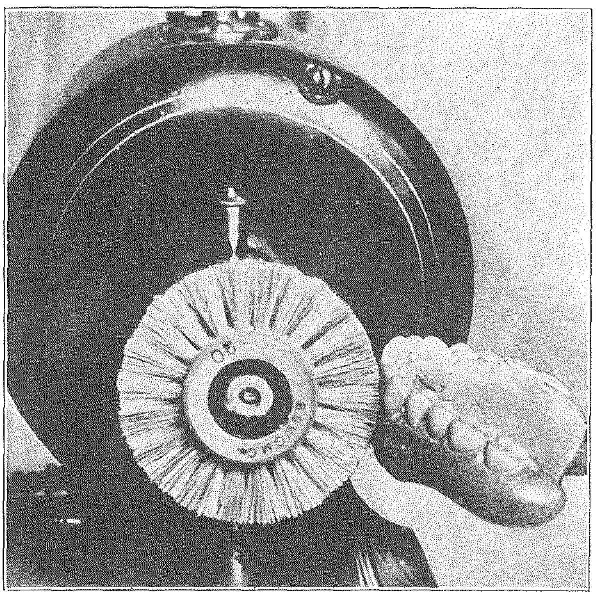


Fig. 294.— Position of Denture Against Wheel in Polishing in the Embrasures

wheel, running at high speed. The application of dry plaster is continued until all of the oil has been removed from the various surfaces.

FINISHING TOUCHES

The polished denture should be cleansed with soap and water, applied with a medium stiff brush and afterward in clear water.

It may then be placed in a small glass vessel covered with alcohol and set in the sun to *solarize* or lighten the pink vulcanite when this step is considered necessary. About one hour will be required to complete the bleaching process, the position of the denture being changed from time to time so that all surfaces may be of uniform color. After solarizing, the denture should again be cleansed in water.

FINAL FITTING IN THE MOUTH

When the patient presents, the upper denture is introduced and tested as to adhesion. When seated, the finger should be passed a number of times from front to back, applying considerable pressure on the lingual surface of the baseplate. This to a considerable extent forces the air from between the contact surfaces, after which the patient is instructed to apply the tongue to the baseplate and "draw the air" from beneath it.

Should the peripheral margins impinge on the muscles or soft tissues to any marked degree the denture should be relieved at such points and the marred surfaces polished.

The lower denture is introduced and seated on its border by drawing the lip and cheeks away from its lower margins and by applying downward pressure to partially expel the air.

Tests of the excursions of cusps of lower against upper teeth in lateral movements should be made, first without and later with interposed carbon paper. The high points are reduced with engine stones until no interference can be detected. The final finish is given the vulcanite with whiting and water applied with clean felt, muslin and brush wheels, free from grit. All scratches should be removed and a highly polished surface developed, not only in the lingual and outer, but in the palatine areas as well.

FINISHING THE PALATINE SURFACES OF A DENTURE

To avoid subsequent irritation of mucous tissues against which the denture will rest, the *palatine surfaces* should be freed from all nodules, the roughened areas smoothed, and a uniform polish given them.

Pumice stone applied with a stiff brush wheel, run at high speed, using but little pressure, followed with whiting and water, will accomplish desired results without in any way interfering with denture adaptation.

Judgment must, of course, be used as to the amount of pressure applied to avoid changing the form of the palatine or peripheral surfaces.

Many avoid polishing the palatine and border areas of dentures, under the mistaken idea that such a step will impair adaptation.

The experience of the writer of twenty years or more, together with that of many others, is offered as evidence that the polishing of all areas of a denture, and particularly those which bear the burden of masticatory effort, is not only possible but imperative, and can be accomplished without perceptible interference to adaptation.

The use of thin tinfoil on the surface of casts reduces to the minimum the amount of polishing required. The use of artificial stone for casts and the coating of cast surfaces with silex aid in the product of smooth vulcanite surfaces.

A final, high polish can be given all surfaces by saturating the denture in thick oil and applying dry plaster freely while holding it against the soft bristle lathe wheel. The application of the plaster must be continued until all oil is removed.

The regrinding of teeth in final trial in the mouth is of utmost importance. Such procedure corrects errors of occlusion occasioned by dissimilarity between mandibular and occluding frame movements, as well as slight errors arising from change in relation of teeth during flask closure and vulcanization.

The prosthetist should keep in mind during the final trial and adjustment of dentures to the mouth the three principal objects he endeavored to accomplish when the case was undertaken, viz., to give his patient dentures that would *be useful, look well, and feel comfortable.*

Construction of a Full Upper or Lower Denture

With slight variations in technic, from that described for full cases, either upper or lower dentures may be constructed by the anatomic method, the natural teeth in the opposite arch being present.

The principal departure is in the method of taking the bite and in registering the protrusive bite. To illustrate, the construction of a full upper denture will be outlined.

The impression, cast, and wax occlusion model for the upper arch are formed as for an upper model in a full case.

Developing uniform contact of the wax rim with occluding teeth is essentially the same as between two occlusion models. The median and high lip lines are determined in the same manner, as is also facial contour.

The condyle ends are located and points marked on the face.

The bite fork is inserted in the occlusion rim and removed.

An impression in compound is secured of the occlusal half or more, of all of the lower teeth, when it can be removed without distortion, and from this a lower occlusion cast is formed.

A layer of softened wax one-eighth of an inch thick is now cut to the form of, and added to the occlusal surface of the upper occlusion rim which should be chilled. The occlusion model is introduced in the mouth, and, by trial, the normal bite is determined, the patient biting into the softened, added layer when instructed, until the natural teeth come in contact with the chilled occlusion rim.

The bite fork is returned to position and firmly luted in the occlusion model, after which the face bow is adjusted in position and the several clamps tightened.

The occlusion model, attached wax bite and face bow are removed and the latter set in position on the occluding frame. The upper cast is seated in upper occlusion model and attached to the upper bow of occluding frame. The impression is removed from the lower cast and the latter seated in the wax bite, care being taken to see that the occlusal surfaces of the plaster teeth rest flat on the corresponding surfaces of wax bite. To be certain that this step may be carried out accurately, the inner and outer margins of the wax bite should be cut away so as to leave little more than the occlusal surface markings of the natural teeth.

The lower cast is then attached to the lower bow of the occluding frame and the face bow and wax bite are removed. Since the bite locks cannot be applied in taking the protrusive bite, the latter step may be carried out as Christiansen first described it, viz., placing a roll of wax on either side between the bicuspids and molars, and having the patient close the mandible while in a protruded position.

The occlusion model should be notched in the molar region so that on removal the protrusive wax bites will be correctly guided to place. The condyle paths of the frame are released, the back spring unhooked, the upper occlusion model set on its cast, the two wax bites placed in their respective locations and the final adjustment of the several factors accomplished by exerting light but steady pressure, through the center of upper and lower casts, as in full cases.

When proper relation is established, the condyle paths are clamped, the wax bites removed, the back spring hooked and the case is ready for arrangement of the teeth, which step is similar to the arrangement of teeth in full cases.

FULL LOWER DENTURES

In constructing a full lower denture, the upper natural teeth being present, the steps are similar in detail, except that the bite fork is attached to the lower occlusion model. In mounting the casts, the occluding frame should be inverted and the lower cast mounted first.

The Gysi System of Anatomic Appliances

The Gysi System of appliances for anatomic denture construction affords means of registering certain movements of the mandible, not possible by any other method. The appli-

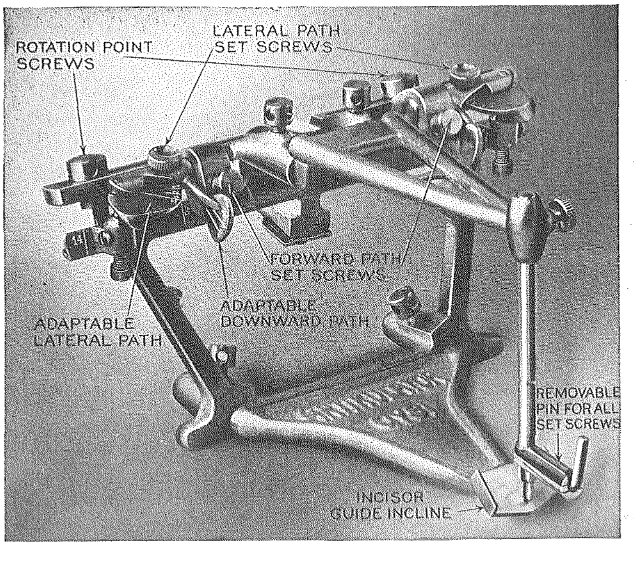


Fig. 295.— The Gysi Adaptable Articulator

ances consist of an articulator having adjustable condyle paths, adjustable lateral rotation centers, an adjustable side movement, and the ordinary hinge movement common to all occluding frames; also a condyle path register, a lateral condyle path register, an incisor path register, and various other accessory appliances.

APPLICATION IN DENTURE CONSTRUCTION

In constructing dentures with these appliances, the steps, up to the application of the face bow, are practically the same as detailed in the preceding chapters. Although the order of procedure may be varied, the following will be convenient and practical:

Register the condyle paths.
Take the bite.
Mount the casts on the articulator.
Adjust the condyle paths of the articulator. (Protrusive.)
Register the incisor path.
Set the rotation centers of the articulator.
Register the lateral condyle paths.
Adjust the lateral condyle paths of the articulator.

REGISTERING THE CONDYLE PATHS, FORWARD MOVEMENT

The condyle path register records the downward and forward movement of the condyles, and also fulfills the purpose of a face bow in mounting casts on the occluding frame. It is applied as follows:

The horseshoe plate is adjusted to the lower occlusion model, the pins of the plate being forced into the wax rim

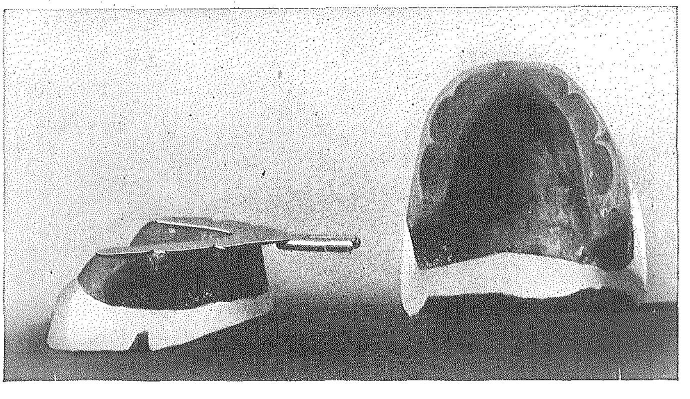


Fig. 296.— Horseshoe Plate Adapted to Lower Occlusion Model

until the plate rests flat upon its occlusal surface. The anterior portion of the plate should extend about three-eighths of an inch labially of the rim, so that later it may serve as a table for recording the incisor path.

The occlusion models are now introduced in the mouth, the condyle path register adjusted to the anterior projections of the horseshoe plate, and the pencils on the horizontal arms of the register brought in contact with face, against the previously marked condyle ends. The adjustment is accomplished by raising, lowering or rotating the pencil posts in their sockets and locking them firmly with the set screws; the pencils are moved inward by means of the rack and pinion adjustment on the ends of the register.

A card, about two by three inches in size, is now inserted and held firmly between the pencil point and the face. Its

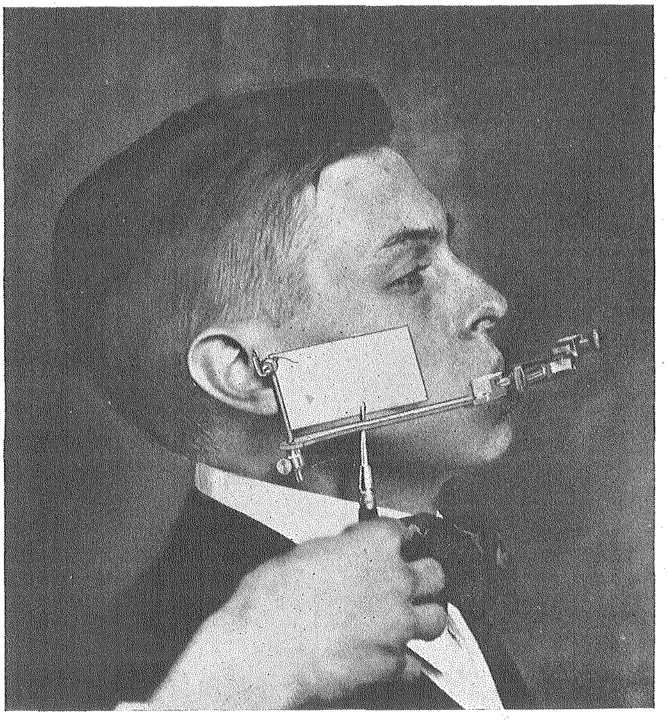


Fig. 297.— Registering the Condyle Path

lower edge should be parallel with the horizontal arm of the condyle register.

The patient is instructed to bite sidewise, so as to project the condyle next the card. During this movement, the pencil point moves synchronously with the condyle and marks on the card the direction of its path. A card is now applied to the opposite side of the face, and a similar registration of the opposite path secured in like manner.

A straight edge is laid on the card, parallel with the *working part* of the condyle path, and a line drawn along it to the lower margin of the card. The protractor is then applied to the card, by means of which the inclination of the condyle path in degrees is determined. The condyle paths of the frame are set according to the readings obtained from the two cards.

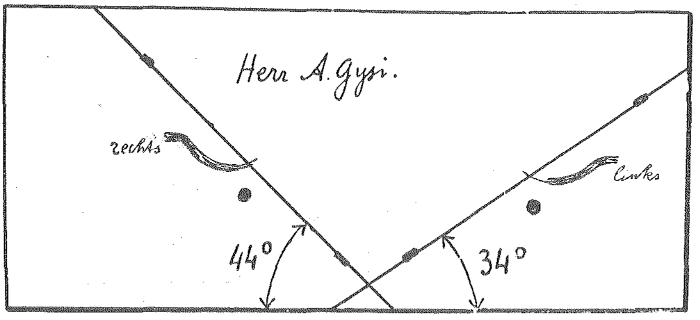


Fig. 298.— Record of Right and Left Condyle Paths of Same Individual, Showing Difference of 10 Degrees in Pitch. (Gysi)

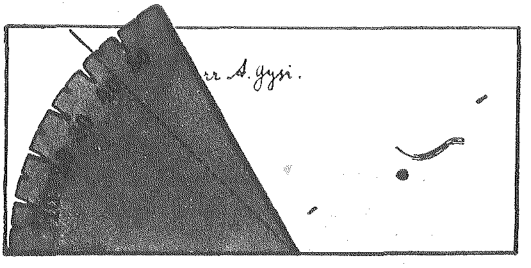


Fig. 299.— Protractor Applied to Card to Determine Angular Pitch of Condyle Path

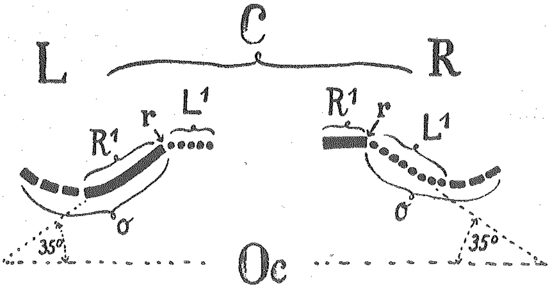


Fig. 300.— Condyle Records with Essential Data Inscribed. Suggested by Dr. Gysi

TAKING THE BITE

The bite is now taken as outlined in Chapter XIX, the horseshoe plate being firmly affixed to the lower occlusion model, for by this means the occlusion models are attached to the condyle register for securing their correct relation to the condyles in normal or resting position in the glenoid fossæ.

When the normal bite is determined, the bite locks are introduced, the condyle register adjusted as before, and the occlusion models removed from the mouth.

In this system, it is found more convenient to seat each cast in its baseplate and hold them in proper position by passing rubber bands around both casts and occlusion models.

MOUNTING THE CASTS ON THE ARTICULATOR

The condyle register to which the occlusion models are attached is set upon its base, the goose-neck rod being raised or lowered as required to bring the pencil points opposite the condyle points of the articulator. (See page 470.)

The iron stand, with condyle register and occlusion models attached, is now moved forward, clear of the articulator.

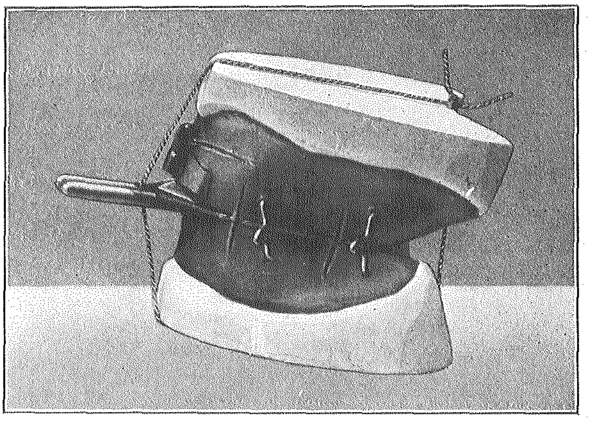


Fig. 301.— Casts Attached to Occlusion Model with String Ready for Mounting on Articulator

Plaster is applied around and over the lower bow, and the iron base pushed back until the pencil points of the register are opposite the condyle ends of the frame; further additions may be made to the plaster around the lower cast, to firmly attach it to the frame.

The upper cast is attached to the upper bow by applying plaster in the usual manner. When set, the condyle register and bite locks are removed, the rubber bands cut, and the occlusion models removed from the casts.

REGISTERING THE INCISOR PATH

A pellet of cotton saturated in oil of cloves is ignited and the anterior end of the horseshoe plate held over it to blacken

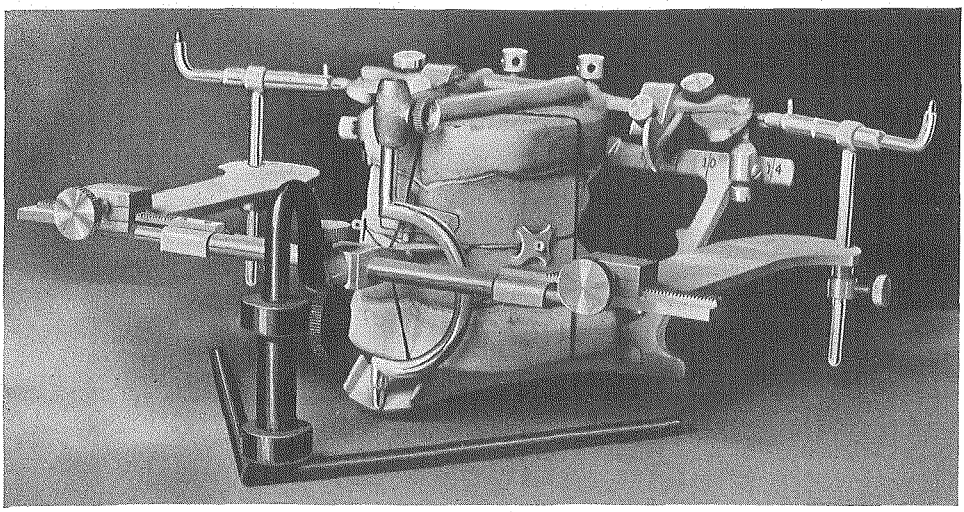


Fig. 302.— Casts and Condyle Register Adjusted to Articulator

the surface. A thin film of wax is flowed over the smoked surface to prevent its being rubbed off.

The incisor path register is now attached to the upper occlusion model so that the pin will project slightly below the occlusal surface. The register must not be set so low as to

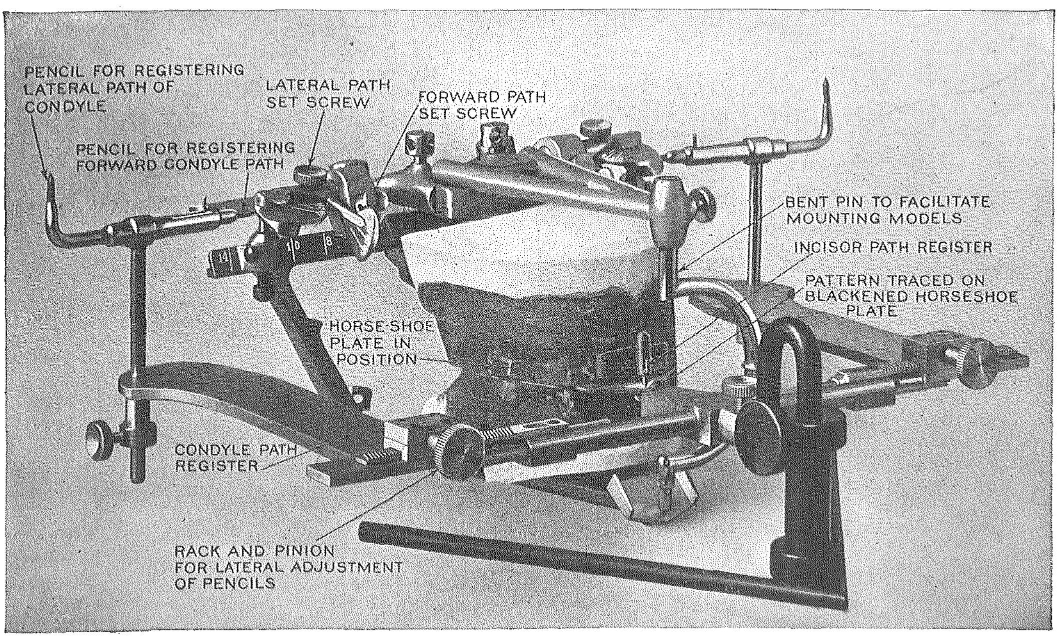


Fig. 303.— Explanatory Cut Showing the Various Adjustments of the Gysi Adaptable Articulator

obscure a view of the pin point in its excursions over the waxed surface of the horseshoe plate.

The occlusion models are now introduced in the mouth and the patient instructed to move the mandible sidewise, at the same time holding the horseshoe plate in close contact with the upper occlusion rim.

By this movement the pin of the register on the upper occlusion model marks an arc on either side of the median line of the horseshoe plate, the centers of which represent the centers of rotation of the mandible. The logic of this is apparent, for the condyles represent centers from which the arcs

Fig. 304.— Registering the Incisor Path

are developed. Usually, several movements will be required to mark distinct lines on the horseshoe plate.

When the record is sufficiently sharp, the occlusion models are removed from the mouth, returned to the casts on the frame, and the latter subjected to lateral movements. The direction taken by the pin of the incisor register should be closely observed. If it follows the arc, the rotation center of the frame is correct, and the latter may be fixed accordingly. If not, the rotation center of the frame should be moved outward or inward as required, until the point accurately follows the arc it made while in the mouth. The rotation center on the opposite side of the frame is determined in like manner.

The object in carrying out the steps as described is to insure correct lateral movements to the frame, so that when the teeth are arranged in the wax rims, the cusp clearance there developed will require but little change when the dentures are introduced in the mouth. It is a step nearer true anatomic movements than can be secured from a frame, the rotation centers of which are fixed the average distance apart.

REGISTERING THE LATERAL CONDYLE PATH

The lateral paths must not be confused with the lateral rotary movements of the condyles. Naturally, when one condyle is the actual center of rotation, the other condyle in moving forward describes an arc, the radius of which corresponds to the distance between the two condyles. It is found, however, that the radius of the arc described by a projected condyle is sometimes greater or less than the distance between the condyle centers.

Again, in some persons, the mandible moves bodily, sidewise, in the lateral rotary movements, and in some cases there is a slight side movement, within certain limits, without any perceptible rotary movement.

The lateral path register has attached to each extremity a glass plate ground on the under side, on which the perpendicular pencil of the condyle path register records the lateral movements of the mandible.

By use of the lateral condyle path register, these side movements in individual cases may be recorded, and the articulator set to reproduce them to a fairly accurate degree. The steps are carried out as follows:

The condyle path register is attached to the lower occlusion model as in taking condyle registration, the perpendicular pencils being turned so that they come opposite the outer ends of the condyles.

The operator stands back of the patient and applies the register, holding it at approximately the same inclination as the pitch of the condyle paths, previously registered. The ground glass plates should rest on the upturned pencil points, and the arms of the register be pressed in until the edges of the plates rest firmly against the sides of the face. The patient is instructed to move the mandible sidewise as before, which movement marks on the under side of the glass, the line or arc described by the moving condyle in its forward excursion.

To translate the lines recorded on the glass plates into degrees, the following plan is adopted:

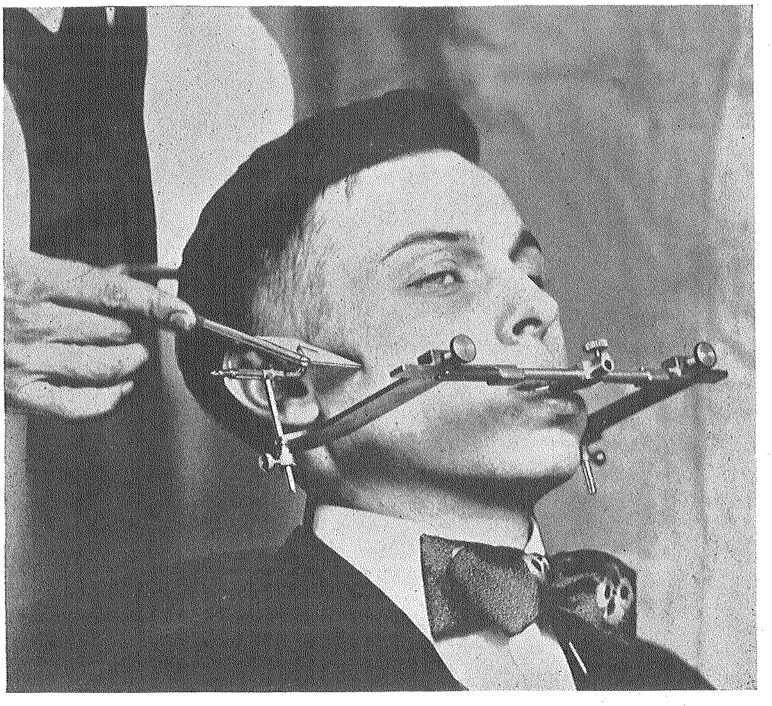


Fig. 305.— Registering the Lateral Condyle Paths

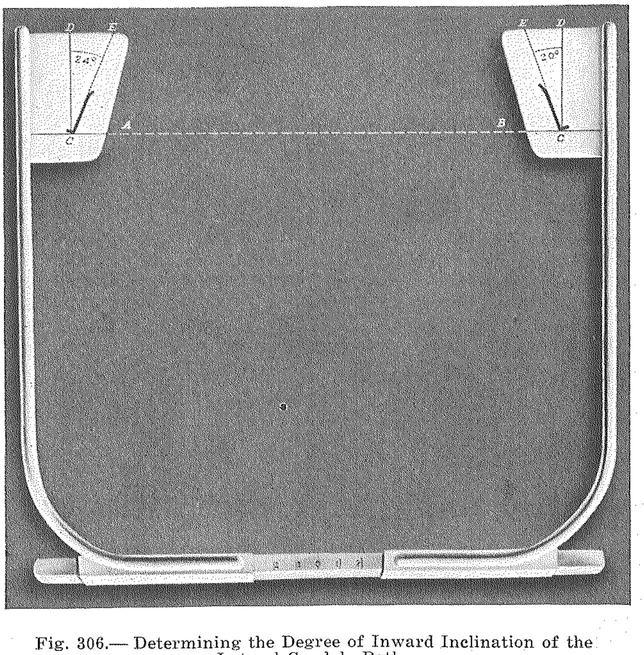


Fig. 306.— Determining the Degree of Inward Inclination of the Lateral Condyle Paths

On a sheet of white paper as wide as the register bow, a base line A B is drawn from side to side (see Fig. 306, page 473). A perpendicular C D is erected on the base line, near one edge of the sheet. The lateral condyle path register is laid on the sheet, the points on the ground glass plate which indicate the beginning of forward movement of the condyle being placed at the junction of base with perpendicular line C, the base line. The points should also be directly over the perpendicular lines. With a straight edge placed beneath the ground glass, and resting on the paper, its edge is brought in line with the lateral path marked on the ground glass, and

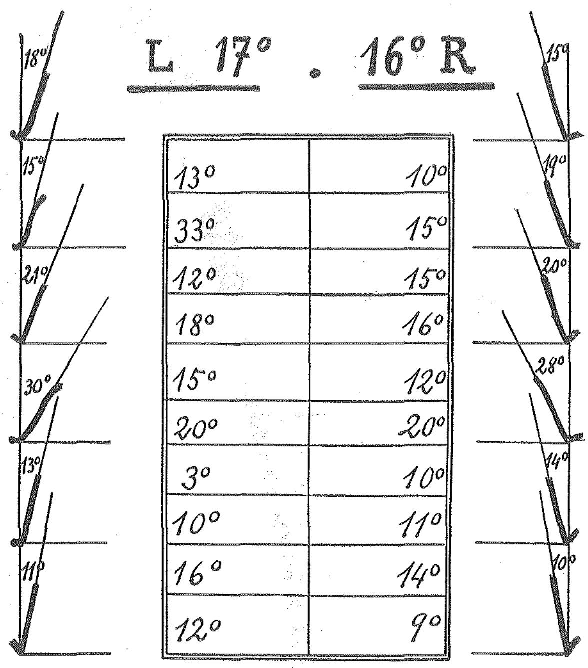


Fig. 307.— A Record of Sixteen Pairs of Condyle Paths. Average Angular Inclination, Inward, of Left Condyle Paths, Seventeen Degrees; Right, Sixteen Degrees

which can readily be seen through the transparent plate. If properly placed, its edge should coincide with the junction of the perpendicular with the base line.

The register is removed and a line drawn along the straight edge on the paper C E. This line usually forms an angle with the perpendicular line, the apex of which is on the base line. By applying the protractor to the angle, the number of degrees included may be read, and the lateral path recorded accordingly on the articulator.

THE ANGULAR INCLINATION OF THE LATERAL CONDYLE PATH

Dr. Gysi states that the average angular inclination inward, of sixteen pairs of condyles recorded, shows 17 degrees for the left and 16 degrees for the right condyle.

This lateral movement of the mandible is evidently the result of an unconscious or involuntary effort of the organism to increase the occlusal function of the molars on the working side, as well as to develop more effective balancing contact on the protruded side. That it is less important than the forward and downward condylar movement is self-evident, yet both should be reckoned with in denture construction.

SUBSEQUENT STEPS OF DENTURE CONSTRUCTION

When the registrations have been determined as outlined, and the articulator adjusted accordingly, the subsequent steps of denture construction are carried out in practically the same manner as detailed in the previous chapter.

Because of the liability of errors occurring, in carrying out the various steps, the completed dentures should be tested with carbon paper, to correct any cusp interference that may exist and remove high points that, without such means of disclosing them, are not discernible to either prosthetist or patient.

CHAPTER XXIII

CONSTRUCTION OF PARTIAL DENTURES

Various Types

A substitute which replaces one or more, but not all of the natural teeth in either arch, is commonly called a *partial denture.* This name is usually applied to a removable substitute having a base plate which rests upon and is principally supported by the mucous tissues covering the bony substructure of the dental arches, in contra-distinction of *bridge work,* which fulfills essentially the same purpose but is attached to, and mainly supported by some of the remaining natural teeth or roots. A piece of bridge work, however, in the broadest sense, is a partial denture, since it replaces a missing portion of the natural denture. The term *bridge* relates to the *manner* of *replacement,* the bridging over of spaces caused by loss of some of the natural teeth.

PLANNING A PARTIAL DENTURE

In planning a partial denture, aside from the general routine steps involved, several factors of importance must be determined, the dominant ones of which are as follows:

First — The materials of which the substitute is to be constructed.

Second — The general outline form of the base plate.

Third — The means of retention to be employed.

Fourth — The class of teeth to be used and the manner of their attachment.

BASEPLATES FOR PARTIAL DENTURES

The base plate is the foundation of a denture which rests upon the oral tissues, and to which the substitute teeth are attached. Through it, under normal conditions, the force of masticatory effort is equalized and distributed to the mucous tissues overlying the bony sub-structure in such manner as to cause no injury to the tissues themselves and no inconvenience to the patient.

Gold and vulcanite, either alone or in combination, are the materials most commonly employed for partial denture bases, preference in most cases being given the former because of its better appearance, conductivity and greater strength with slight bulk as compared with vulcanite. However, there are many cases where vulcanite alone can be used to good advantage, and other cases in which its use with gold is indispensable, particularly where much restoration of border contour is required.

PARTIAL DENTURES OF VULCANITE

The outline form and size of a partial denture is governed to a great extent at least by the position of the teeth to be replaced. The manner of retention, however, has an important bearing on the linear dimensions of the base plate. When clasps or retaining appliances of similar character are used, the terminals of the base plate should be extended beyond these means of attachment when necessary, so as to develop *denture balance,* as explained under the heading, "Indications and Contra-Indications Governing the Application of Clasps." (See page 246.)

By drawing a line or laying a straight edge from one clasp or attachment to the other, the linear extension, both mesially and distally, necessary to secure correct denture balance, can readily be determined.

In upper partial dentures, when retention depends upon atmospheric pressure and adhesion, the base plate should cover a considerable portion of the palatine vault, but seldom to such an extent as in a full denture.

With the great variety of frictional appliances available and improved methods of their construction the retention of partial dentures is very much simplified, and the form of upper dentures can be materially reduced in size over those in which atmospheric pressure is employed.

In width, the base plate of an upper partial denture need seldom exceed from one-fourth to five-sixteenths of an inch, where it passes along the lingual surface of the natural teeth, when retained in place by frictional appliances.

The base plate need only be considered as a frame-work or splint for holding the teeth in position, the saddle, which rests upon the border and supports the tooth, coupled with but slight bearing of the base plate proper upon the tissues, usually affords ample resistance to masticatory stress.

The thickness of a base plate of vulcanite is, of course, governed somewhat by its width, but not altogether, since a thin, wide base plate will, under use, fracture more quickly than a thicker but narrower one containing an equal or even less bulk of material. By actual measurement, a very narrow base plate, if constructed of a good quality of vulcanite, need not exceed from one-sixteenth to one-twelfth of an inch in thickness except when absorption of tissues requires a greater amount for restoration of lost border contour.

TECHNIC OF CONSTRUCTION OF PARTIAL UPPER VULCANITE DENTURES WITHOUT CLASPS

In all cases an accurate plaster impression of the teeth and tissues involved should be secured in plaster. From this impression a cast should be developed in magnesium oxychlorid, or Spence's plaster, because of the greater hardness of these materials.

When loss of but few teeth has occurred, these not being contiguous, a mash bite of sufficient bulk to take an impression of the lower teeth and project labially so that the bite fork of the face bow may be firmly imbedded in it, will usually prove satisfactory for mounting the upper cast in correct position on the occluding frame, and for developing the lower cast as well. Or an impression of the lower arch can be secured, a cast developed from it and the special bite fork, designed for partial cases, can be used for securing the correct relation between the mandible and maxilla, after which the two casts can be mounted on the frame in a similar manner to an edentulous case.

TAKING THE PROTRUSIVE BITE

Should it be deemed advisable to take a protrusive bite, it is accomplished as follows: Place two rolls of wax between the bicuspids and molars, one on either side; have the patient protrude and bite as in full cases where this step of condyle registration is carried out. The two bites are removed from the mouth and placed in position on the lower cast, the condyle slots of the frame loosened and the back spring unhooked. The upper cast is then moved backward and pressed downward until the teeth take their proper position in the bite. It is usually necessary to trim away the buccal and lingual margins of the wax bite before seating the casts, so that it may readily be seen when they are in exact position. Care should be taken not to distort the wax during the trimming process. The condyle slots are now set firmly as the wax bites indicate, the wax removed, and the back spring again connected, when the case is ready for the selection of the teeth.

SELECTING AND GRINDING THE TEETH

When only a few teeth are missing, it is seldom necessary to try the wax model denture in the mouth, therefore the use of a hard, unyielding base plate, such as is used in full cases, is uncalled for. A good quality of sheet base plate wax will answer the purpose.

Teeth of suitable size and color are selected to fill the spaces. When possible to do so, plain teeth should be selected

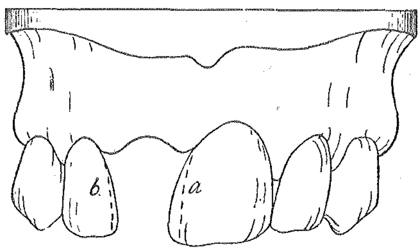


Fig. 308.— Reduction of Proximate Surfaces of Teeth Where Space Has Become Constricted

and ground to accurately fit the border, thus obviating the application of artificial gum restoration. They should be of sufficient length not to require tipping inward at their cervical ends to meet the border and thereby be thrown out of alignment.

When teeth adjoining a space have moved toward each other, for example, a central and opposite lateral incisor, thus reducing the space occupied by the lost central, it is often advisable to disc away their proximating surfaces. This in-

Fig. 309.— Plate Teeth Backed, with Lingual Extension Added, for Close Bite Case

creases the width of space and decreases the width of the immediately adjoining teeth so that the replacement will more nearly harmonize in form and proportion with the other incisor than would be the case were such change not made. (See a, b, Fig. 308.)

By highly polishing the surfaces so reduced, no injury to the natural teeth is liable to result.

There is, however, a limit to the application of plain teeth in partial cases. When gum restoration is required and the line of junction of the artificial with the natural gum tissue is visible, a gum section tooth, or if two or more contiguous teeth are missing, a gum section block which includes the teeth required should be selected and ground to neatly fill the space and restore the lost tissues with porcelain. When

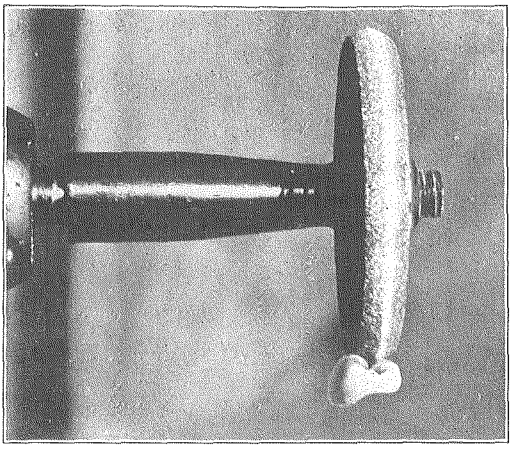


Fig. 310.— Stone with 120° Bevel Face for Reducing Marginal Ridges of Bicuspids and Molars

such a block is not procurable, plain teeth may be selected and a porcelain gum attached by baking as described under the heading, "Special Uses of Porcelain." (See page 619.)

In some cases it may be possible to apply "Protesyn" in partial restorations, but since this material depends entirely upon undercut spaces for its retention, it will be difficult to develop the necessary anchorage in limited spaces. Pink or granular gum restorations are the least desirable of any of

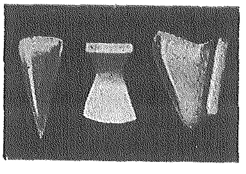


Fig. 311.— Fogg's Interstitial Gum Facings

the materials mentioned and when possible their use should be avoided in all partial cases.

When two or more plain teeth, not requiring gum restoration, approximate, "Fogg's Interstitial Gum Blocks" can be used to advantage in filling the embrasures, thus avoiding the display of vulcanite in these spaces. These also, together with the method of application, are described under the head of "Special Uses of Porcelain," on page 620.

WAXING THE CASE

The teeth having been ground and waxed into position, the base plate is applied to the lingual surfaces of the teeth and given its desired outline form. The wax should be allowed to extend occlusally on the lingual surfaces of the natural teeth sufficiently to furnish a reasonably broad bearing for the base plate, for retention purposes. A single thickness of ordinary sheet wax will not afford enough bulk of material for the base plate and for loss of material as a result of finishing the vulcanite. Two sheets will render the case too bulky, therefore the first sheet can be thickened somewhat by

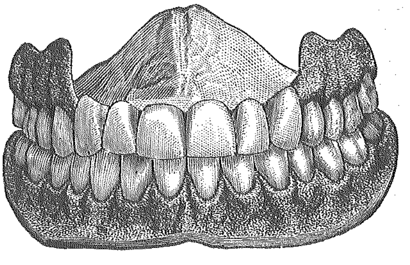


Fig. 312.— Type of Denture in Which Fogg's Interstitial Gum Facings Are Indicated

burnishing a slight addition of wax to it over all surfaces and more where deficient contour requires. The wax should extend well above the offset shoulder on the lingual surfaces of the porcelain teeth so as to insure ample material for developing smooth surfaces in the final finishing.

FLASKING THE CASE

When plain teeth have been ground to the border, no gum restoration having been required, the teeth may be imbedded in the first section of the flask with the cast of the mouth. Frequently, in spaces where gum sections have been fitted and absorption of the border is marked, so that considerable space exists between the border side of the block and the cast, gum sections may also be invested the same as plain teeth. Special care must be taken in packing the case to fill the space between the block and cast with rubber before closing the flask, otherwise the vulcanite is liable to be deficient from failure of surplus rubber being forced into the space. When, however, the space between cast and block is constricted, so that it will be difficult to introduce the rubber, the case should be invested so that the block will be caught and held by the plaster investment in the second half of the flask. This simplifies the packing of the case so that the vul-

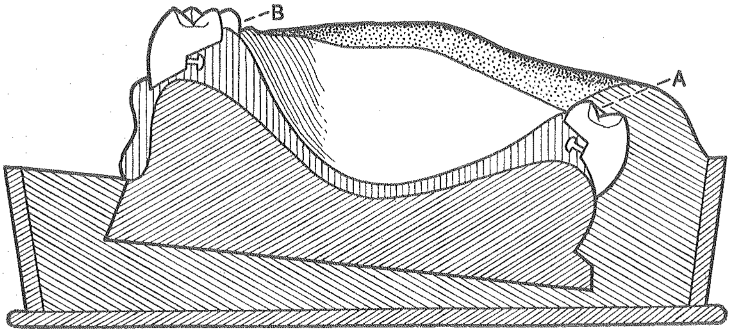


Fig. 313.— Sectional View of Flask, Showing How Teeth with and without Gum Restoration Should Be Invested

canite will flow freely back of and surround the block as desired in the final closing of the flask.

Sometimes both methods of investing the teeth are adopted in the same case. When the replaced teeth are on opposite sides of the cast, the latter can be set more deeply in the flask on that side occupied by the plain teeth without restoration than on the other side where gum restoration has been applied. This gives maximum strength with minimum bulk to the plaster which supports the plain teeth.

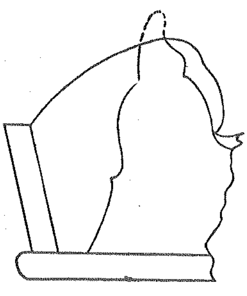


Fig. 314.— Removal of Excess of Plaster Teeth in Flasking

Projecting plaster teeth should be trimmed even with the lingual margin of wax, and the outer surfaces of the cast backed up with plaster and rounded down to the line of separation of the flask in such manner as to obliterate all undercuts and strengthen the cast.

The points involved in flasking any case are, first, to support the cast under its base, so that it will not fracture under the stress of closing; second, to construct a matrix in which to mold the basic material which will not yield in forcing out the excess rubber, will not permit the teeth to become dislodged, and, third, to so shape the invested case in the first half of the flask that the second will readily separate from it without producing fracture of the investment.

Partial Dentures of Vulcanite with Clasps

GENERAL CONSIDERATIONS

When a partial denture of vulcanite is to be retained in position with clasps, the order of procedure is as follows:

Take impressions of the teeth to be embraced by the clasps, and from these develop metal dies. Construct the clasps as described under the heading, "Technic of Clasp Construction," see page 500. Attach the anchorage lugs to the clasps in such position that they will neither interfere with correct alignment of the porcelain teeth nor require extra bulk of vulcanite to cover them.

The clasps are now placed in position on the teeth in the mouth and a mash bite secured, using the face bow if the case calls for such procedure. Should the clasps come away with the bite, they are returned to proper position on the teeth.

An impression in plaster is now taken which should include all of the teeth involved in developing correct occlusion, and all of the border surfaces to be covered by the substitute.

On removal from the mouth, the broken parts of the impression, if fractured, are replaced and firmly luted together, the clasps adjusted in correct position in their respective matrices and wedged apart so that each wing rests in contact with the matrix wall of the impression. Should any of the plaster which flowed under the anchorage lug, next the border, have become broken and lost in removal of the impression, a little wax should be flowed over the lug and the general contour of the impression be restored in this manner. When the loss of impression in this area is extensive and cannot be restored with comparative accuracy, a new impression should be secured.

A cast is now developed in the usual manner, using preferably some of the harder materials for this purpose. When hardened, the impression is carefully removed to avoid displacing the clasps or fracturing the teeth.

The wax bite is now trimmed freely on that side that receives the working cast, so that both teeth and clasps may occupy the same position in the bite that the natural teeth and clasps sustained to it, when in the mouth.

The steps from this point on are essentially the same as those concerned in the production of a partial vulcanite case without clasps.

In case it is considered necessary to try the wax model dentures in the mouth, which is sometimes done for the purpose of testing occlusion, the base plate should be formed around the clasp lugs in such manner that the denture may be released without disturbing the clasps from their position on the teeth. Under no circumstances, in the class of dentures under consideration, should the clasps be disturbed from the time the impression is filled until the case is vulcanized.

When, however, the base plate consists of metal, the clasps are usually permanently attached to it in the preliminary constructive stages, as will be explained later. In such case they will come away from the cast with the base plate.

In flasking the case, special care should be taken to cover the exposed ends of the clasps with the plaster investment in the first section of the flask, so as to hold them firmly in position after the wax is removed and during the packing and closing of the case.

It is also frequently advisable, before packing the matrix, to place between the anchorage lug and the cast a small wedge of vulcanite, of similar color to the basic rubber being used. to prevent displacement of the clasp by the rubber in the matrix in the closing of the flask.

The wedge can be cut from an old base plate, should be clean, and all surfaces freshened so as to insure close union of the new rubber with it. When neatly applied, no difference in color will be noticeable, and practically all danger of clasp displacement will be obviated.

Partial Lower Dentures of Vulcanite

The construction of partial lower dentures of vulcanite, either with or without clasps, is much the same as for similar upper cases. Attention should be given one important detail which differs from upper partials, particularly in those cases where the anterior teeth are present, and the replacements occur along the posterior borders.

While in upper partial cases the stress of mastication is resisted directly by the saddle under the replaced tooth or teeth, yet the comparatively flat or somewhat flaring surfaces of the lingual border base plate, which rests upon the mucous tissues, receives some of the stress also and imparts general stability to the denture.

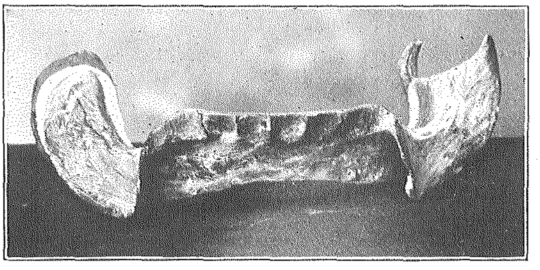


Fig. 315.— Labial View of Lower Partial Vulcanite Base Plate

In lower cases but little if any support is afforded the denture by the lingual border surfaces of the base plate next the teeth, because of the generally perpendicular relation of these surfaces of the natural tissues. It is therefore necessary to extend the base plate well up on the cingulæ of the anterior

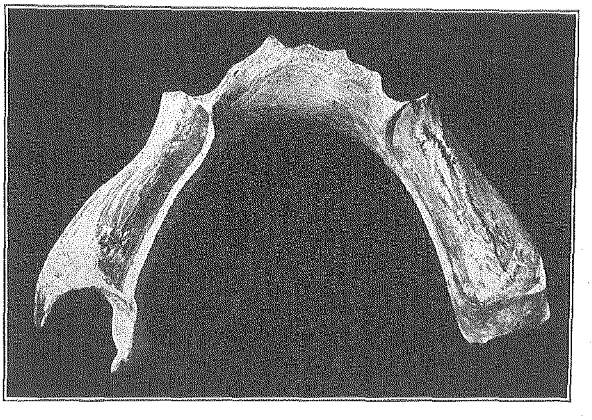


Fig. 316.— Occlusal View of Lower Partial Vulcanite Base Plate, Showing Finishing Shoulders for the Second Addition of Rubber

teeth, otherwise if this is not done, irritation and absorption of the lingual gingival tissues will occur in a very short time. The application of stop clasps to the first bicuspids, or even the second bicuspids, when the replaced teeth are situated to the distal of the clasps, will practically overcome the tendency of lower partials to tip anteriorly. The use of clasps without stops in the same location and under the same conditions usually augments the undesirable conditions mentioned.

Frequently, in difficult cases, it is advisable to construct the base of vulcanite to which, at the same time, clasp may be attached. This base plate is then fitted in the mouth the same as a gold base denture, a mash bite taken and the teeth selected, waxed, ground to meet requirements and vulcanized to the previously constructed base.

By forming finishing shoulders on the base against which the second addition of vulcanite will finish and using a slightly different shade of rubber, very artistic results can be realized.

The introduction of the lingual bar of metal for lower and the over-arch bar for upper cases combined with improved forms of frictional retention appliances, have proven so satisfactory that the technic of partial denture construction has been practically revolutionized within the last few years.

MOUNTING THE CASTS ON THE OCCLUDING FRAME

When a mash bite has been taken, in conjunction with the face bow, it is advisable in these, as in many other similar cases, to attach the face bow to the occluding frame and develop the *occlusion* cast before adjusting the *working* cast or that one to which the artificial teeth are to be fitted, in the bite. The reason for so doing is that the bite which receives the working cast must be trimmed away freely so that the occlusal surfaces of the teeth may rest perfectly on the wax surfaces impressed by the natural teeth. This cannot be determined accurately unless practically all of the buccal, labial and lingual surfaces of the bite are cut away sufficiently to expose these occlusal areas to view, as has been previously stated. Now, if an attempt is made to force the working cast into the bite, or if the bite is trimmed before the occlusion cast is developed, distortion of the wax will most certainly occur, and later on, when the occlusion cast is developed, the relation between the two will be incorrect.

Summarized, the steps are as follows:

Apply face bow, with mash bite attached, to the occluding frame. Fill the occlusion side of the bite with plaster, attaching it to the bow of the frame. Trim wax bite to receive the working cast, being careful not to injure the plaster teeth of the occlusion cast while doing so. Adjust working cast in trimmed wax bite and attach to occluding frame. When the plaster has set, warm the wax, open the frame and remove the wax from the occlusion cast.

REGISTERING THE CONDYLE PATHS IN PARTIAL CASES

An ordinary protrusive mash bite, when properly trimmed so that the teeth of both casts may correctly enter their impressions, will serve to set the condyle paths of the occluding frame to coincide with those of the patient.

ARRANGING THE TEETH

Teeth of suitable form and color are selected and arranged as in full cases, the plaster teeth on the occlusion cast serving as a guide in developing correct alignment and occlusion. Care must be taken, therefore, not to mutilate the occlusion model by attempting to force the porcelain teeth into imperfectly softened wax by closing the frame as in full cases. Such procedure nearly always fractures the occluding plaster teeth and destroys the only means of testing the accuracy of occlusion in the constructive stages of the case.

When the very slight connection between the wax saddles and anchorage spurs is considered it will readily be seen that trial of the wax model denture in the mouth is impracticable. Even when saddles of Ideal Base Plate are formed and firmly luted to the anchor spurs, to serve as a foundation on which to arrange the teeth, the benefits of a "try in" of the case is questionable, because of the general disturbance of relation of the several parts to each other, which commonly occurs during such procedure.

The points of interference between porcelain teeth and those on the occluding cast should be noted and correction made by grinding as each tooth is set in position. When the protrusive bite is taken, as outlined, the relation of the lower and upper teeth to each other in lateral movements should be tested and corrections made accordingly. The necessity of developing perfect teeth on the occlusion cast and of avoiding their fracture during the arrangement of the substitutes is, therefore, of extreme importance.

The case is waxed to the required outline form and given the desired surface development of the finished denture, when it is ready for flasking.

FLASKING THE CASE

Partial cases of the type here described are flasked the same as ordinary vulcanite dentures, except that the anterior lingual surface of the cast should be filled with plaster in the first investment of the case, so as to enclose the exposed portion of the lingual bar and hold it rigidly during subsequent procedures of flask separation, removal of wax, packing the rubber, final flask closing and vulcanizing.

Since these steps, as well as finishing the case, are similar to those of ordinary cases, the details need not be repeated.

LOWER PARTIAL GOLD BASE DENTURES

In replacing lower posterior teeth it is frequently advisable, and a common method of practice, to construct a gold base and attach the substitute teeth to it with vulcanite, or other means, as conditions require.

One of the older methods, which in favorable cases has proven very satisfactory, is carried out as follows:

A die and counterdie of the case are developed in the usual manner, on which a gold base, usually of 28 or 29 g. and 20 k.

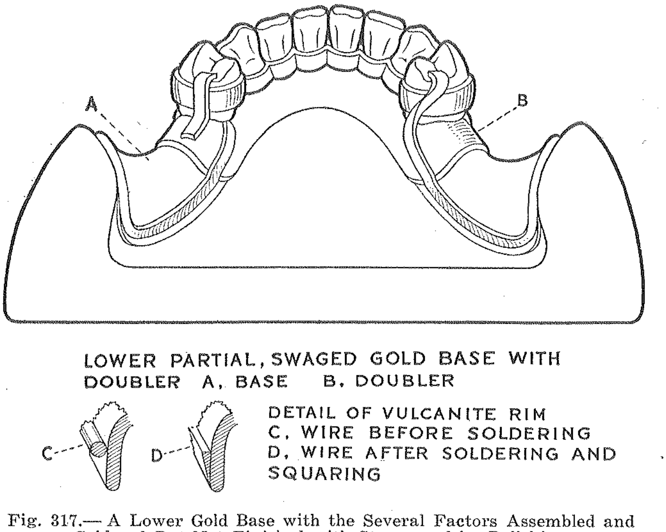


Fig. 317.— A Lower Gold Base with the Several Factors Assembled and Soldered But Not Finished with Stones and by Polishing

is swaged. The lingual band of gold which connects the two saddles should extend well up on the cingula of the anterior teeth to prevent settling of the denture under stress as previously mentioned. The principal base should be reinforced with a doubler, anteriorly, and extending back of the teeth clasped on either side, about one-half inch. This doubler may be of 29 or 30 gauge gold. The base plate and doubler are pickled, polished and united with solder, trimmed to correct outline and reswaged. Clasps are developed on independent metal dies constructed for the purpose. These are fitted to the teeth in the mouth. The base plate is trimmed to take its proper position on the border without interfering with the clasps. An impression is then taken of the teeth clasped, preferably of one tooth at a time, with clasp in position, and including the contiguous part of the base plate. The base plate can thus be held in position while the plaster can be applied in a small hinged tray. When set, the impression is removed, the clasp and base plate adjusted in position, luted firmly with wax and a small cast developed, which holds the clasp and base plate in correct relation during soldering.

When united, the base plate is returned to the mouth and an impression of the other tooth and clasp secured in like manner. This clasp and the base plate are united as just outlined. The metal structure is now pickled, polished and returned to the mouth for final bite and impression.

FORMING THE FINISHING SHOULDER FOR VULCANITE WITH GOLD PLATE

In these, as in practically all cases of gold base dentures, to which the teeth are attached with vulcanite, a shoulder should be formed against which to finish the latter. This may be done by cutting narrow, parallel-sided strips of gold plate of whatever curvature is required and applying and soldering the same along the line on the base plate where the vulcanite should terminate. These strips are applied and soldered neither at right angles to nor flatly against the base plate, but usually somewhat slanting so as to form a V-shaped groove, interiorly, while the outer surfaces form a continuous curve with gold base and vulcanite. This method is not only practical and economical, but artistic as well. It is particularly applicable to those cases where border absorption has progressed unequally and where, if correct contour be given the case, the vulcanite will be disposed in unsymmetrical outline on the base. In such case a strip of suitable width and curvature can be cut, contoured, applied and soldered to the base in such manner as to develop normal contour to the denture, and symmetrical exposure of the vulcanite as well.

FORMING THE SHOULDER WITH WIRE

The most common method of developing the finishing shoulder for the vulcanite is by soldering a wire along the line on the base plate as indicated by the terminal margin of the previously contoured wax. That surface of the wire presenting toward the vulcanite area is squared out with stones and plug finishing burs, while the outer surfaces of wire and solder are given the approximate curvature of the finished case.

The wire not only affords a finishing shoulder for the vulcanite, but when united to the gold base imparts rigidity to the latter to almost any degree desired, depending on the gauge used and the amount of solder applied.

EXTENT TO WHICH THE WIRE IS APPLIED PERIPHERALLY

A shoulder wire is applied along those areas on a base plate where loss of contour of the border becomes plainly noticeable. This applies not only to lines parallel with the border crest but to the end or perpendicular lines as well. In lower partial cases, of the type under consideration, the wire which forms the anterior terminal shoulder will usually be laid parallel with the disto-lingual line angle of the tooth clasped, or at such point that when the vulcanite is applied and the case finished, the general lingual contour of the case is continuous with that of the base plate along the lingual surfaces of the natural teeth.

The wire should extend from the anterior lingual shoulder margin, distally, along the lingual border, curve over the crest of the latter to the buccal side and pass forward along the margin to near the anterior terminal of the base plate. It should not rise perpendicularly as on the lingual side because the presentation of a line of gold in this area is unsightly and unnecessary as well. By trimming the base plate a little scant at the anterior buccal terminal the artificial gum material can overrun the latter and thus obviate the display of any gold. The ability to recognize lost border surfaces and contours and lay the shoulder wires in correct position to restore them is an art that should be acquired by every prosthetist and one which, when developed, stamps him a master of his calling.

LINGUAL BAR DENTURES

A very common and satisfactory method of replacing the lower posterior teeth is by means of saddles either of gold or of vulcanite, combined with the lingual bar to serve as a foundation for carrying the substitute teeth. Various methods of retention are employed, the most common of which will now be mentioned.

RELATION OF LINGUAL BAR TO ORAL TISSUES

In constructing lower lingual bar cases the assembling of the several parts in correct relation to each other and to the oral tissues must be carried out in a definite, systematic and orderly manner. The position of the bar in reference to the lingual border surfaces is particularly important. When in the finished denture, if allowed to touch the soft tissues, or to bear upon them with any degree of force, it will cause more or less discomfort, sometimes so much so as to require reconstruction of the case. On the other hand, the bar cannot be placed too far from the border or too near the gingival margin of the gums, or tongue movements will be interfered with.

It is impossible to state definitely the exact position of the bar as each case possesses peculiarities of its own. Usually when placed from one-fourth to three-eighths of an inch below the gingival margin, when the lingual margins will permit,

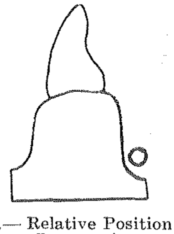


Fig. 318.— Relative Position of Lingual Bar to Tissues

and about one twenty-fifth of an inch from the border tissues, neither tongue movements will be interfered with nor will the border tissues be impinged upon.

FORMS OF LINGUAL BARS

It is not possible to here describe all of the various forms of bars used, nor the many general methods of construction followed in these cases, but an outline of the principal steps will be given to serve as a foundation in this work. A case of replacemnt of the posterior teeth involving a lingual bar, stop clasps and vulcanite saddles will be described.

Technical Steps in Lingual Bar Cases

First, impressions of the teeth for clasp construction should be secured, and these appliances developed in accordance with steps previously described.

The clasps are placed in position on the teeth and a plaster impression secured of the lingual areas of the border next which the bar will rest, and of sufficient border areas back of the teeth clasped to indicate the manner in which the terminal ends of the bar can be bent to best advantage for anchorage purposes. The clasped teeth must also be embraced by the impression.

To prevent marring of the cast while adapting the lingual bar it should be formed from some of the harder materials, as Spence's plaster or oxy-chloride of magnesia.

The cast having been formed a measurement of the length of wire to be used in making the bar is secured, usually with a smaller wire which can be readily bent, or preferably with a piece of 12 gauge electric fuse wire. The latter wire is very pliable and can be formed to the exact shape of the permanent bar, its ends flattened for retention purposes and any peculiar bends which the case calls for can be discovered before attempting to conform the very rigid wire of precious metal. This step will not be considered necessary by the experienced wire bender, but will prove most useful to the beginner.

High-grade clasp metal wire, or iridio-platinum, from 12 to 11 gauge thickness, is usually used for the bar in order that it may stand the various stresses to which subjected in the constructive stages and in subsequent use, without bending.

Two pieces of 16-gauge wire are sometimes bent separately to the form desired and afterward united with solder. This plan is followed by those who find difficulty in conforming the heavier gauge wire. Care should be taken to fill the V-shaped spaces between the two wires with solder. When imperfectly filled, food lodges in them and the doubled wire feels uncomfortable to the tongue.

To develop good anchorage in vulcanite saddles, it is necessary to extend the bar back of the clasped teeth from one-half to five-eighths of an inch. The bar should be bent outward and upward, to the crest of the border, each terminal end flattened broadly and a hole drilled through it, or a short cross-head soldered on to prevent the gradual loosening of the saddle under stress.

The flattened ends of the bar should be warped to lie parallel to, but not quite in contact, with the border surfaces. The ideal position for the terminal ends of the wire in the finished case is in the center of the saddles.

VARIATION IN FORM OF CONNECTION BETWEEN LINGUAL BAR AND CLASP

A common and very practical method of constructing the skeleton frame work for a lingual bar case is as follows:

The bar is conformed anteriorly to the cast, as previously described, but instead of being carried back of the teeth embraced by the clasps and terminating in the vulcanite saddle it is bent upward and outward at the disto-lingual angle of each of the clasped teeth, in such position as not to render the lingual side of the case bulky nor interfere with arrangement of the substitute teeth.

This manner of connection of clasp and bar affords no anchorage of metal framework to saddles. To supply such attachment, a piece of clasp wire of the same gauge as the bar, about one-half inch long, is flattened throughout about two-thirds of its length, bent to conform to the curvature of the border crest and distal surface of the tooth and clasp and soldered to the latter. The better plan is to fit the anchor spur in the angle between the turned-up end of the lingual bar and clasp and form the connection principally between the two wires, thus obviating too broad an attachment to the clasp. Another method of anchoring the lingual bar to vulcanite saddles is as follows:

The bar is adapted to correct lingual curvature, as described. The terminals, instead of being bent outward and over the crest of the border, pass backward, parallel with the lingual periphery of the saddle on either side, or it may lie somewhat above the peripheral margin of the saddle, so as to be entirely enclosed with the vulcanite.

Two ribs of rigid metal are bent to the bucco-lingual contour of the borders and soldered to the lingual bar, one at the distal extremity of the latter, the other midway between that point and the clasped tooth. These ribs, as well as the bar, should be enclosed within the vulcanite.

SOLDERING THE CLASPS AND BAR IN CORRECT RELATION TO EACH OTHER

The bar, when properly conformed, is blocked in position on the cast by interposing a small pellet of wax under each terminal end and one anteriorly. While the wax is soft the bar is pressed to the exact position desired and luted by melting a portion of the wax to both bar and cast. The excess wax is then trimmed away, a small amount of investment mixed and flowed over the bar at these three points, leaving the greater portion of metal exposed.

A strip of 20-gauge clasp metal, about one-eighth inch wide, is fitted between each clasp and the bar, the lower end of the strip resting between the bar and cast, the upper end extending above the gingival margin of the clasp so that the solder may develop a broad attachment between the two. No effort need be made to fit the strip accurately to the cast, since any slight space that may exist between the two will later on fill with vulcanite.

Flux is now applied and the bar and clasp on each side are connected with solder, flowing it not only in the joints but over the strip as well, to stiffen it and form a rigid connection. This method, it will be seen, does not require the removal of the clasps from their position on the cast, and therefore the relation between them and the teeth they embrace is the same as when in the mouth. When soldered the case is removed from the cast, pickled, polished and washed and is now ready for the final bite and impression.

A slight variation from the above method is sometimes carried out whereby the attachment of clasps and bar may be made as described and stops developed on the clasps at the same time. This refers to cases in which stops were not developed on the clasps or soldered to them during the constructive stages or before the impression was taken.

The strip which forms the connection between bar and clasps, either of clasp plate or half-round wire, is cut of sufficient length to reach from the bar across the clasp and to the point where the occlusal rest or stop should terminate. It is then annealed and with pliers shaped to meet the requirements of both standard and stop, when it is attached with solder, as described.

Sometimes the location of the stop will be out of normal alignment with position of the clasp and bar connection. In such case the stop can be formed separately and soldered at the time of connecting the bar and clasp. It will be found most convenient, and accurate as well, to form the stops on the clasps and unite them during the constructive stages, at which time more perfect adaptation can be secured while the clasps are on the metal dies.

TAKING THE WAX BITE

The bar, with clasps attached, is now introduced in the mouth and its relation and that of the clasps to the tissues and teeth verified. If correct a wax mash bite is taken with the appliance in position, care being taken to include all necessary teeth, and the border areas as well. In this, as in practically all classes of extensive replacements, the face bow should be applied and the bite carefully removed without distortion.

TAKING THE IMPRESSION

The final impression in all cases should be in plaster. In cases of the class under consideration a full impression of the border surfaces to be covered by the saddles, the teeth clasped and the anterior teeth to slightly below the gingival line is essential. Lingually the impression should extend deeply enough to embrace the bar opposite the teeth clasped, but not necessarily anterior to these locations.

Special care must be observed in taking both bite and impression that undue stress is not brought upon the anchor spurs posteriorly, or the lingual bar anteriorly of the teeth clasped, otherwise the framework will be tipped and thrown in an abnormal relation to the teeth and oral tissues. By enclosing the terminal ends of each anchor spur in a small mass of soft modeling compound, then pressing the bar down until the clasps take their proper position on the teeth and the bar its correct relation to the border, the framework can be balanced and steadied while taking the impression. The compound serves the purpose of temporary saddles and when properly applied to the border becomes a part of the impression.

The impression usually fractures and comes away in pieces. These should be cleared of debris, reassembled and luted firmly together, varnished and a cast of hard material constructed on which to vulcanize the case.

ARTIFICIAL STONE

Recently there has been placed on the market an artificial stone product which can be mixed with water and which will harden in about four hours. It is dense and hard and will stand rough usage. It softens somewhat during vulcanization and is more readily removed from the vulcanite than is oxychlorid of magnesia. This product is specially useful in the construction of partial, and, in fact, all cases where the preservation of relations of several parts in constructive stages is essential. The material referred to is "Weinstein's Artificial Stone," prepared by C. A. Nielsen Co., New York.

The Lingual Bar Combined with Gold Saddles

In cases of this type, one of the common methods of construction is as follows:

First — Impressions of the teeth to be clasped are secured and clasps constructed by methods previously outlined.

Second — A full impression, in plaster, is secured of the lower arch, including all of the parts concerned in the formation of saddles and lingual bar. In most cases the impression should be scraped along the border crests slightly, but the relief so afforded should not extend to anterior or posterior terminals.

The derived cast is trimmed and converted into a model, so as to readily withdraw from the sand matrix, and a die and counterdie formed.

Third — Saddles are swaged to the border surfaces and trimmed to approximately correct peripheral outline.

Fourth — The lingual bar is adapted to the required contour of the case, using the die as a model on which to do the fitting. The Benson Plier is particularly well adapted to the work of bar bending, the wire being held in the concave depression back of the beak contact.

In gold saddle cases, the terminals of the bar should lie parallel with and rest against the lingual margin of the saddles to which they are afterward soldered. By proper trimming, the upper margin of the bar may be formed into a finishing shoulder for the vulcanite attachment of the teeth.

If any doubt exists as to the depth to which the lingual border of the saddles can extend without impingement on the tissues the safest plan will be to test the saddles in the mouth before uniting them to the bar.

Fifth, after the saddles are trimmed to correct lingual width they are returned to the die, the lingual bar adjusted as described under the preceding heading, "Lingual Bar Dentures," page 490.

The terminal ends of the bar are now firmly waxed to the saddle margins, care being taken while adjusting it to avoid springing the bar. It is frequently a good plan, after the bar is perfectly adjusted to the two saddles, to unite one end only with its saddle, remove from the die, invest and solder the two together. The partially constructed frame is returned to the die and careful adjustment secured between it and the opposite saddle, after which they are invested and united as in the first instance.

Sixth, the skeleton denture is pickled, cleansed and introduced in the mouth for final peripheral trimming and general adjustment.

Seventh, the clasps having been formed are adjusted to the teeth, the denture base introduced, trimmed where interference with clasps occur and the relation between clasps, teeth and baseplate secured as ordinarily accomplished or by the compression method described, when such procedure is indicated.

Eighth, when clasps and baseplate are united and the denture base cleansed, it is returned to the mouth for final impression and bite. By usual methods, casts are produced and mounted on the occluding frame.

Ninth, the teeth are occluded, and when deemed advisable, cases of this type can be removed from the cast for final trial in the mouth.

Tenth, after flasking and separating the case, if the saddles have not previously been spurred with a graver, this step should be carried out before final closing of the packed flask. In addition to this method of anchorage, small loops of wire should be soldered on the saddles and the latter coated with a film of thin chloro-rubber to act as a cementing medium between gold and vulcanite.

Settling of Dentures from Use

When a denture of any type is introduced in the mouth and worn for even a short time the mucous tissues on which it rests will, under pressure, yield slightly, and as a result the denture will *settle,* as it is commonly termed. The amount of such settling varies in different individual mouths and frequently in different areas of the same mouth, depending on the thickness and condition of mucous tissues.

It is apparent, as a result of such settling, particularly in partial dentures, that two and possibly three conditions adversely affecting the usefulness of the denture may develop.

First, the maximum service of the denture will be impaired by the greater or less loss of occlusal contact which invariably occurs. Second, when the substitute is fitted with retention appliances, and no provision is made for settling of the denture, undue stress may be brought upon the anchor teeth. Third, as a result of the preceding condition peridental inflammation of the roots of the teeth embraced by the clasps, or to which the denture may be anchored by other means, is liable to ensue. By the display of careful judgment as to the probable amount the tissues will yield under working conditions, and carrying out certain steps to compensate for such settling, the difficulties mentioned may be avoided. These steps will now be briefly detailed:

In the construction of a partial vulcanite denture to which stop clasps are adjusted, a piece of cardboard should be placed between the stop and the occlusal area of the tooth on which it rests, at the time of placing the clasp on the tooth for final impression. The area of the cardboard need not exceed that of the occlusal area of the stop. Its thickness should be gauged by the extent it is estimated the denture will settle; it may range from the thickness of a sheet of medium weight writing paper to that of a heavy visiting card. The piece of card can be attached to the stop by flowing between the two a thin film of wax. After the impression is removed, and before constructing the cast, the cardboard should be removed from the stop. As a result of interposing the cardboard as described, the clasp occupies a position on the tooth slightly nearer the plane of occlusion than it did on the die, during its construction, or would occupy if placed on the natural tooth, without the interposition of the cardboard.

The final result of such procedure is that when the completed denture is placed in the mouth the stop may project slightly above the occlusal surface of the tooth it embraces. After a short period of use, oftentimes within twenty-four hours, the settling of the denture will bring the stop in contact with the tooth.

In occluding the teeth, in partial cases, it is advisable to set the substitute teeth so that they strike strongly against the opposite occluding teeth to insure strong contact occlusally when introduced in the mouth.

To further insure good contact between the replaced teeth and those in the opposite arch, after settling of the denture has occurred, the teeth on the substitute should not be ground to perfect occlusion on first introduction of the finished denture in the mouth. This should be done, however, after a lapse of twenty-four to forty-eight hours, provided the patient has worn the denture in the meantime.

COMPENSATING FOR SETTLING OF GOLD BASE SADDLES

The preceding method is also applicable to the adjustment of clasps to a gold base denture, but the following plan, when it can be carried out with accuracy, is to be preferred:

The clasps are placed in position on their respective teeth, without interposing the cardboard, as described, and the denture base introduced and seated on the border.

A suitable tray is selected and softened modeling compound placed within, on each side, but not anteriorly, so as to embrace a portion of the central area of each saddle. Neither the anterior teeth nor clasps should be embraced by the compound. Pressure is brought upon the tray to force the impression material, not only on the border crests, but over the buccal and lingual areas of the saddles as well. There should be sufficient bulk to the compound so that the impressions of the two sides may be secured without depressing the tray below the level it should occupy in taking the final impression. When chilled the impression may usually be removed without disturbing the position of either baseplate or clasps.

Both anterior and posterior terminals of each impression are removed, by cutting, leaving a ridge about one-fourth inch wide extending from buccal to lingual, across the tray. These transverse ridges of compound, one on either side of the tray, are actual cross-sections of the impressions and are designed to force the saddles firmly in contact with the tissues while the plaster impressions are secured of the base plate, the teeth and the unattached clasps.

Each side of the tray is now filled with sufficient plaster, of suitable consistency, to secure impressions of the desired parts. When introduced and properly centered, pressure is applied and the tray forced borderward until the ridges of compound come in contact with the saddles. The pressure is now increased to a very considerable extent, the idea being to compress the mucous tissues to nearly the full extent of their yielding capacity, after which casts are developed and the clasps soldered.

When the clasps are permanently attached to the base plate and the latter is returned to the mouth, it will be seen that the stops of the clasps usually stand slightly above the occlusal surfaces of the teeth embraced.

By repeating the same steps for producing pressure on the base, in taking the final impression, the teeth, when ground and adjusted to the base plate as usual and later are permanently attached to the denture, will strike the occluding teeth strongly in occlusion. They should not, however, be ground to perfect occlusion at first sitting, but time be given for the tissues to yield before making final correction.

Dr. Goslee suggests placing a small post of wood between the saddle and occlusal surfaces of the opposite teeth, the mouth being open sufficiently for the introduction of tray. By means of this post the patient can compress the tissues under the saddle during the hardening of the impression. A half tray, such as is used in partial cases, by having its floor slotted to accommodate the post, is used for carrying the impression material to place.

To relieve strain on anchor teeth, elliptical springs uniting the clasps with base plate have been demonstrated by Dr. L. J. Weinstein of New York, who ascribes the suggestion to a Connecticut practitioner.

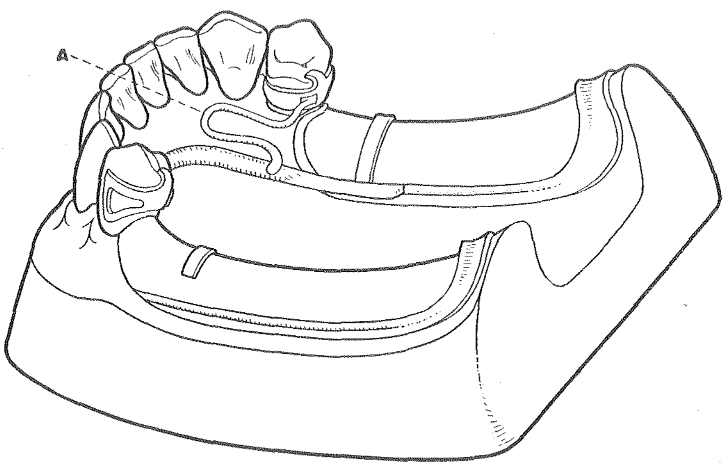


Fig. 319.— An Elliptical Spring, Attached to Lingual Bar and Flat Band, Open Center, Stop Clasp

With the several fundamental principles of partial denture construction outlined, of both vulcanite and gold bases in conjunction with stop clasps, the application of various other forms of retention appliances will be outlined.

The Roach Continuous Loop Clasp

TECHNIC OF CLASP CONSTRUCTION

An impression of the tooth which the clasp is to embrace, and the proximating tooth also, is secured which should be filled with modelite, a very hard cement-like substance, which sets quickly and will withstand rough usage without marring readily; or a die may be formed of Melotte's metal. A piece of 18, 19 or 20 gauge, sixteen per cent platinized clasp metal wire, about 2 inches long, is required for each clasp. The gauge depends on the length of the loop and bows and the stress to which it will be subjected.

The wire is annealed and bent in the middle to form a close, parallel staple, after which it is opened slightly and pressed down between the two proximating teeth, the ends bent outward and around the buccal and lingual surfaces of

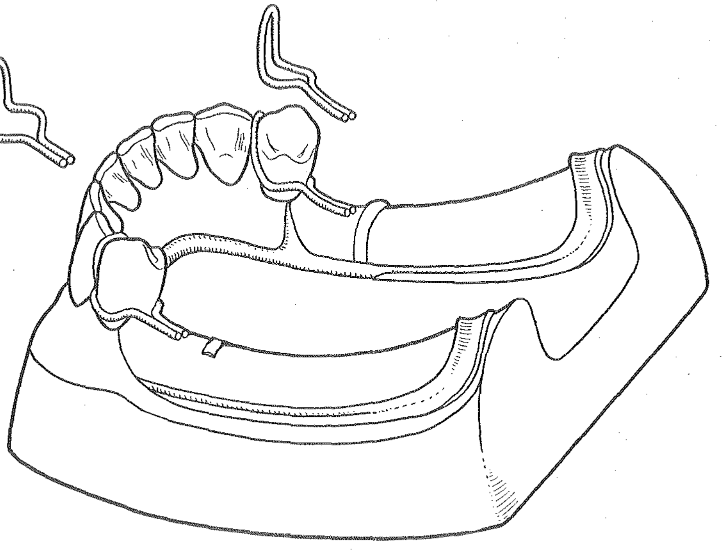


Fig. 320.— Roach Open Continuous Loop Clasp. Clasp Applied to Lower Lingual Bar, Gold Saddle Case. Notice Finishing Shoulder for Vulcanite Formed by Soldered Wire to Saddle. Also Rib Extending from Lingual Bar, Over Border Crest, for Strengthening Purposes

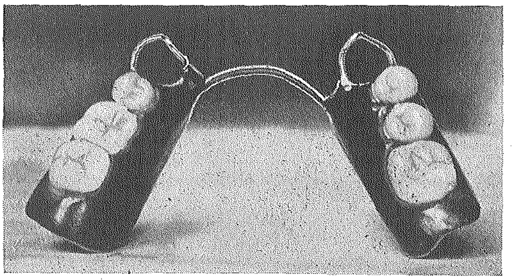


Fig. 321.— Occlusal View of Lower Partial

the tooth to form the buccal and lingual spans so as to embrace it closely. It must clear the gingival tissue at all points.

The adaptation is completed by bending the buccal and lingual terminals so as to form a projecting lug for attachment to the baseplate, or by uniting with solder and turning the extreme outer ends slightly apart, they will serve for an anchorage in vulcanite.

In most cases, when the embrasures between the proximating teeth, in which the vertical loop of the bow will rest, are free from gingival tissue, the wire on both buccal and lingual sides should be carried well into these spaces and comparatively close to the gingiva before turning it to form the horizontal spans. By so doing the tendency of the distal end of the denture to leave its border is overcome.

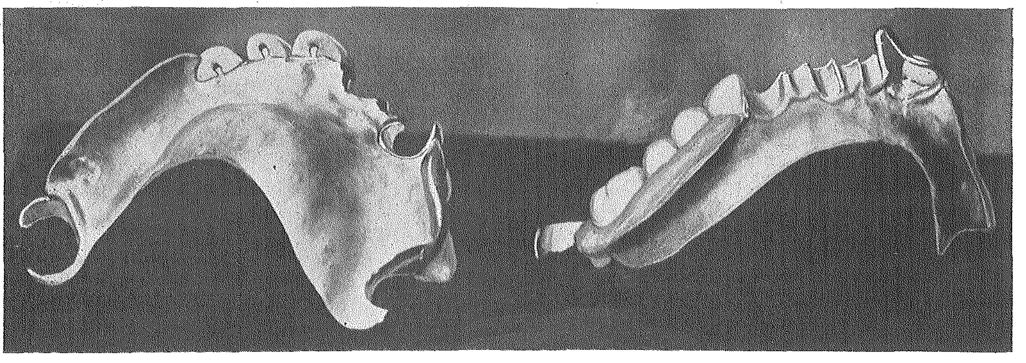


Fig. 322.— Partial Upper and Lower Gold Base Dentures. The Upper Denture Is Fitted with Steel Facing and Flat Band Clasps. The Lower Denture with Roach Continuous Loop and Flat Band Clasp

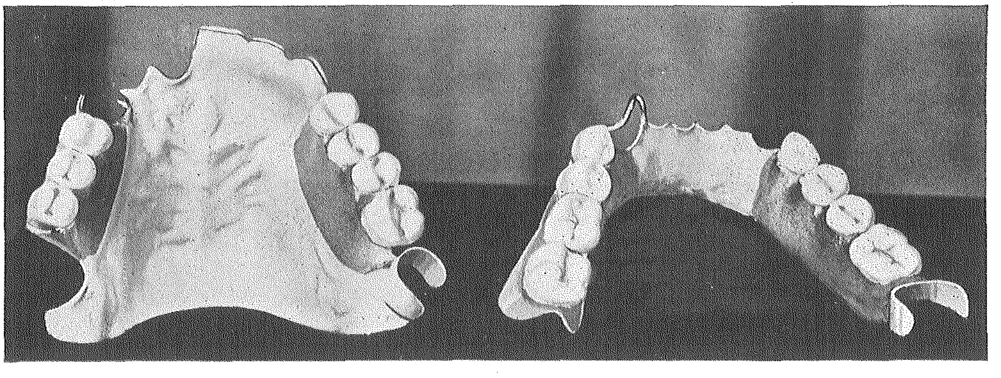


Fig. 323.— Lingual View of the Preceding Cases

APPLICATION OF THE CONTINUOUS LOOP CLASP

The application of clasps of this type to a lingual bar gold saddle case is as follows:

The saddles and bar having been formed as previously described, the baseplate is introduced and the clasps adjusted to their respective teeth. The lugs of the clasps are bent so as to rest on the saddles. An impression is now taken, using the pressure method when advisable, when on removal and reassembling of the parts a cast of investment is developed and the clasps soldered to the baseplate.

THE ROACH OPEN LOOP CLASP

The open loop clasp is constructed and applied in much the same manner as the continuous loop clasp. When clasps of this type are to be formed a heavier wire should be used, since, not being continuous, as is the preceding clasp, it is liable to be bent with use unless the wire is comparatively rigid.

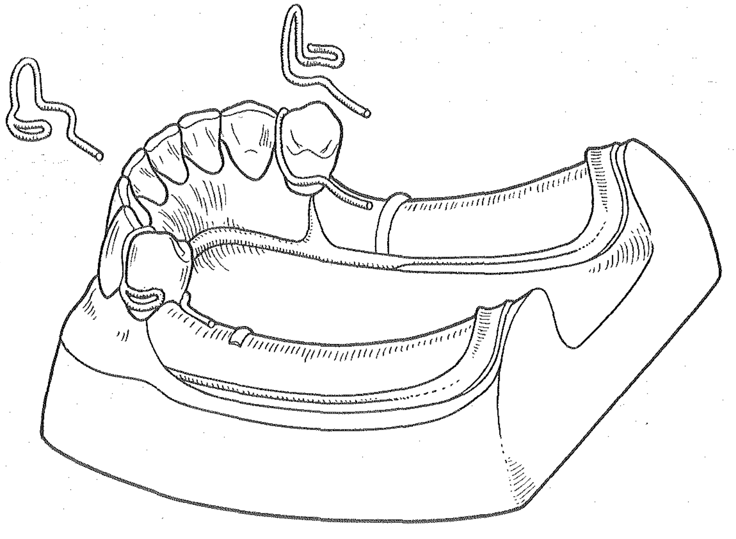


Fig. 324.— The Roach Open Loop Clasp

The outer end may be returned back upon itself or be bent in any manner to take advantage of a depressed area on the tooth, thus adding to its stability.

The open loop clasp may be formed, first, as a double bow clasp, the two terminals united with solder to form a rigid lug for attachment and the outer loop severed and bent as conditions indicate or they may merely be severed without bending.

The advantages of this type of clasp are manifold. The long, linear contact of the wire, with varying surfaces of the tooth insuring great clasping property, together with but little superficial area of tooth surface covered, is the principal one.

No provision need be made, as with stop clasps, for the settling of the denture, since, with slight effort, the vertical loop can be raised by bending the horizontal bows occlusally when occasion requires.

Dentures fitted with loop clasps do not feel rigid and unyielding, as is often the case when non-resilient clasps are used, yet they are retained and rest firmly in position.

The loop clasp, by its form, obviates the necessity for a stop in most instances, excepting when no proximating tooth is present.

THE BALKWILL CLASP

A clasp similar in form to the open loop has been in use in England for many years. A loop clasp, together with one

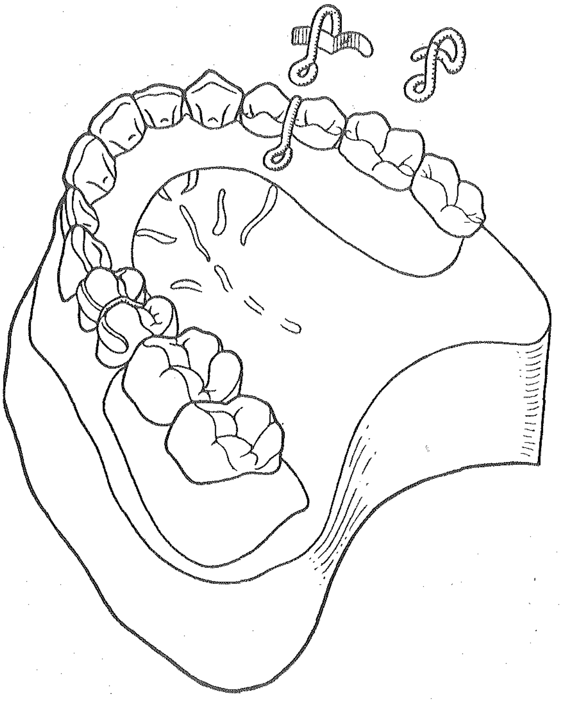


Fig. 325.— The Balkwill Open Loop Clasp and Modification

of modified form, was described and illustrated by Balkwill in his book on Mechanical Dentistry, edition of 1880.

The modified form of clasp referred to consisted in adapting a strip of clasp metal to the buccal surfaces of two proximating teeth and connecting it with denture base on the lingual side with a wire loop.

Still another form of retaining appliance is shown in the Dental Cosmos, Vol. 56, page 1194, by Dr. Heinricksen.

This appliance consists of a loop of clasp metal bent to the curved contour of the gingival tissues, and having a ball terminal which rests in the embrasure against the tooth on the opposite side from the replacement. The wire is bent so as not to impinge on the soft tissues nor does it touch the tooth except at its terminal end.

To render the appliance effective there must be good contact, in normal position, between the natural and proxi-

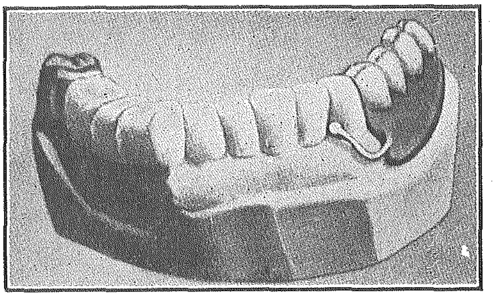


Fig. 326.— The Heinricksen Partial Loop Ball Pointed Clasp

mating porcelain tooth on the denture, and the ball must be placed close to the gingiva. If in the case illustrated the contact of the ball was near the occlusal or incisal area and contact between the teeth was defective or close to the gingiva the action of the loop would be to unseat the denture at its distal terminal.

The Roach Ball and Tube Attachment

This appliance consists of a ball with projecting spur for anchorage purposes and a tube of heavy clasp metal which re-

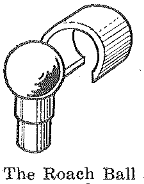


Fig. 327.— The Roach Ball and Open Tube Attachment

ceives the ball. The tube is slotted throughout one side to accommodate the passage of the spur.

Application of the Roach Attachment

The usual method of applying the ball and open tube attachment is as follows:

The crown, inlay, Carmichael attachment, or whatever means may be employed, for securing anchorage to the natural tooth or root is first constructed and temporarily set in place. For convenience of description, a crown will be considered as the means of attachment.

The position of the ball, which should be close to the gingivæ, yet not touching it, is marked. To conserve space for adjusting the substitute teeth to the saddle, the ball should be set somewhat to the lingual of the border crest, yet not so far as to produce unnecessary bulk on the lingual side of the finished denture.

Remove crown from the mouth and drill a hole at point marked for the reception of the ball stem. When applied to a shell crown, the stem should be cut short, so as not to interfere seriously with the inner periphery of the crown. The shoulder of the stem should rest flat against the surface of the crown.

When soldered, the surplus, if any is present, is removed and the crown is returned to position on the root. A slot is made in the saddle, directly beneath the location of the ball to permit the free passage of the denture base to and from position without interference. The denture is now seated on its border.

An impression in plaster is taken, by the pressure method, if indicated and when set, is removed, the crown usually coming away with it. If not, the crown is removed and placed in the impression. The latter is now prepared, and partially filled in with Modelite, into which one or two small wood screws are inserted so as to leave the heads freely exposed and projecting. The remainder of the impression is filled with plaster or investment compound, and when hardened the impression is removed.

The case now consists of a cast representing a portion of the mouth carrying crowns with attached balls and saddles, all in correct relation to each other. The next step is to attach the tubes to the saddles in the correct relation to the balls. The tube may be attached to the saddle by various means, but the following method, suggested by Dr. Roach, is, for several reasons, the most practical:

A piece of 15-gauge clasp metal wire, from one-half to three-fourths inch long, is bent at right angles, flattened slightly on one side, the tube laid and soldered on the flattened surface parallel with the vertical arm. This wire is called the contact bar, because it not only affords attachment of the tube to saddle, but the vertical portion at its upper extremity is bent to lie in contact with the anchor crown, at normal contact point.

The bar is now bent so as to bring the tube to a vertical position sufficiently high so that the ball rests in its lower end.

The parts now sustain this relation to each other: the horizontal arm of the bar rests on and lies in contact with

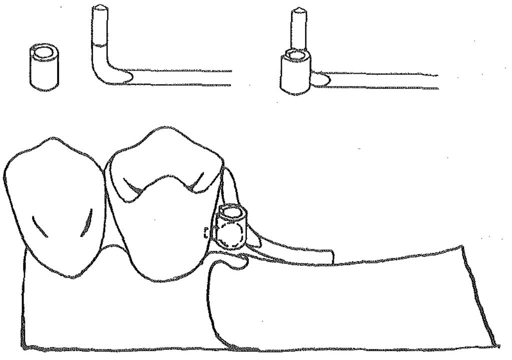


Fig. 328.— Diagrammatic Cut, Showing Relation of the Several Factors of Roach Appliance

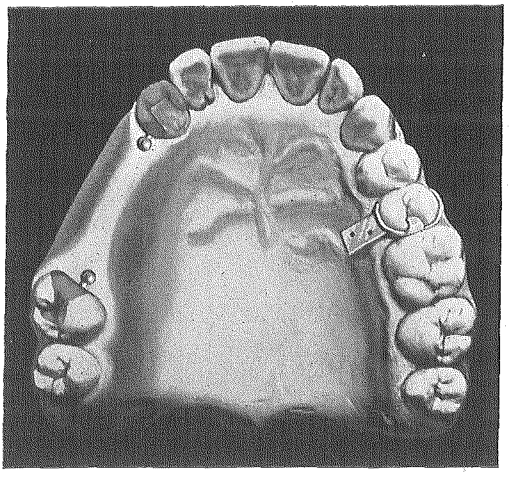


Fig. 329.— The Roach Attachment Combined with Stop Clasp

saddle; the vertical arm, at its upper extremity, rests at point of contact with the anchor crown; the tube, vertically placed, contains the ball near its lower extremity.

When this adjustment has been perfected, the horizontal arm is waxed firmly to the saddle. A mix of investment is applied around the tube, vertical arm, and anchor crown, a very small amount being sufficient to hold the part in correct relation. The horizontal arm is now soldered firmly to the saddle. A similar adjustment and attachment is now made between tube, contact bar and saddle on the opposite side.

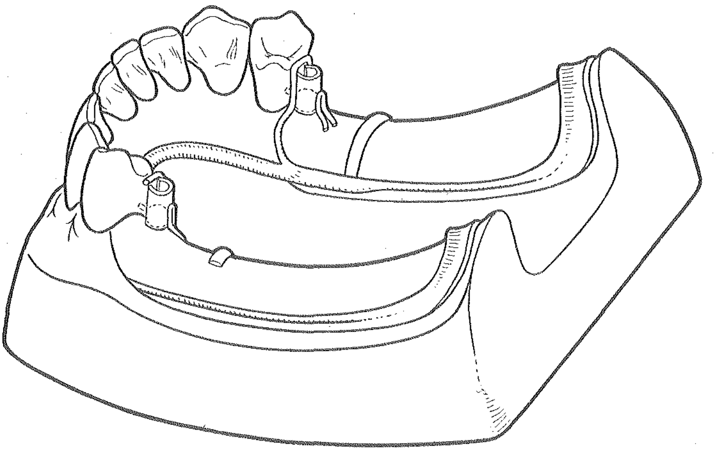


Fig. 330.— Roach Attachment, Showing One Form of Contact Bar

These appliances, in favorable cases, when properly adjusted, afford most efficient means for retention. In addition, should the denture settle, the tube follows without restriction by the ball. The necessity for fixing the tube high on the vertical arm in the constructive stage is apparent.

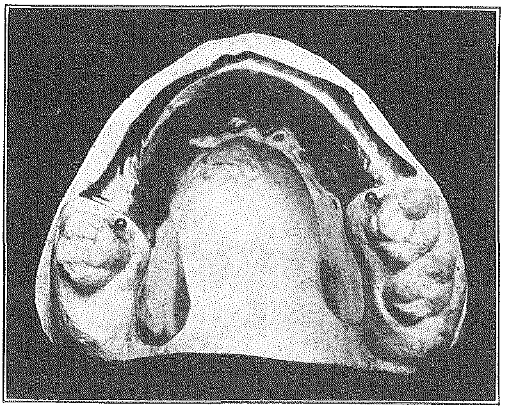


Fig. 331.— Anterior Restoration with Roach Attachment Applied

When the denture is subjected to masticatory stress the tube rotates on the ball, without subjecting the anchor tooth to side stresses or strains. The contact bar, resting as it does on the contact point of the tooth, prevents the raising of the distal end of the denture, yet in no way resists compressive force.

By the exercise of a little ingenuity, the ball and tube attachments may be applied to advantage in many ways for the retention of partial dentures in both arches. They may also be combined with clasps of various types, or with the Gilmore or other standard attachments in such manner as to reduce to the minimum danger of injury to the remaining natural teeth.

THE MORGAN ATTACHMENT

This attachment consists of two parts, one of which telescopes within the other. The outer consists of a flattened, open loop or partial band, called the "keeper," and is attached to

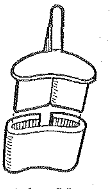


Fig. 332.— The Morgan Anchor and Keeper

the crown or inlay of the anchor tooth. The other part, which fits within the keeper, is termed the "anchor" and is attached to the substitute or denture base.

In applying these attachments to a denture it is necessary that they should be as nearly parallel as possible, so that the

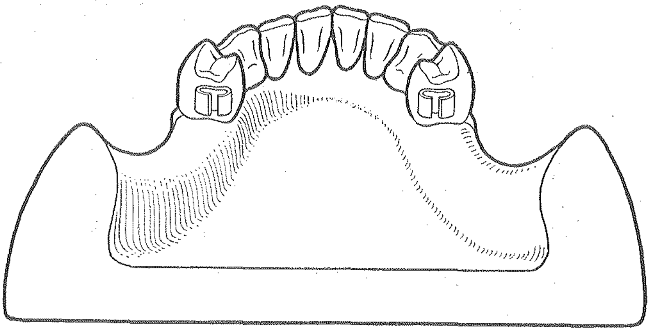


Fig. 333.— Crowns with Morgan Keeper Attached

appliance may be introduced and removed without difficulty.

An appliance called a "soldering jack" is used for paralelling the keepers and for holding them in position against the crown while soldering.

TECHNIC OF APPLICATION

An impression, with crowns in position, is taken and removed, the crowns coming away with it. From this a cast of investment material is formed of usual size and proportions.

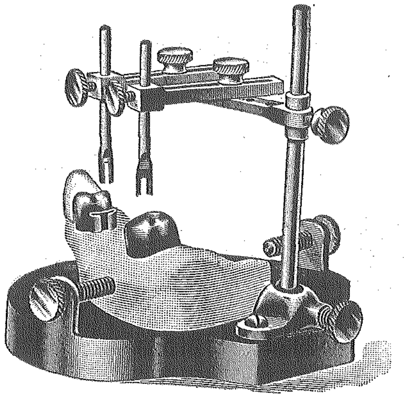


Fig. 334.— Soldering Jack Used with Morgan Appliances

This is set upon and clamped to the base of the soldering jack. A keeper is adjusted to the perpendicular arm of the jack. The latter is moved so as to bring the attachment against the

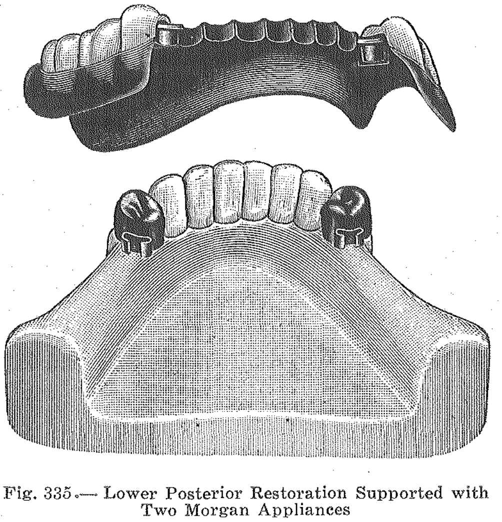


Fig. 335.— Lower Posterior Restoration Supported with Two Morgan Appliances

crown surface at the correct angle and in proper position, where it is united with solder to the crown. Without changing the perpendicular relation of the main post which governs the direction of the arm, the set screw of the latter is released, it is raised from the keeper already soldered; the other keeper is adjusted to the arm, when it is rotated against the other crown and attached in a similar manner.

The crowns may now be permanently set. The anchors are next placed in position in the keepers for the final impres-

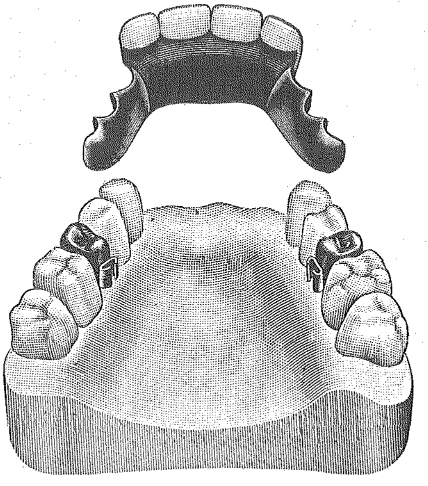


Fig. 336.— Upper Anterior Restoration Sustained by Two Morgan Attachments on Bicuspid Teeth

sion. When allowance is to be made for settling of the denture a U-shaped piece of cardboard can be interposed between the flange of the anchor and the occlusal end of the keeper. The impression is now taken and removed, the anchors com-

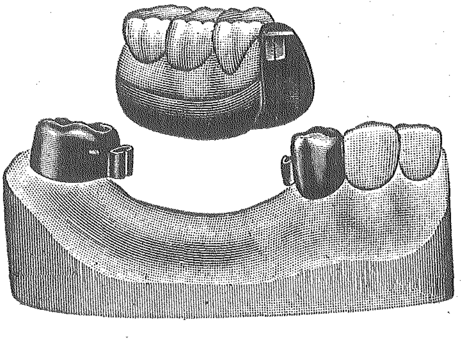


Fig. 337.— Posterior Restoration Supported at Each End with Morgan Attachment

ing away with it or, if not dislodged, are removed from the keepers and returned to place in the impression.

A piece of heavy German silver plate, bent to resemble the keeper but about one-half inch long, is passed over each anchor and the impression filled with plaster or hard cast material. The German silver posts which receive the flanges of the keeper prevent the disturbance of relation of the latter to the cast. Loops should be soldered on the extension of the anchor for attachment in vulcanite work.

In case of a gold base denture, when the projection of the anchor does not touch the base, a piece of heavy plate may be adjusted between the two and all united with solder. The steps from now on are carried out as in an ordinary vulcanite case.

THE CONDIT ATTACHMENT

The Condit attachment consists of two pieces, the inner, a clasp metal tube, open at the side and ends, which is at-

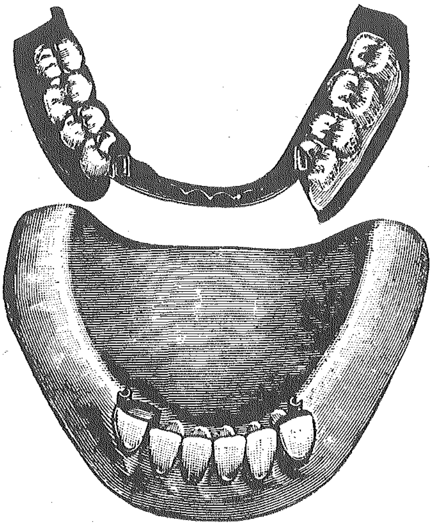


Fig. 338.— Lower Partial Denture with Condit Attachments Applied to Cuspids

tached to the anchor crown, the open side toward the space to be filled. The outer part is a telescoping tube, open at the side and one end. To the other, or occlusal, end is attached a floor, in the center of which is fixed a rigid post, the same diameter as that of the inside of the inner tube. It will be seen that this appliance possesses greater grasping property than any of the other standard types described, since the inner tube grasps the center post of the outer appliance, while the outer tube grasps the outer surfaces of the inner tube.

The application of these appliances is similar to that of the Morgan, just described, a paralleling device being necessary for the proper adjustment of the inner tubes to their respective crowns.

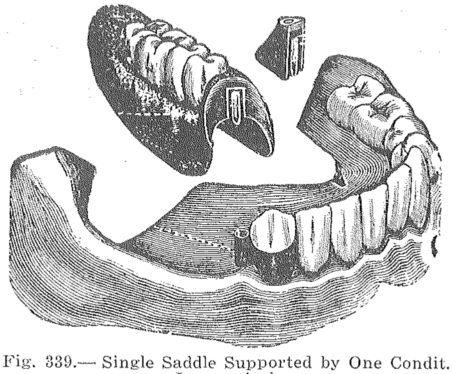


Fig. 339.— Single Saddle Supported by One Condit. Impractical

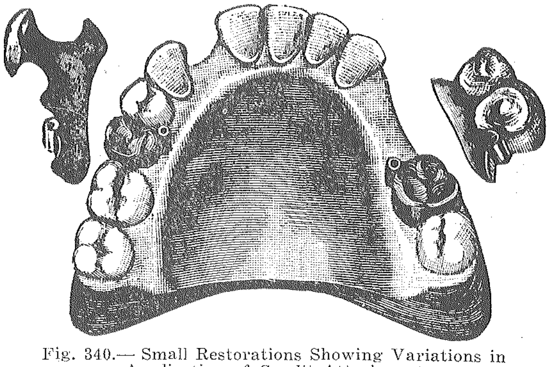


Fig. 340.— Small Restorations Showing Variations in Application of Condit Attachment

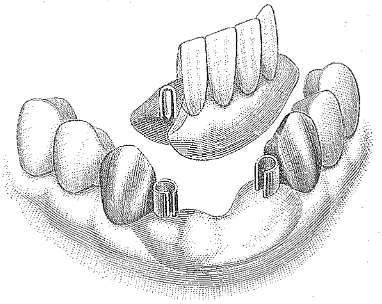


Fig. 341.— Lower Anterior Saddle Restoration Condit Attachments

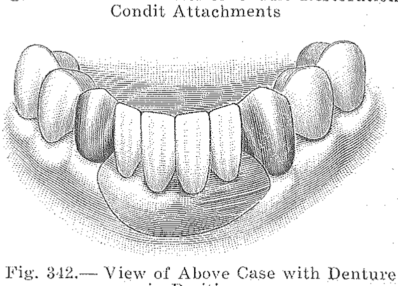


Fig. 342.— View of Above Case with Denture in Position

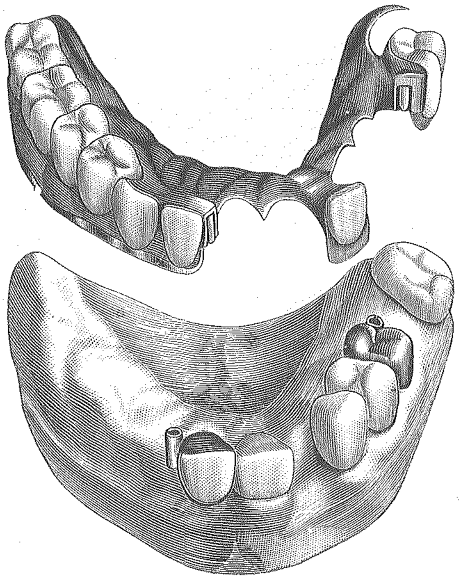


Fig. 343.— Partial Upper Denture Supported by Two Condit Attachments

When ample occluso-gingival space exists, these appliances, when properly balanced and adjusted, serve a most useful purpose.

THE GILMORE ATTACHMENT

This appliance consists of a U-shaped clip or clasp of rigid yet resilient metal, the flanges of which receive a 14-gauge wire. No paralleling device is needed other than the eye in adjusting this attachment to a case, but at the same time

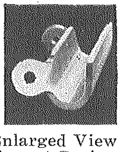


Fig. 344.— Enlarged View of Gilmore Attachment Designed for Metal or Vulcanite Work

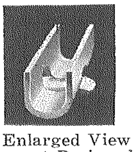


Fig. 345.— Enlarged View of Gilmore Attachment Designed for Vulcanite Work

when two or more are used in a denture they should be placed with flanges as nearly parallel as possible with the line of direction of introduction to and removal from the mouth.

APPLICATION OF THE GILMORE ATTACHMENT

The application of the Gilmore attachment varies in different cases according to the position of the anchor teeth and the spaces to be filled.

For example, in a lower partial denture in which the posterior teeth, back of the cuspids or bicuspids, are to be replaced, it is necessary to provide against the movement of the denture away from the anchor teeth. The necessity for

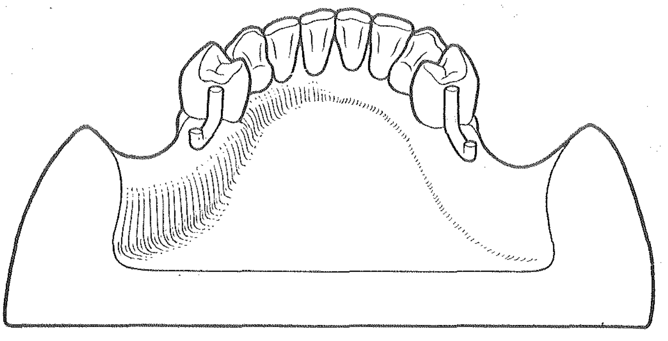


Fig. 346.— Bars Bent Perpendicularly to Prevent Distal Movement, Applied and Soldered to Crowns, for Gilmore Attachment

this is apparent, since the attachment itself cannot resist horizontal movement, under stress, of the denture along the ridge. When the space to be filled is bounded anteriorly and pos-

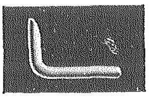


Fig. 347.— Angle Bar Bent to Set Against Crown and Alveolar Border

teriorly by natural teeth, these prevent such movement and the application of the appliance is simple.

The technic of application of the Gilmore appliance in the

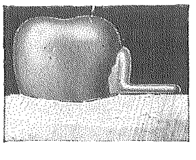


Fig. 348.— Crown with Bar Applied for Gilmore Attachment. The Vertical Arm Lies Too Close to Gingival Area of the Crown, Also Should Extend Nearly to Occlusal Surface

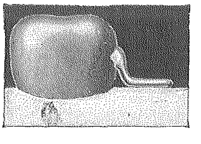


Fig. 349.— Crown with Bar Applied for Gilmore Attachment. The Bar Should Not Encroach Too Closely on Gingival Tissues Next to Crown

first case mentioned, all of the teeth posterior to the first bicuspids having been lost, is as follows:

Crowns are constructed for the first bicuspids and placed in position, but not cemented to their respective roots.

An impression is secured and removed, the crowns usually coming away with it. From the impression, a cast, composed of investment material, is secured. To the distal surface of each crown a piece of 14-gauge wire of iridio-platinum or highly platinized clasp metal is adapted.

The wire should be bent so as to lie in contact with the occlusal two-thirds of the crown; at the gingival third it should leave the crown surface at a gradually increasing slant to form a clearance space for the protection of gingival tissue. The horizontal portion of the wire should conform to and rest lightly upon the border, its position being usually slightly to the lingual of the crest. At a distance not exceeding three-eighths of an inch from the crown the distal end should be turned up sharply at a right angle. The direction of this vertical portion of the wire should be parallel with the line of direction of introduction and removal of the denture. Its height may vary from one-sixteenth to three thirty-seconds of an inch. When the wire is properly conformed it is waxed in position against the distal crown wall, and a mix of investment is made and applied over the bar along the ridge, being careful to enclose the distal, vertical end. This is necessary to obviate possible lateral rotation of the end against the crown wall in soldering. The wax is removed from the joint, flux applied and the bar is soldered to the crown.

It is frequently advisable to extend the solder somewhat beyond the area of the bar connection with the crown to render the latter rigid. A better plan is to adapt and solder a piece of plate to the distal wall of the crown during the constructive stages. The addition should be attached with high-grade solder, so that the union may not later be disturbed in soldering the bar.

When the bars are attached the rough surfaces of both crown and bar are removed and given the final finish. The crowns are again returned to position in the mouth and a bite and final impression secured. The teeth are occluded, the case carved, flasked and separated, and the matrix packed as usual.

ADJUSTMENT OF CLASPS TO BARS

A strip of cardboard, cut to fit between the flanges of the attachment, is pressed in place against the inner, curved surface of the attachment, and the latter set in position on the bar. This is to allow for subsequent settling of the denture.

The clasp should occupy a position about midway between the crown and terminal end of the bar. It should be ranged with flanges parallel or as nearly so as possible, with those of the opposite attachment; that is, both attachments should be placed so that the flanges stand perpendicular. Furthermore,

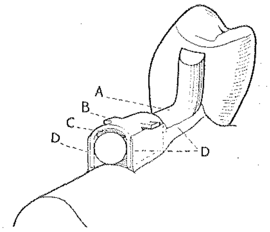


Fig. 350.— Diagrammatic Cut Showing Relation of the Several Parts of a Gilmore Attachment

they should be forced as closely to the bar as the interposed cardboard will permit.

The last step before closing the flask consists in obliterating the spaces between bars and borders so as to exclude the rubber in closing the flask. This is necessary so that the

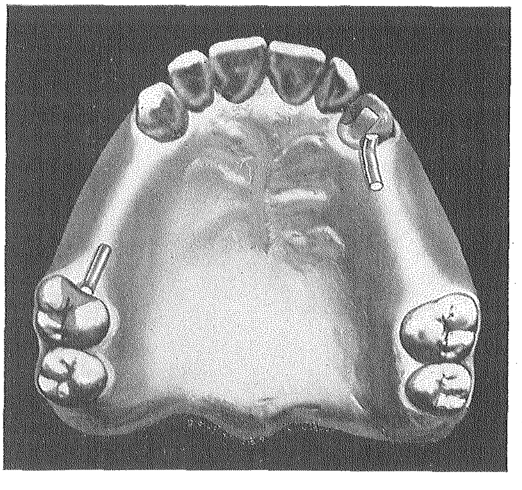


Fig. 351.— Case in Which It Is Unnecessary to Bend Terminal End of Bars Vertically from the Border. Gilmore Attachments

bars and crowns may later be removed from the vulcanite without mutilation. A thin mix of plaster is applied in the space between the borders and bars, and along the outer sides of the flanges as well, so that the surfaces are free from undercuts. The plaster should not enter the openings beneath anchor lugs, nor surround the latter. (See Fig. 350, page 517.)

When the plaster has hardened, the flask is closed and the case vulcanized. On opening and cleansing the denture, the

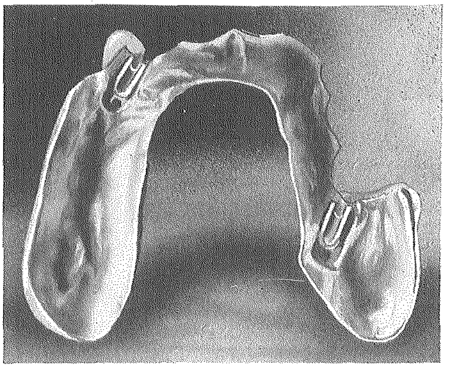


Fig. 352.— Palatal View of Gold Base Partial Denture Sustained by Two Gilmore Appliances

surplus vulcanite is removed. A thin blade instrument is passed along on either side of the bar and flanges, to remove as much as possible of the plaster which was built in under the bar. With a little careful pressure and manipulation, the bars will part from the vulcanite without difficulty, after which the case is finished. The margins of the groove which receives

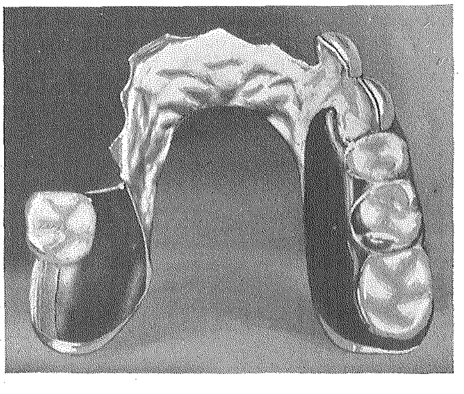


Fig. 353.— Lingual View of Preceding Cases

the bar should be smoothed and a round bur of approximately the diameter of the bar should be applied in the groove to deepen it slightly and also to deepen the opening into which the terminal end of the bar enters. This step is carried out to provide for future settling of the denture.

Oftentimes two or three widely separated roots or teeth can be utilized for supporting a denture. Roots should be filled and post inlays, which extend neatly to the peripheral

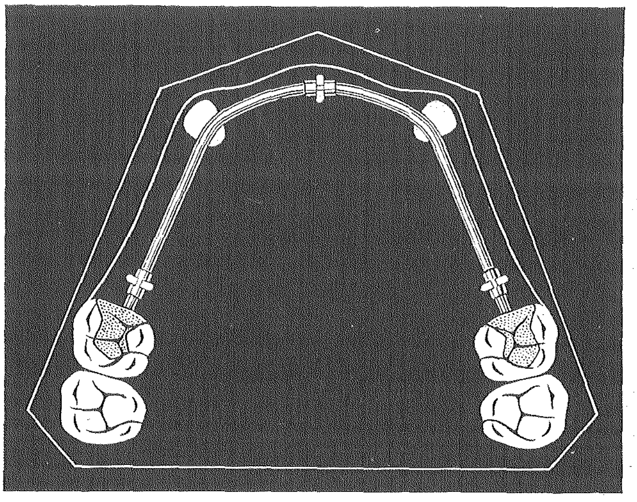


Fig. 354.— Alveolar Bar Supported by Two Roots and Two Inlay Attachments. Three or More Gilmores May Be Attached as Required

margins, constructed for anchorage purposes. Bar attachments may be combined with crowns set on roots of teeth or with inlays set within tooth crowns and all connected by a

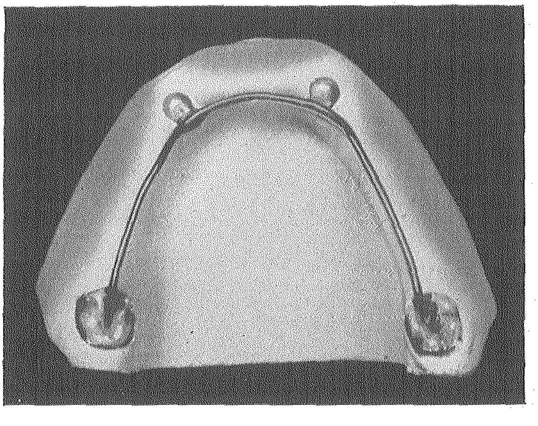


Fig. 355.— Extensive Restoration by Means of Alveolar Bar and Gilmore Attachments

border bar. It is frequently advisable, when only two or three teeth remain, to remove the crowns and inlay the roots as described. By this procedure there will be no break in the

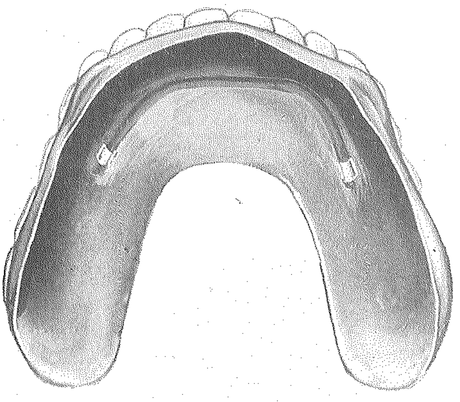


Fig. 356.— Full Denture, Palatal View, Showing Groove For Alveolar Bar with Gilmore Appliance Near Extremities

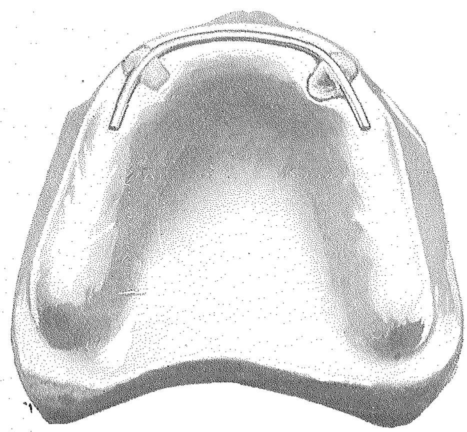


Fig. 357.— Alveolar Bar Supported by Two Cuspid Roots. A Gilmore Attachment Should Be Placed Back of Each Root and One in the Median Line

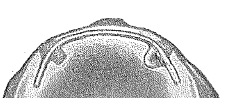


Fig. 358.— Anterior Alveolar Bar, Attached to Two Cuspid Roots

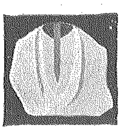


Fig. 359.—Sectional View of Root with Dowel and Inlay to Which Alveolar Bar Is to Attach

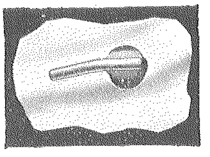


Fig. 360.— Occlusal View of Inlay in Position on Root, with Alveolar Bar Attached

continuity of the artificial gum restoration, nor in the alignment of the substitute teeth.

This system, as well as the others previously described, are capable of a wide range of application. In fact, they seem limited only by the skill of the prosthetist.

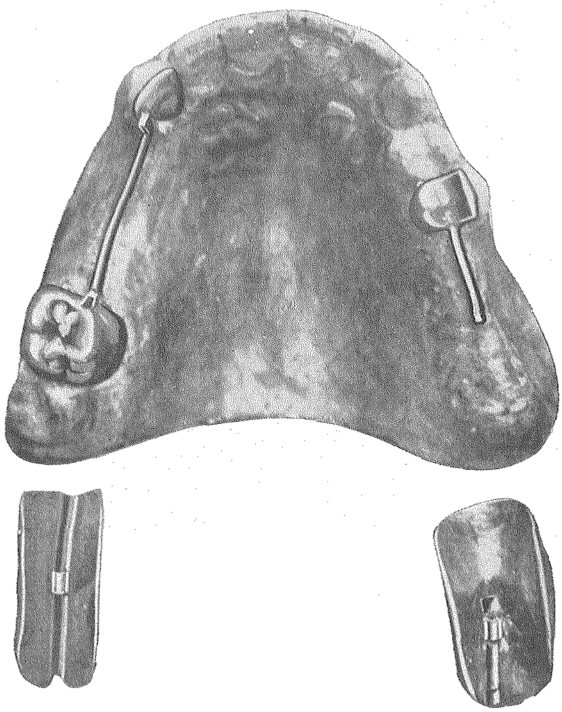


Fig. 361.— Two Other Variations in Application of Gilmore Appliances

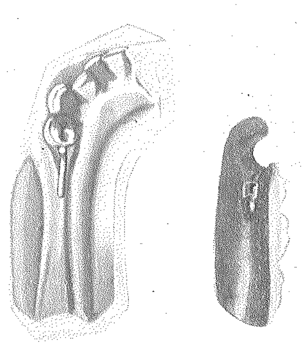


Fig. 362.— Gilmore Attachment Movement of Denture Distally Prevented by Locking Against Mesial of First Bicuspid

THE PALATAL ARCH BAR

The palatal arch bar fulfills a similar purpose in upper partial dentures as the lingual bar in lower cases. The idea of a bar is not to afford support by its bearing against the

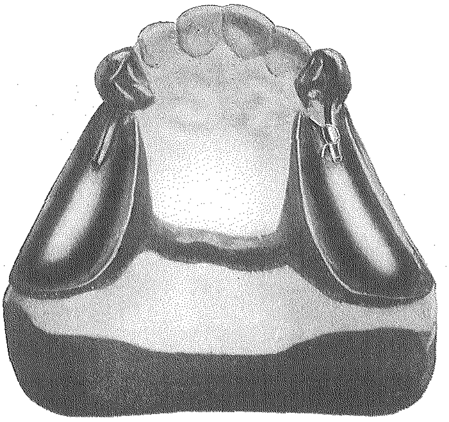


Fig. 363.— Gold Saddles, Palatal Arch Bar, Gilmore Appliances

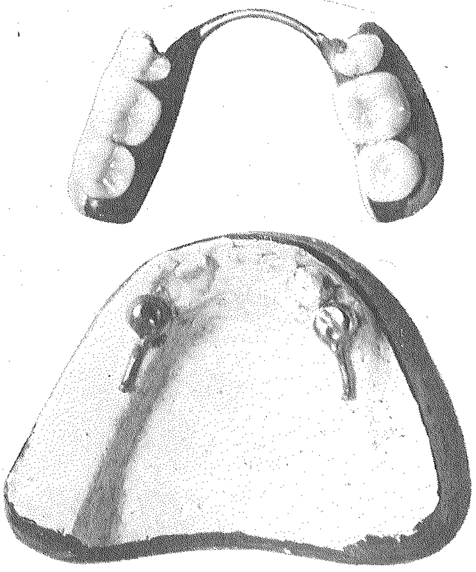


Fig. 364.— Lingual Bar, Gilmore Appliances

tissues, but to unite widely divergent points of support by means of a light yet rigid structure, and convert them into what has been termed *multiple anchorage.* This may be accomplished quite as efficiently in the upper as in lower arch.

Briefly stated, the system of partial denture construction as practiced to-day consists in developing light, rigid structures, supported in the mouth in such manner as to cause no injury to the remaining natural teeth, nor subject the anchor teeth to undue strain or injury.

The Kelly Attachment

The Kelly attachment consists of two small thimbles, each closed at one end, which telescope one within the other, with reasonably tight contact.

Retention of a denture, however, in which these appliances are utilized, is not dependent upon the closeness of

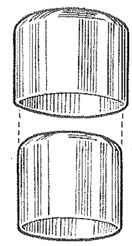


Fig. 365.— Enlarged View of the Kelly Attachment

adaptation of the thimble walls, but upon diverging or converging the appliances in setting them upon the anchor teeth.

APPLICATION OF THE KELLY ATTACHMENT IN VULCANITE WORK

Caps are formed and fitted with dowels to prepared roots. To these caps the inner thimbles are adjusted and soldered so as to present from one-sixteenth to one-sixty-fourth inch divergence from, or convergence to, each other.

The outer are set in position on the inner thimbles and an impression secured. The cast produced from the impression carries the two outer thimbles as projections above the border surfaces. Frequently a shell crown is constructed to telescope loosely over the outer thimble, as its presence on the cast prevents placing an ordinary vulcanite tooth in this location. The vulcanite fills the space and forms the bond of union between the thimble and crown. The case is carried through in the usual manner, the thimbles remaining with the cast in flask separation, but they become a component part of the denture.

When finished, the margins around the opening of the thimbles are slightly beveled and smoothly polished.

In introducing the denture, the yield of the peridental membranes of the roots involved, together with some slight spring in the denture itself, permits the inner thimbles to enter the outer, although not in perfect alignment. When seated, however, no strain upon the anchor roots is noticeable.

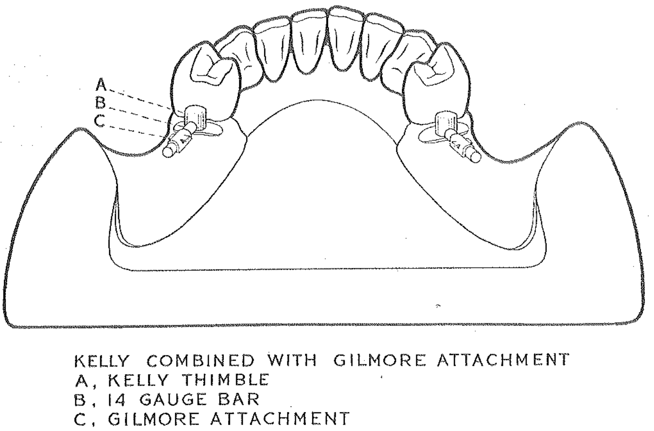


Fig. 366.— Combination of Kelly with Gilmore Attachments. Sketch from Case of Dr. A. F. James

These attachments, slightly modified, are frequently combined with others, as, for instance, the Gilmore. They can be applied in gold base dentures with even greater ease than in vulcanite work, the outer thimble being soldered to the baseplate. The thimbles vary in size from one-sixteenth to three-thirty-seconds of an inch in diameter, or even larger.

THE GRISWOLD ATTACHMENT

This attachment consists of two triangular-shaped telescoping tubes, the outer one open along the angle, the other, or inner, being slotted through the middle of one side.

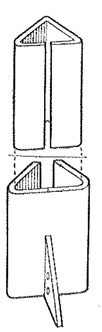


Fig. 367.— Enlarged View of Griswold Attachment

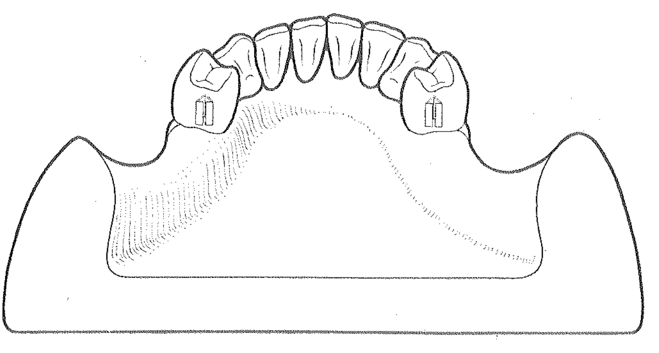


Fig. 368.— Sketch of Griswold Inner Tubes in Position

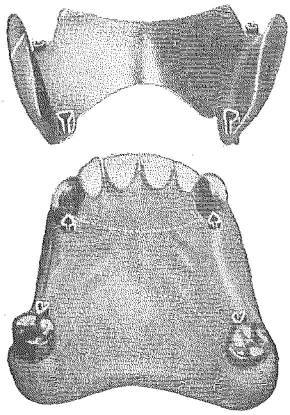


Fig. 369.— Vulcanite Alveolar Arch Bar or Strip. Denture Supported by Four Griswold Attachments

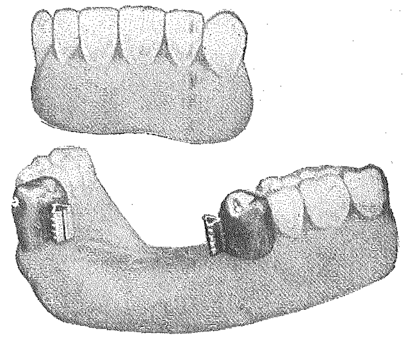


Fig. 370.— Upper Anterior Restoration Saddle Denture Supported by Griswold's on First Bicuspids

The smaller is attached by its apex to a crown or inlay, while the other is soldered to the gold base or enclosed within the vulcanite.

Forms of Porcelain Teeth

Porcelain teeth as supplied by the manufacturers are divided into two classes, known as *plain* and *gum* teeth. Each of these classes can again be subdivided into two classes, *vulcanite* and *plate* teeth.

PLAIN TEETH

A plain tooth represents the crown, or a portion of the crown, of a natural tooth in porcelain. Since teeth of this type are designed to take the place of lost natural teeth, they represent, more or less perfectly, the anatomic forms of the natural organs in general outline. The linguo-gingival areas of most porcelain teeth are deficient, or lacking in contour, to afford means for attachment to the metal or vegetable material which forms the structure of the substitute.

MEANS OF ANCHORAGE

Metallic pins are most commonly used for anchorage purposes, one end of each pin being enclosed and fixed in the porcelain by fusion of the latter around it, the other end projecting for attachment within the substitute material. A plain tooth is usually supplied with two pins, vulcanite teeth having headed pins while in plate teeth the pins are straight.

Another means of anchorage consists in developing within the porcelain some mechanical form of attachment, as dovetailed projections, or countersunk, depressed areas, with small openings extending through the proximate surfaces, as in diatoric and similar forms of teeth.

Plain Teeth for Vulcanite Work

Teeth of this type are designed for use with plastic bases, of vulcanite and celluloid, headed pin, and diatoric teeth being the most common forms used. These are manufactured in

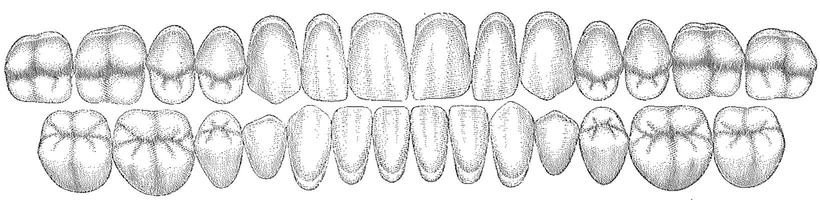


Fig. 371.— Set of Twenty-eight Plain Teeth, Vulcanite (S. S. W.)

great variety as to length, width and color, some in no wise resembling natural tooth forms, while others approach very closely to anatomic types.

Both platinum and alloys of base metal, usually a nickel alloy, are used for pins of vulcanite teeth, the latter being employed because of its cheapness. Unless protected by a film of

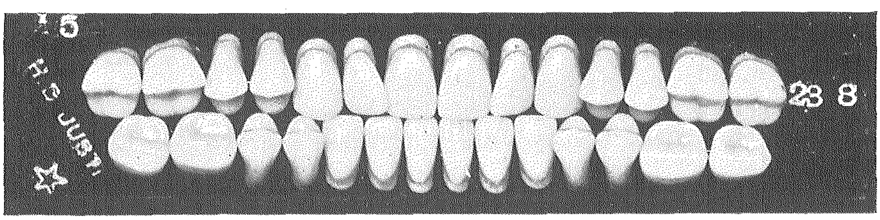


Fig. 372.— Set of Twenty-eight Plain Teeth, Vulcanite (Justi)

non-oxidizable metal as an electro-deposition of gold, base metal pins are liable to disintegration with use in the mouth.

The oxidation of base metal pins during fusion of the porcelain frequently causes discoloration of the latter, sometimes to such an extent as to render the product unfit for use. This occurs most frequently in anterior teeth, where the bulk of porcelain is limited. To overcome this difficulty, thin platinum tubes, the inner ends flanged, are baked in the teeth, in the location of the pins, and the base metal pins are afterward soldered within the tubes.

ADVANTAGES OF PLAIN TEETH IN VULCANITE WORK

There are two principal advantages in the use of plain teeth in vulcanite work as compared with gum teeth.

First, they are more easily arranged in anatomic alignment, and, if necessary, can be readily modified to meet usual and unusual occlusal and esthetic requirements.

Second, they can be placed in restricted locations and spaces where gum teeth cannot be used.

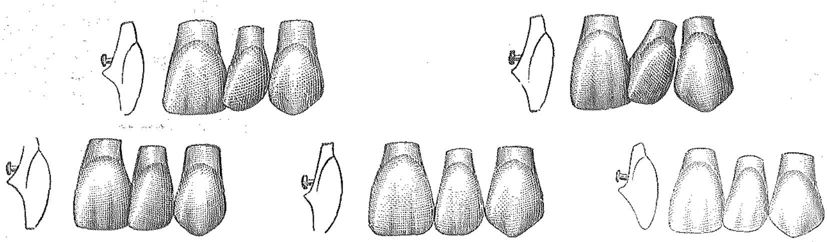


Fig. 373.— Various Sizes of Plain Teeth, for Vulcanite or Celluloid, Constricted Cervices

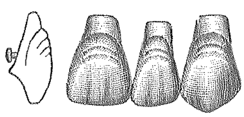


Fig. 374.— Plain Teeth, Vulcanite Transverse Corrugations, Constricted Cervices

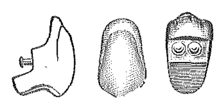


Fig. 375.— Plain Teeth, Bicuspids, for Vulcanite

OBJECTIONS

The principal objection to the use of plain teeth, where gum restoration is necessary, is on account of the gum material at present available. Pink vulcanite is opaque, and under most favorable conditions affords but little resemblance to living, healthy gum tissue.

The silicate cements are being tested, as to durability, as a substitute for gum restorations. This material fulfills esthetic requirements quite as well as porcelain.

Diatoric Teeth

Diatoric or pinless teeth are so formed as to afford anchorage for plastic materials around and within the porcelain. Teeth of this type, when bulk of material is not too restricted, and the mechanical retention forms are well proportioned, are capable of withstanding masticatory stress quite as well as pin teeth. In addition, they are much less expensive, a factor of some importance at times.

Diatoric molar and bicuspid teeth, when slightly modified by grinding, are frequently used in conjunction with gold, in

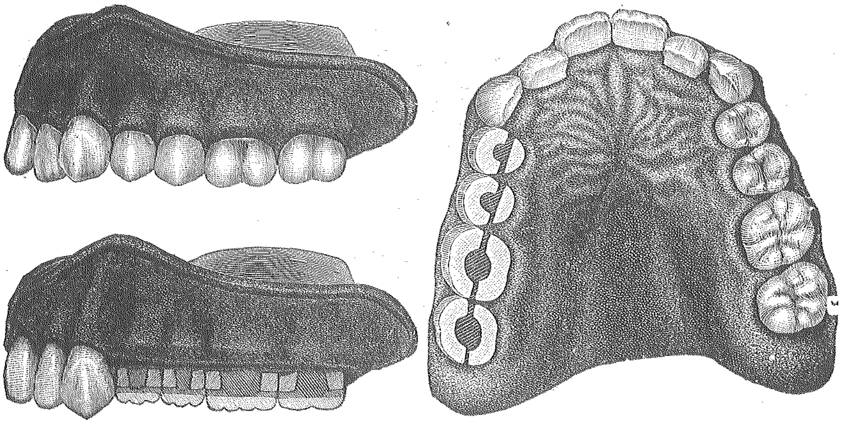


Fig. 376.— Diatoric Teeth Arranged in Full Upper Denture with Sections of Some Teeth Removed to Show Vulcanite Anchorage

the construction of bridge work, the technic being similar to that employed in the application of full or partial porcelain crowns, for such purposes.

COUNTERSUNK PIN TEETH

A countersunk pin tooth consists of a fully contoured porcelain crown, in the base or cervical portion of which is a depression from which projects a headed pin for anchorage

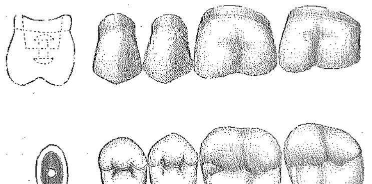


Fig. 377.— Countersunk Pin Teeth, Posteriors

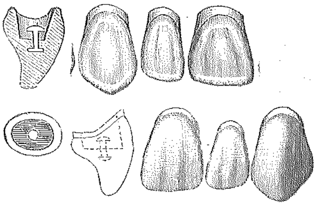


Fig. 378.— Countersunk Pin Teeth, Anteriors

purposes. The advantage of this type of tooth in denture construction is due to the fact that the full lingual contour of each tooth, which the basic material need not envelop to any extent, feels more comfortable, and enables the patient to speak more distinctly than when such contour is deficient.

ASH'S TUBE TEETH

A tube tooth consists of a fully contoured porcelain crown, having an opening extending entirely through it from cervical base to occlusal surface or just to the lingual of the incisal

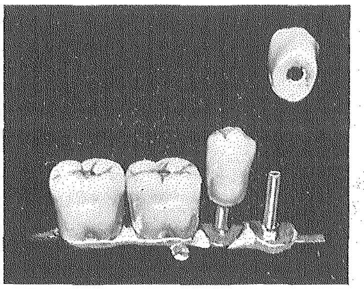


Fig. 379.— Tube Teeth, Bicuspids and Molars (Ash's), Set on Gold Casting, in Which Iridio-Platinum Pins Are Enclosed, Showing Application in Bridge Work

edge. Teeth of this type are occasionally used in conjunction with vulcanite, a headed pin or wire, slightly smaller than the opening, and longer than the crown being fitted to each before

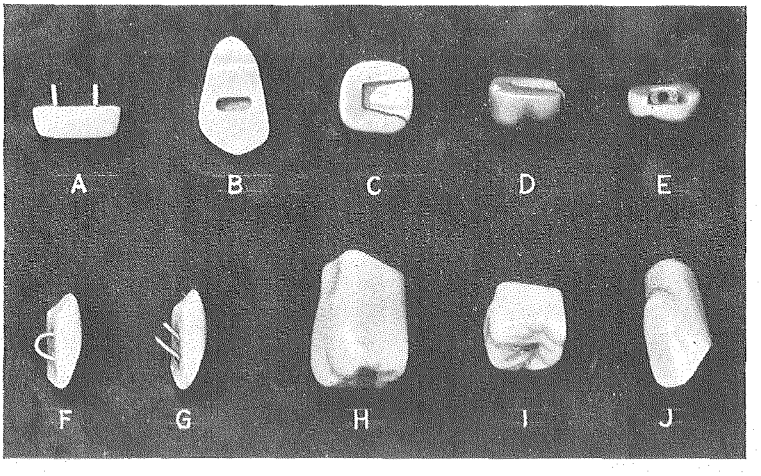


FIG. 380.— VARIOUS FORMS OF ASH'S MINERAL TEETH
A — Porcelain Tip with Pins for Anterior Restorations
B — Flat Back Repair Facing
C, D, E — Very Short Bite Molars, Diatoric
F, G — Dimelow Facings
H, I, J — Tube Teeth

packing the case. The head of the pin projects slightly beyond the cervical end of crown. In closing the packed flask, the rubber is forced into the vacant space in the tube and around the pin head and thus firmly anchors the tooth in place.

These teeth are capable of a wide range of application in crown and bridge restorations as well as in metal base denture construction, but unfortunately are not easily procured or extensively used in this country.

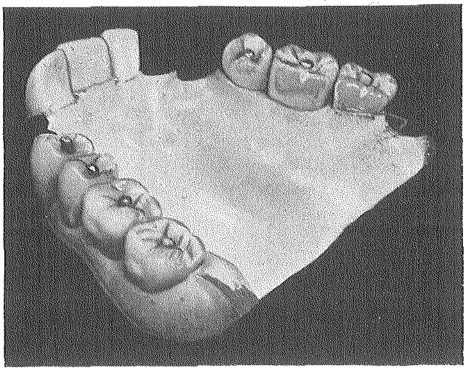


Fig. 381.— Partial Denture, Gold Base, Tube Teeth (Ash's)

PLAIN PLATE TEETH

A plain plate tooth consists of a veneer or partial crown of porcelain. It is usually supplied with two straight, headless pins which project from the flattened lingual surface. Teeth of this type are designed for use with metal, in crown, bridge and denture work. Because of the liability of fracture occurring in these teeth during soldering operations, and the further difficulty of replacement, when fractured from any cause, facings of the replaceable type are gradually coming into general use for the purposes mentioned.

VARIOUS FORMS OF PLAIN TEETH

There are various forms of plain teeth designed for special purposes, among which may be mentioned the Dimelow

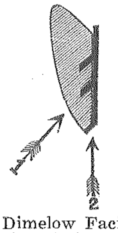


Fig. 382.— Dimelow Facing with Backing Adjusted

Fig. 383.— Backing with Staple Pins Adapted for Dimelow Facing

facing, consisting of a flat back veneer, having two holes in the location usually occupied by the pins, and which slant slightly, from lingual to labial, incisally. These holes receive two pins, projecting at a corresponding angle from the substitute. Mechanical anchorage is thus afforded by the slant of the pins as well as by the cement which serves as a bond of

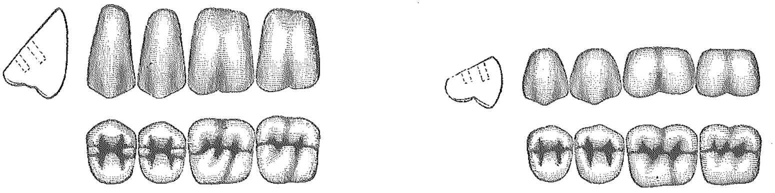


Fig. 384.— Short and Long Bite Bicuspids and Molars, Dimelow Teeth

union between the two factors. This tooth is used principally in repair work for crowns and bridges.

ASH'S FLAT BACK REPAIR FACING

This tooth consists of a flat back veneer, having a transverse, oblong, dovetailed opening in its lingual surface, for the

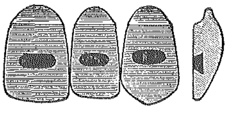


Fig. 385.— Flat Back Repair Facing Used Principally in Crown and Bridge Repairs

reception of a metal projection on the substitute and for the cementing medium. It is used principally in repair work on crowns and bridges.

ASH'S HELIX TOOTH

This tooth consists of a flat back veneer, having a cylindrical, threaded opening in its lingual surface, in the center

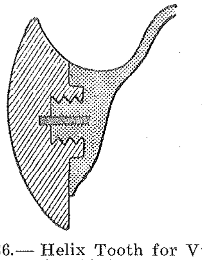


Fig. 386.— Helix Tooth for Vulcanite (Ash's)

of which is a threaded metal pin. A slight collar surrounds the opening, which may or may not be ground away as conditions of adjustment demand.

SADDLE BACK TEETH

Teeth of this type are intended for use in those cases where the alveolar ridge is prominent, and space is con-

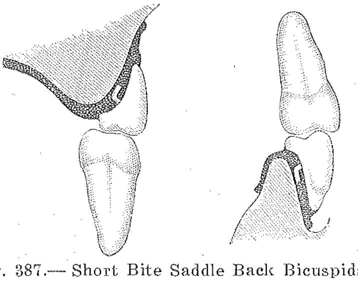


Fig. 387.— Short Bite Saddle Back Bicuspids

stricted. They are intended principally for vulcanite work, although those supplied with plain or headless pins are often used in crown and bridge work.

CONTINUOUS GUM TEETH

The teeth used in continuous gum cases are of the plain type, but differ from those described in having cervical extensions which resemble the outer surfaces of the roots.

These extensions serve two purposes. First, they afford support to the tooth in its attachment to the platinum base,

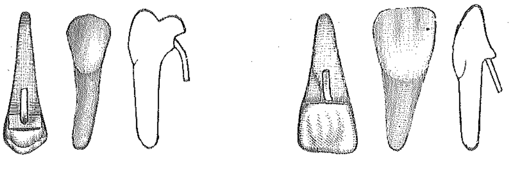


Fig. 388.— Continuous Gum Teeth

during fusion of the added porcelain, and second, being composed of high fusing porcelain, they supply a portion of the required bulk or contour of the denture proper, thereby proportionately reducing contraction in the bulk of continuous gum body, due to fusion.

GUM TEETH FOR VULCANITE WORK

Gum teeth, as their name implies, have an extension rootward, which in contour and color represents the natural gum tissue. They are made in single tooth sections and in blocks of twos and threes for full dentures. Special sections of two, three, and even four teeth are procurable, for use in partial denture construction. Sections of this type are indicated in

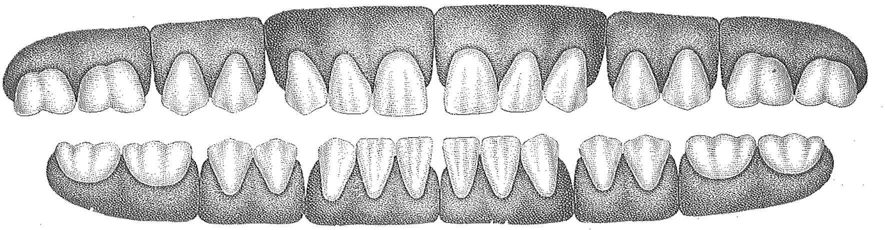


Fig. 389.— Set of Twenty-eight Gum Section Teeth (S. S. W.)

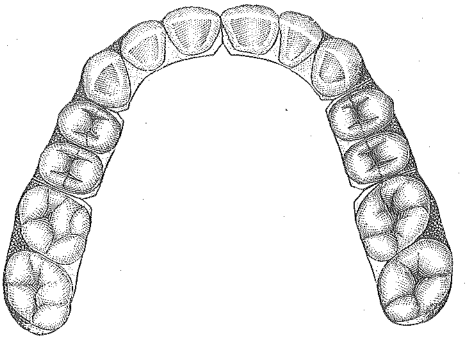


Fig. 390.— Occlusal View of Gum Section Teeth, Joints Ground

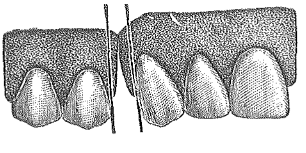


Fig. 391.— The Usual Relation of Adjoining Blocks of Gum Section Teeth Before Grinding

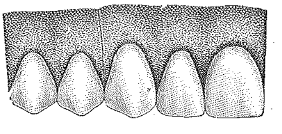


Fig. 392.— Two Gum Sections, Joints Ground

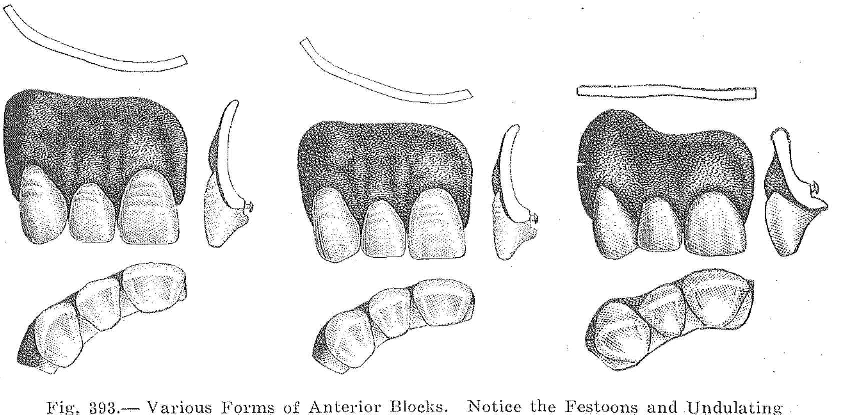


Fig. 393.— Various Forms of Anterior Blocks. Notice the Festoons and Undulating Surfaces of Gums

cases where gum restoration is required, and the joint between natural and artificial gum is visible.

Because of the difficulty in developing anatomic occlusal requirements in full dentures, gum section teeth are not used in such cases to any extent.

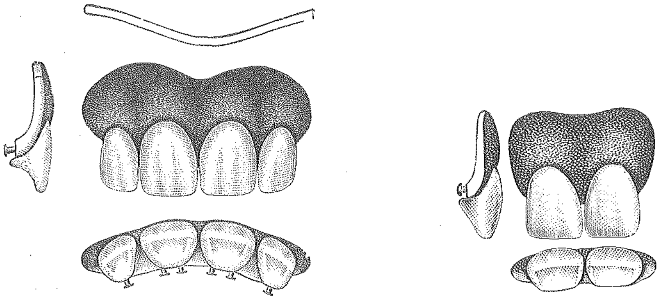


Fig. 394.— Special Forms of Gum Blocks for Anterior Replacements

GUM TEETH FOR METAL WORK

Since there is a wide range of difference in contraction and expansion of metal and porcelain the use of gum teeth in conjunction with gold or other metals is confined to single teeth or blocks.

Gum teeth designed for metal work have flat backs, and straight or plain pins. Special care must be used in soldering operations to avoid fracture of the porcelain, which occurs from unequal distribution of heat, sudden changes of temperature and difference in expansion between teeth and metal.

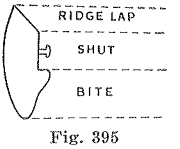


Fig. 395

Proportionate Parts of Teeth

In selecting a tooth for any given case attention should be given to the shape and angle of its cervical end or "ridge lap," the "shut" and the "bite."

RIDGE LAP

This term refers to the beveled surface of a tooth which slopes lingually from its cervical portion to the lingual side. The ridge lap varies in its length and angular inclination in different teeth, although the *shut* and *bite* in the same teeth may be alike. Likewise, either the shut, or bite, or both, may vary, while the ridge lap will be the same.

When the alveolar ridge is prominent, but little absorption having occurred, and the lip line is high, teeth with long

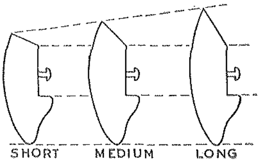


Fig. 396

ridge lap are indicated. When much absorption has occurred and but little, if any, of the ridge shows when the lip is raised, teeth with short ridge lap are indicated.

THE SHUT

The *shut* refers to the space between the upper and lower alveolar processes, or between the teeth of one arch and the alveolar process of the opposite arch. The *shut* of an arti-

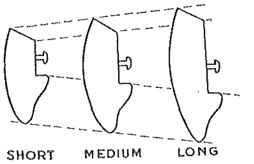


Fig. 397

ficial tooth is indicated by the distance between its lingual shoulder and the angle formed by its ridge lap with its lingual surface.

THE BITE

The *bite,* or *overbite,* in artificial teeth refers to the distance between the incisal end of a tooth and its lingual shoulder.

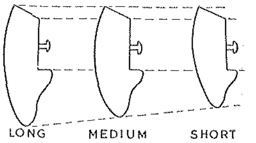


Fig. 398

In selecting teeth, special care must be given this point. When teeth with short bite are selected, and the case demands considerable overbite of the upper over the lower teeth, the lingual shoulders must be ground away to a greater or less extent, to secure the desired relation, which frequently weakens the porcelain.

Another case in which long-bite teeth should be used is in lower anterior replacements. By the use of long-bite teeth much less vulcanite is required to develop proper lingual con-

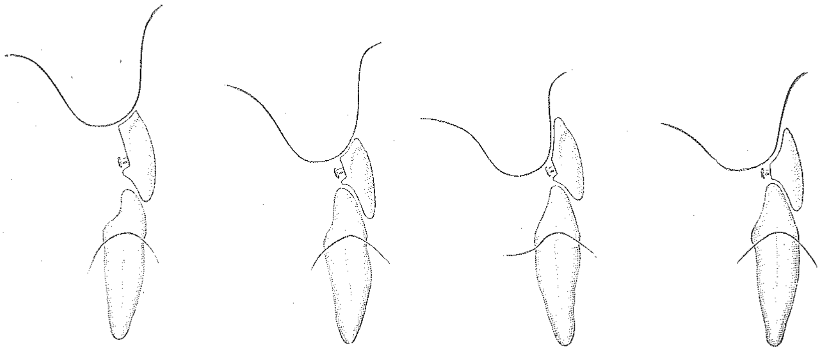


Fig. 399 SHORT RIDGE LAP Long Shut, Medium Bite

Fig. 400 MEDIUM RIDGE LAP Short Shut, Long Bite

Fig. 401 EXTRA LONG RIDGE LAP Short Shut, Medium Bite

Fig. 402 LONG RIDGE LAP Short Shut, Long Bite

tour than when this portion of the crown is devoid of normal contour.

This portion of the tooth may be, and usually is, described as having a *long*, *medium* or *short* bite.

THE TOOTH SHADE GUIDE

Most manufacturers of porcelain teeth provide a *shade guide* on which, in some manner, are displayed the different shades or colors of teeth supplied by them. These guides usually are composed of from twenty-five to forty sample central incisors of average size, all differing in shade, tone or tint. By means of a guide of this type, teeth of suitable color may be selected with a reasonable degree of accuracy.

Some prosthetists without a special knowledge of the laws of harmony are able to arrive at satisfactory results in the selection of teeth of appropriate shades for any individual case.

How they do it or why the results are satisfactory they do not attempt to explain further than it is by guesswork or intuition.

Intuition, however, in color science is not the result of guesswork, but is due to a more or less conscious or unconscious development of color function in the visual organs, as has been explained.

APPLICATION OF THE TOOTH SHADE GUIDE IN PRACTICE

The patient should be seated facing a direct light. The face, eyes and hair should be scanned as a whole, to determine the general color scheme of the complexion and to estimate, as closely as possible, the complementaries of the tints there displayed.

By careful observation, with a little experience, this examination enables the prosthetist to select from the shade guide a tooth of the general tints required. The first selection, even if possessing the fundamental tints indicated, may not meet requirements. The tooth may be too light, or too dark, or it may need the addition of some primary or secondary color of greater or less intensity, to develop the necessary harmony. If not pleasing, other teeth are tested until one is found that, by its presence in the mouth, creates the impression of harmony and is satisfying to the esthetic sense.

Strong colors displayed in the complexion call for strongly marked shades of teeth, within certain limits of course, while a person having a complexion made up of weak colors must be supplied with teeth of neutral tints, or highly attenuated colors of a generally neutral tone.

Porcelain teeth are perceptibly darkened by the shadows of the lips and oral cavity, some more than others, depending on their translucency or power of transmitting light.

In selecting teeth, therefore, it is advisable to test them not only in direct light but to change the position of the patient so that the teeth may be subjected to both lip and oral shadows, and the effect noted. When tested by direct light only, too light a shade of tooth is liable to be selected, with the result that in the finished denture the teeth will appear too dark.

When a suitable color of tooth has been selected a record should be made of its number, and from this teeth of a corresponding color number are procured.

A New Gum Facing

Protesyn, a silicate cement, has been recommended and is being used to a limited extent, as a substitute for pink, or granular pink, gum facing, in vulcanite dentures.

It is semi-translucent in texture and compares favorably in appearance with porcelain for gum restorations. The most serious objection urged against this material is that a denture to which it is applied must be kept moist at all times, otherwise the protesyn will contract and fracture.

The following illustrations, with descriptive text, have been supplied by the L. D. Caulk Co., Philadelphia:

"There is scarcely a process in the practice of dentistry that is simpler than the making of a Protesyn denture. The esthetic effect is striking, as it reproduces absolutely the appearance of the natural gum, giving a result not approached with any other material. A package of Protesyn is sufficient to make from six to ten dentures. The method of manipulation has been carefully worked out by the manufacturers and experienced dentists, and must be followed absolutely if the best results are to be secured. The successive steps in making a Protesyn denture are pictured and described as follows:

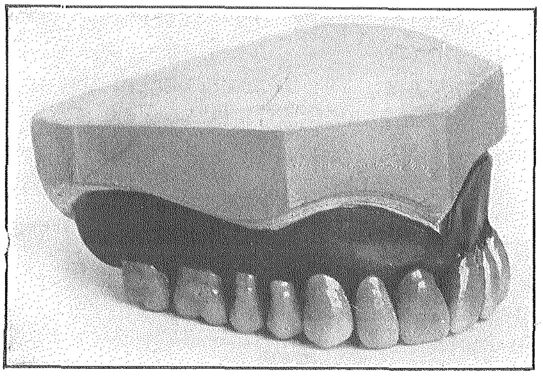


Fig. 403.—I

I. One thickness of baseplate wax is placed on the cast in the usual manner; the teeth are set up and waxed up from the palatine side. An undercut is left at the labial cervical margin for retention of the Protesyn between the teeth and vulcanite.

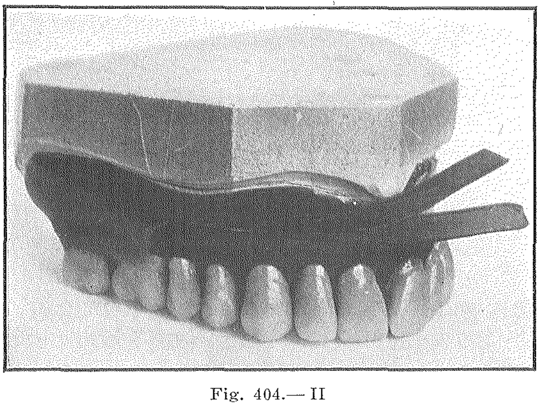


Fig. 404.—II

II. Putting on the rim. Cut and attach one or two strips of wax (depending on the labial fullness desired), and attach the strip or strips to the top of the plate, making an undercut for Protesyn retention.

III. A fully waxed up cast ready to be flasked, packed with rubber and vulcanized. The polished and finished den-

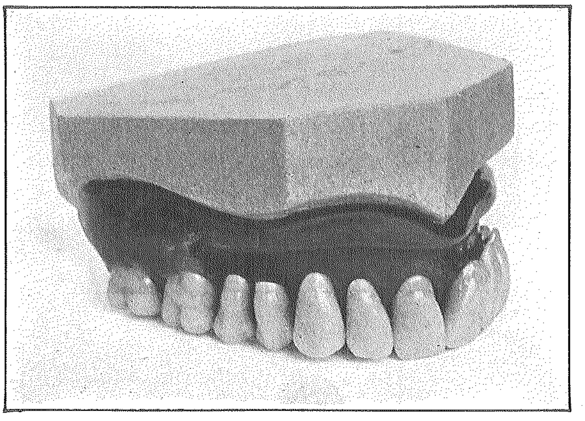


Fig. 405.— III

ture will naturally be a duplicate; it is then ready for the Protesyn. Mix a sufficient quantity at one time to complete

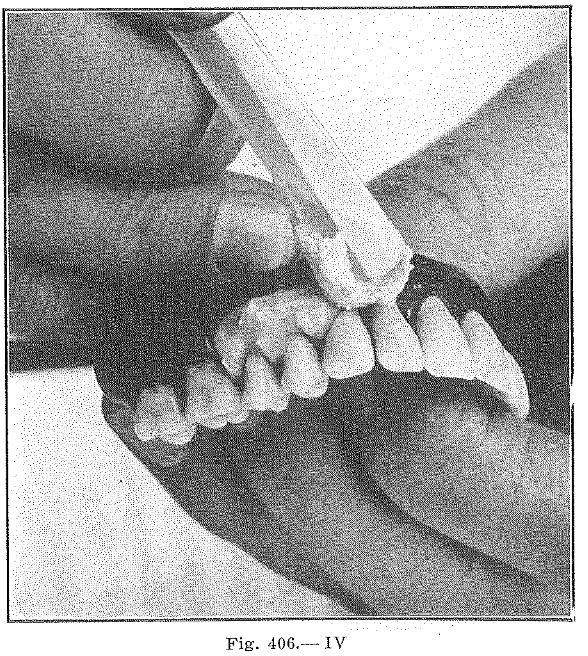


Fig. 406.— IV

the denture. In making the mix, a large, strong agate spatula is required. The consistency should be about the same as a correct mix of Synthetic Porcelain. The mix, however, may be made with more deliberation than a mix of Synthetic, inasmuch as Protesyn is slow setting, and therefore the operator has ample time to secure the proper consistency without haste. A period of from twenty to twenty-five minutes is available from the time the mix is begun until the Protesyn is molded and festooned, before the mass becomes too hard to work. When ready for the denture, the Protesyn must be a stiff, homogeneous mass.

IV. The method of putting Protesyn on the plate. Small successive quantities are taken on the spatula and forced into the space provided for it, drawing the spatula across the front rim of the denture, continuing until the whole space is filled slightly to excess.

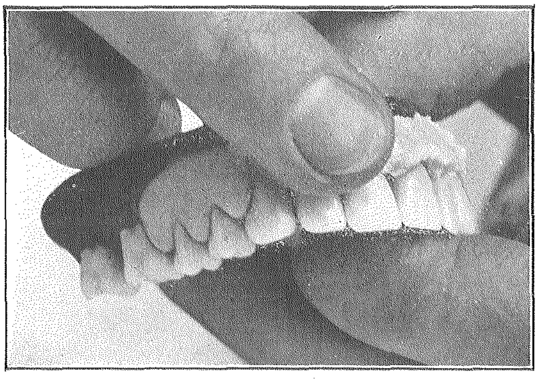


Fig. 407.— V

V. Shaping the Protesyn. At this stage the mass is patted and smoothed and forced fully into the undercuts. The finger must be slightly anointed with the lubricant. Avoid folds and laps of Protesyn.

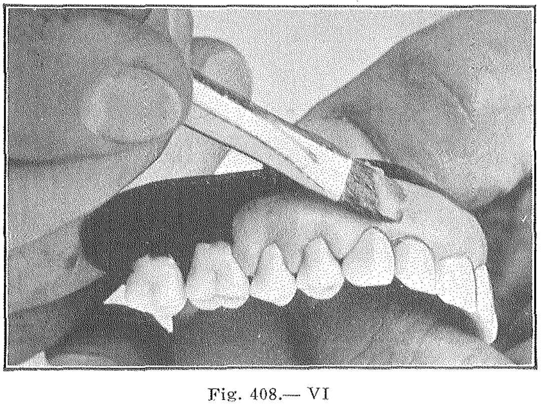


Fig. 408.— VI

VI. Coating lightly with Protesyn lubricant preliminary to the molding.

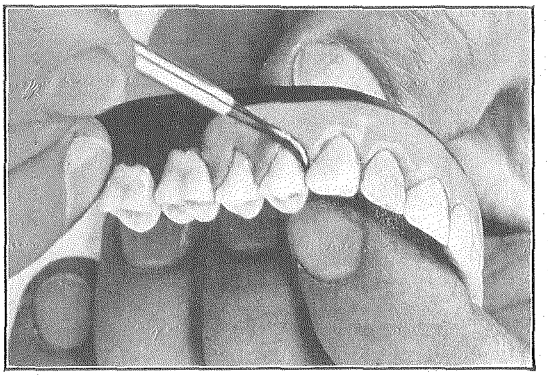


Fig. 409.— VII

VII. Using a tantalum instrument to force back the Protesyn and to define the gum margins.

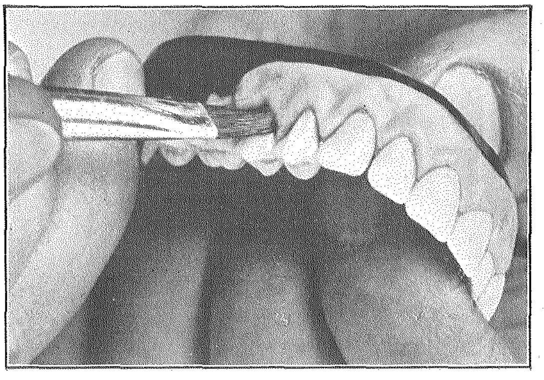


Fig. 410.— VIII

VIII. Finally smoothing and finishing the gum margins with Protesyn brush No. 1.

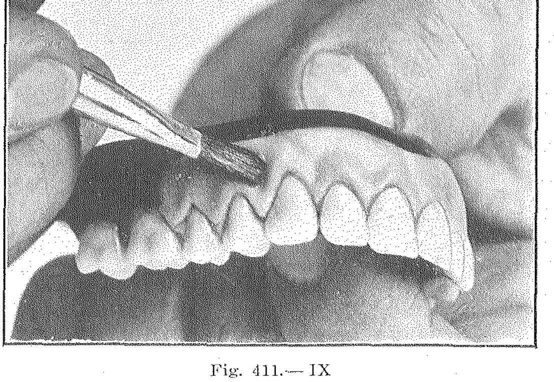


Fig. 411.— IX

IX. Forming the festoons, showing how easily and artistically this may be done with Protesyn.

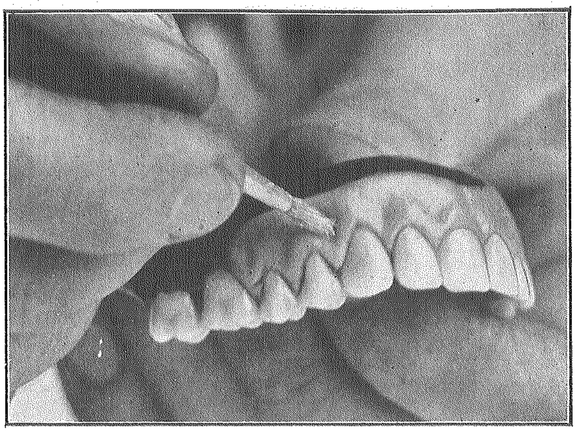


Fig. 412.— X

X. Stippling with brush No. 2. The area indicated at the point of the brush as shown in the picture is the only part of the natural gum that shows a decided stippled effect. Over-stippling and excessive festooning, besides being unnatural, render the denture less sanitary.

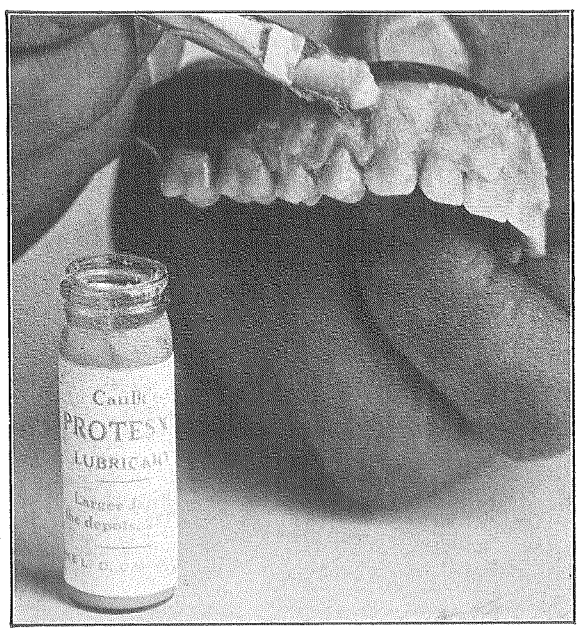


Fig. 413.— XI

XI. The completed denture coated with Protesyn Lubricant. When the denture is finished and, five or ten minutes later, the Protesyn sufficiently hardened, it must be immediately heavily coated with Protesyn Lubricant, exercising care in its application not to mar or obliterate the festooning.

XII. A period of twenty-four hours must elapse after the Protesyn denture has been finished, coated with lubricant

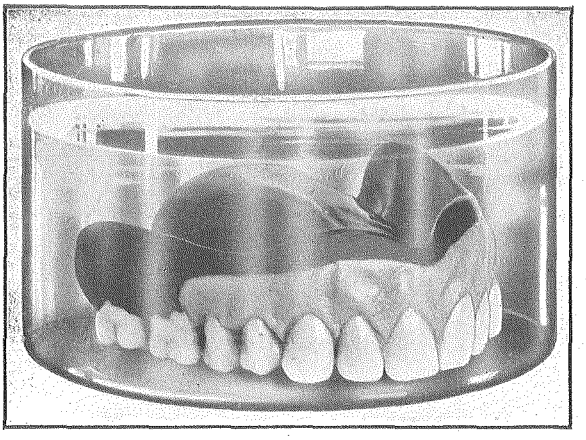


Fig. 414.— XII

and laid away, before it is cleaned and placed in water. To clean, use a brush, soap and water.

XIII. Method of removing Protesyn from a denture in case repair of the vulcanite becomes necessary. This is done after the denture has been repaired and otherwise finished. We do not recommend the old Protesyn to remain after it has

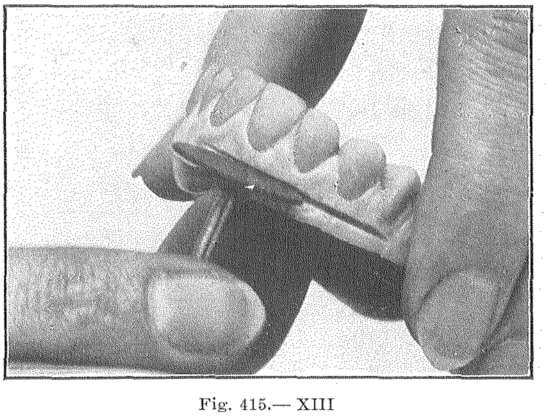


Fig. 415.— XIII

been through the vulcanizer. Use a knife-edge carborundum wheel. Cut a longitudinal groove and chip the Protesyn away with chisels or scalers. Then thoroughly remove all of the old Protesyn and apply new.

XIV. An upper and a lower Protesyn gold denture articulated. In these cases the Protesyn is extended to the undercut of the turned-up or wire-soldered rim, the teeth being anchored by the usual cleats and vulcanite attachment pala-

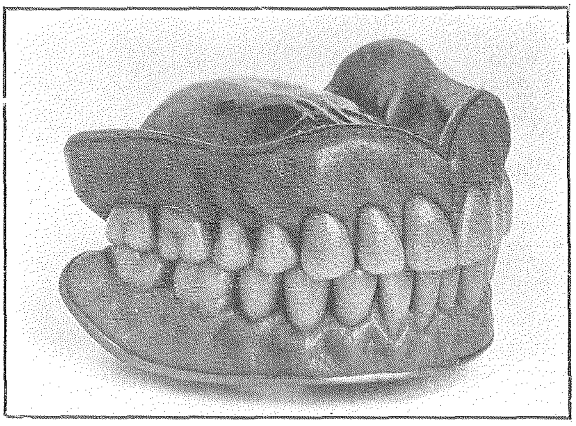


Fig. 416.— XIV

tally. Spurring on the labial face may also be resorted to for added attachment, as in the case of vulcanite.

XV. Here are shown a removable bridge and a lower Protesyn denture. This suggests the wide use of Protesyn in bridge-work. In this lower denture (as also in No. 12, shown

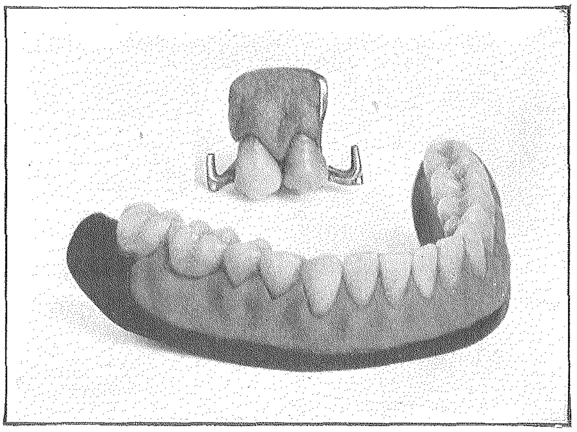


Fig. 417.— XV

in the bowl of water) the Protesyn is used conservatively, allowing ample body of vulcanite margins for rim-fitting, without destroying the undercut for Protesyn. These cases also show the Protesyn extended beyond the high lip-line.

In the making of Protesyn dentures these requirements must be observed. The mass must be mixed to the proper consistency. The plate when finished must be heavily coated with lubricant and laid aside for twenty-four hours, when it is cleaned and placed in water. Henceforth, it must always remain in water when not in the mouth of the patient. The patient must be instructed on this point.

Natural Dentures Reproduced in Porcelain Teeth and Wax

The following series of cuts have been introduced to show some of the commonly occurring variations in arrangement of the natural teeth. These cases represent as nearly as possible, by means of porcelain teeth arranged in wax, the conditions found in the mouths of living subjects. Most of these illustrations have appeared in the past in the Dental Cosmos and several of them appear in the American System of Dentistry, 1888, in an article on celluloid and zylonite by Dr. W. W. Evans.

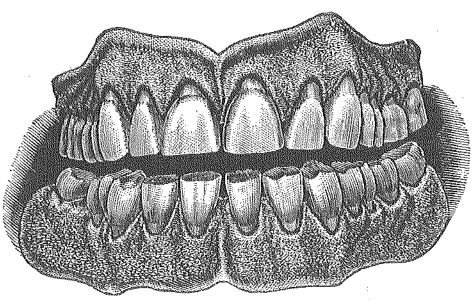


Fig. 418.— I

I. Appearance of teeth of person past middle life, gum recession, strongly marked mechanical abrasion.

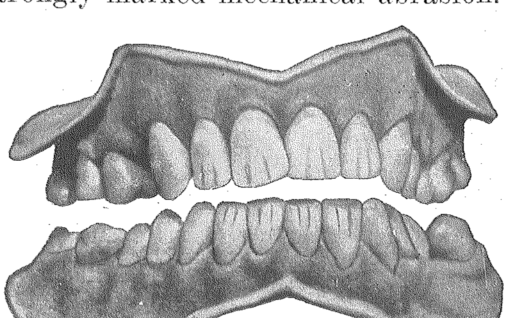


Fig 419.— II

II. Teeth of a woman of thirty to thirty-five. There is rather long overbite, and the chamfering of the edges of the lower incisors is plainly seen. The right central overlaps the left. Two teeth are lost from these arches, the right upper first bicuspid and the left lower first molar. The upper denture is provided with plumpers to restore disturbed facial contour.

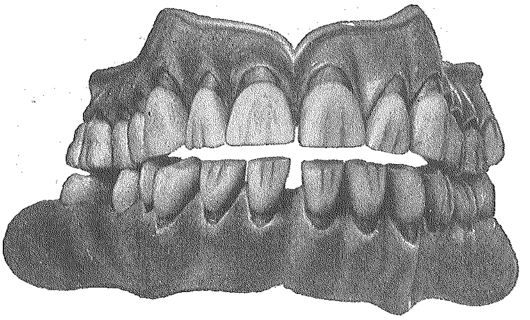


Fig. 420.— III

III. The denture of a man past fifty years of age. The teeth are inclined well forward, with end to end occlusion. The effect of wear is seen on the incisal edges of the lower incisors, and indicated by the squaring of those of the upper, lower incisors separated, as is often seen, gums receded.

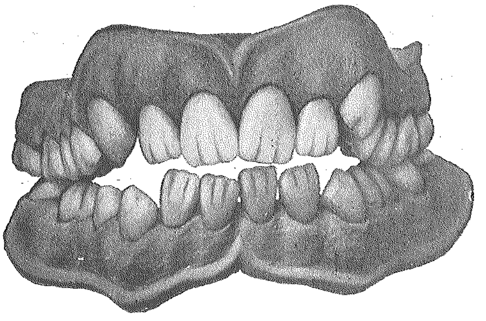


Fig. 421.— IV

IV. The denture of a girl of twelve or thirteen years of age. The cuspids are not yet fully erupted, and the incisors show a very marked example of the *cusplets* which adorn them when first erupted.

V. The denture of a man between twenty-five and thirty years of age. Teeth are fully developed, large, with a long overbite. The upper cuspids are elongate and incline slightly inward. The lower incisors are considerably crowded and inclined. The upper right first bicuspid and lower left first molar have been lost. Two fillings are shown in the upper central incisors.

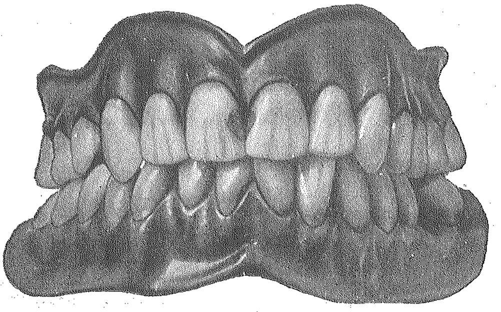


Fig. 422.— V

VI. The denture of a young woman between eighteen and twenty years of age. All of the teeth are fully erupted,

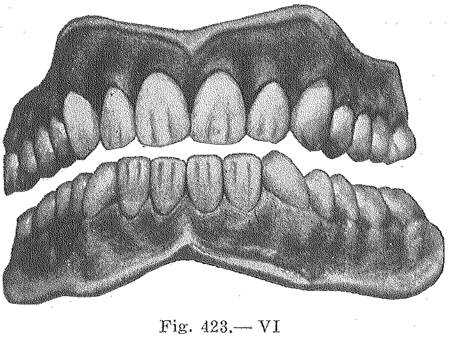


Fig. 423.— VI

and the little cusps of the incisors are nearly effaced. Every tooth is in a healthy condition.

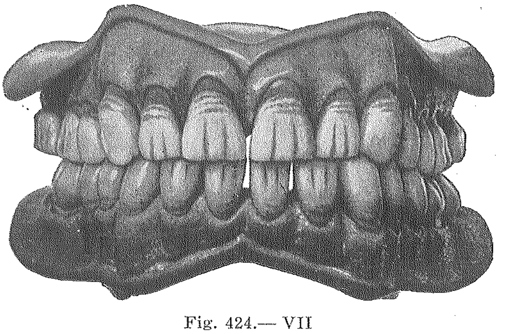


Fig. 424.— VII

VII. The denture of a man between forty and fifty years of age. Occlusion almost end to end. Some recession of the gums. Plumpers to restore disturbed facial contour.

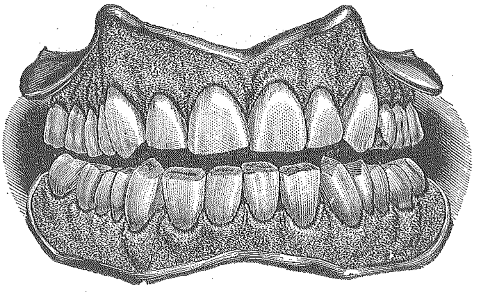


Fig. 425.— VIII

VIII. Denture of a man between fifty and sixty years of age. The teeth show wear from use.

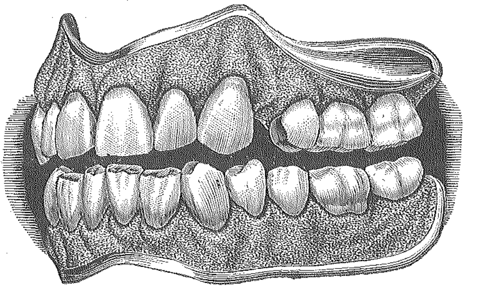


Fig. 426.— IX

IX. Teeth of a man about fifty years old. Left upper first bicuspid lost. Teeth show mechanical abrasion. Plumpers.

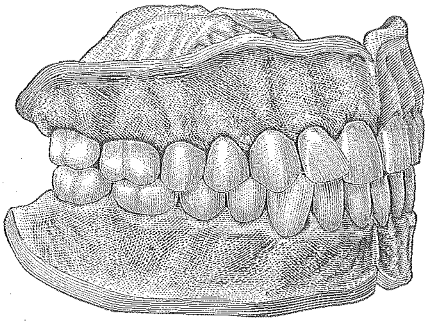


Fig. 427.— X

X. Overlapping lateral incisors. Gums are prominently ridged, indicating position of roots.

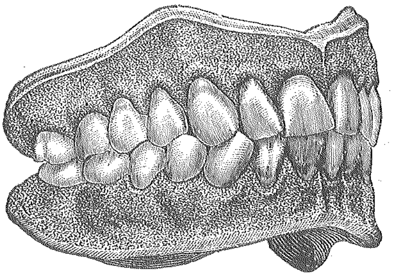


Fig. 428.— XI

XI. Teeth arranged with close bite, considerable overlap, lateral rotated.

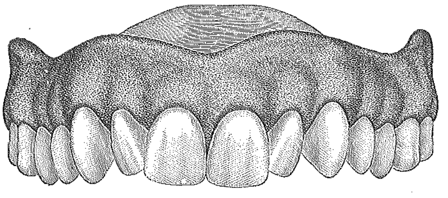


Fig. 429.— XII

XII. Central incisors rotated outward distally. Laterals rotated inward distally and slightly within the arch.

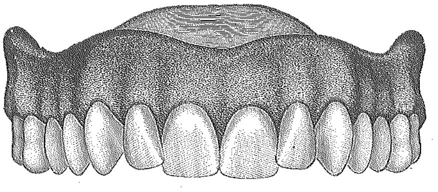


Fig. 430.— XIII

XIII. Centrals inclined inward, laterals overlapping, cuspids prominent.

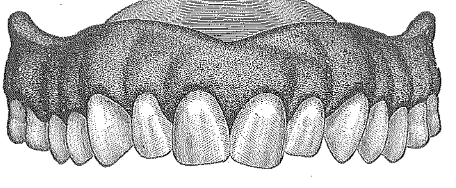


Fig. 431.— XIV

XIV. Centrals V-shaped. All incisors diverging strongly from incisal edges apically.

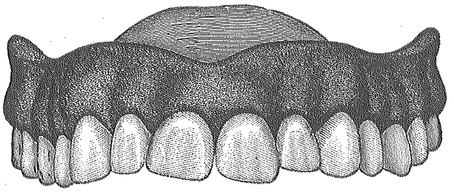


Fig. 432.— XV

XV. Incisors out of alignment.

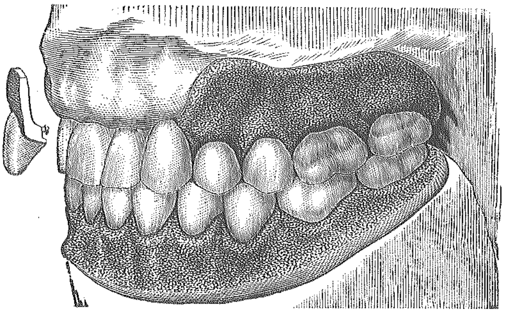


Fig. 433.— XVI

XVI. Plain teeth ground to border. Gum restoration from cuspids backward.

CHAPTER XXIV

CELLULOID DENTURES

Of the plastic vegetable bases used in denture construction, celluloid presents the most natural appearance, closely approaching porcelain in the translucent, live-tissue color of the gums and mucous membrane.

It is not generally as durable as vulcanite, frequently discoloring and rapidly disintegrating in some mouths, while again it proves satisfactory in other cases. Its value as a denture base is largely dependent upon the manner of manipulation of the material during construction, as well as on the care bestowed upon it by its possessor.

Discovery of Celluloid

In 1855 an Englishman by the name of Parks invented the material now known as celluloid, and which he named *parksite* or *zylonite*. In 1859 a man by the name of Mackintosh, also in England, patented the material called collodion, from which he constructed denture bases. This substance was improved upon by Dr. McClelland of Louisville, Ky., in 1860, who gave it the name of *rose pearl*. The denture base was made from sheet collodion, moistened in alcohol and ether sufficiently to render it plastic for securing adaptation to the cast. The teeth also were attached with additions of the same material, similarly softened. Dentures so constructed showed decided tendency to warp in drying out.

The Newark Manufacturing Company, organized in this country in 1869, began, and for a number of years conducted, a series of experiments to determine the possibilities and limitations of this material. After the lapse of a number of years and the expenditure of large sums of money, during which time many almost insurmountable difficulties were met and overcome, a product of stable character was finally evolved, capable of application to innumerable purposes.

Composition of Celluloid

Celluloid is made from *pyroxylin,* or the woody fiber of plants. This material is treated with nitric and sulphuric acids, after which it is known as *nitro-cellulose,* or *guncotton,* a highly explosive substance.

The proportions of this material with other substances, as used for dental purposes, are about as follows: Guncotton, 100 parts; camphor, 40 parts; white oxide of zinc, 2 parts; vermilion, .06 part.

Zylonite is made by first dissolving the guncotton in ether, or methyl alcohol, and then combining it with the other ingredients. Celluloid is made by effecting the union of the several ingredients by means of heat and pressure, without first dissolving the guncotton.

MANUFACTURE OF CELLULOID

The following abbreviated description of the manufacture of celluloid appeared in the *Dental Cosmos,* January, 1875, being a reprint from an article in the *American Artisan:*

"After the pulp is ground in the beater engine, and the camphor and whatever coloring matter may be desired are thoroughly incorporated with it, the substance being kept, meanwhile, at the proper temperature, the superfluous water is removed by pressure and absorption, a peculiar porous material, made especially for the latter purpose, being employed.

"During the process of drying under pressure and absorption, the material becomes nearly converted, so that it is no longer nitro-cellulose, but imperfect celluloid. In so far as conversion has taken place, its properties have undergone a total change. All that remains to convert it into the various articles referred to is manipulation under heat and pressure, during which the chemical combination is completed.

"For some qualities of the material desired to be produced, a small percentage of alcohol is added in the subsequent manipulation. As evidence that there is a perfect chemical combination, and not a mere mechanical mixture of the materials, the fact may be stated that camphor in its uncombined state is an extremely volatile substance when exposed to the air; in its combination with nitro-cellulose it loses this property altogether. An enumeration of the properties of the material, which we shall give anon, will be further proof of the chemical combination.

"When the material is properly converted, comparatively no shrinkage takes place. There is no escape of the camphor, unless an excess has been employed, and in that case the excess of camphor will escape from the surface of the celluloid; but whatever uncombined camphor remains in the interior, it is so closely imprisoned by the solid surfaces that it cannot escape. By varying the proportion of the excess of camphor, different degrees of solidity and flexibility are obtained. . . .

ADVANTAGES CLAIMED FOR CELLULOID

"Without the admixture of coloring matter it has a pale amber color. If it is desired to make the material white, like ivory, oxide of zinc is used, and for other colors various mineral pigments are incorporated with it, or dyes soluble in alcohol, or any of the analine dyes, may be caused to permeate the material to give it any desired color. It is hard and elastic, having a hardness ranging from horn to that of ivory. It is as tough as whalebone. In elasticity it greatly exceeds ivory. . . .

"Celluloid is also a very fair non-conductor of heat and electricity, not quite so much so as hard rubber, but approximating the latter very closely in this particular. . . .

"While it is so good a non-conductor, it is not perceptibly electric. . . .

"But perhaps the most remarkable property of this otherwise very remarkable material is the fact that it becomes plastic at a temperature of from 250 to 300 deg. F., and this property enables it to be molded with facility into a great variety of forms for ornament and utility. Pure celluloid has a specific gravity of about 1.4.

"A profitable and successful industry, based upon these properties of celluloid, is the manufacture of dental plates. The material can be made precisely the color of the palate and gums.

COMPARATIVE STRENGTH OF CELLULOID AND VULCANITE

"It is much stronger than rubber and has a perfectly clean surface. It may be more easily manipulated than rubber, as it does not require to be vulcanized. It possesses all the valuable qualities of rubber for dental purposes with none of its defects. It requires only about 1/60 as much vermilion to give the proper color to celluloid as is required to impart the usual color to rubber. The danger of salivation, which sometimes occurs in the use of rubber for dental purposes, is, therefore, obviated. The difficulties encountered in the application of celluloid to dental plates have been very great, and many failures were at first experienced, but with untiring perseverance the inventors have pursued the subject until, during the last year or two, they claim to have produced an article possesing all the requirements desired, not a single failure having been experienced through any fault of the material made within a twelvemonth past."

The foregoing claims are somewhat exaggerated in several respects, but, taken as a whole, the description of this material is an admirable one. Just about the time celluloid came into use, much litigation was in progress between the Goodyear Rubber Company and members of the dental profession, who refused to pay a royalty to the above-named company for the privilege of using vulcanizable rubber for dental purposes. At that time celluloid was welcomed and widely used, but owing to the fact that its properties were not fully understood, and that the methods of manipulation were not perfected, many failures have been recorded against it. These failures will now be mentioned and the causes explained.

DISADVANTAGES OF CELLULOID AS A DENTURE BASE

First.— In some cases there seems to be a gradual solution of the substance by the fluids of the mouth. Such action results in thinning and the consequent weakening of the baseplate. The material around the pins of the teeth is gradually worn or dissolved away, thus allowing the latter to become displaced under the stress of mastication.

Second.— When used for some time, in many instances a very disagreeable odor develops, so objectionable that the denture cannot be worn with comfort.

Third.— The baseplate often becomes badly discolored, assuming a dirty, brown appearance, and, in the case of smokers, a black film, extremely difficult to remove, forms on the surface.

Fourth.— Liability of the cast to become distorted in molding the celluloid blank over it. When this occurs, failure to secure adaptation to the oral tissues results.

Most of these objectionable features mentioned are largely due to faulty technic, and can be obviated to a great extent by exercising care. When the blank is molded over the cast in the presence of oil, steam or glycerine, the volatile constituents are not eliminated as they should be, but, on the contrary, the celluloid seems to take up some of the liquids and becomes reduced in density and less resistant to the action of the fluids of the mouth.

GENERAL METHODS OF MANIPULATION

The best results are attained by pressing celluloid in a dry chamber, at high temperature, continuing the process as long as may be consistent with the work in hand. By this method the volatile constituents are driven off, the material rendered more dense and compact, while its elasticity will be increased and its color improved over the product resulting from the moist process.

Steam, oil or glycerine softens the plaster cast and flask investment as well, rendering them more susceptible to compressive force and consequent distortion in closing the flask. When dry heat is employed, the flask contents become hardened by the evaporation of the moisture before the compression force is applied, and consequently there is less liability of warpage or distortion occurring than by the moist method.

The chief objection to the dry method is due to the danger of burning the blank during the process of pressing. By cutting ample waste gates in the plaster investment surrounding the matrix, so that no surplus material comes in contact with the metal flask, this danger is largely overcome. An extra large sized flask for investment purposes is necessary in order to afford the needed space for deep and wide gates.

The flask should be of the same general form as a vulcanite flask, but larger and heavier throughout. The guide-pins should be strong and long enough to hold the two halves of the flask in proper relation to each other when separated as they must be by the introduction of the unpressed blank.

CONSTRUCTION OF THE WAX MODEL DENTURE

The construction of the wax model denture for a celluloid case differs in no essential particulars from that for a vulcanite case. The wax contour model is constructed and fitted in the mouth to establish the bite and the direction of the condyle paths. On this the teeth are occluded and tried in the mouth for appearance, alignment, occlusion and balancing contact, after which it is returned to the cast, the latter detached from the occluding frame, and the case is ready for investment in the flask.

FLASKING

Upper cases should be invested in the shallow half of the flask; lower cases in the deeper portion, in order to conserve space. In upper cases the anterior part of the cast is elevated, more or less, to insure a parallel relation between the several surfaces of the cast and the guide-pins, or the line of direction in which the two halves of the flask must travel in closing. Should undercuts be present, the material may fail to find its way into them on account of the matrix mar-

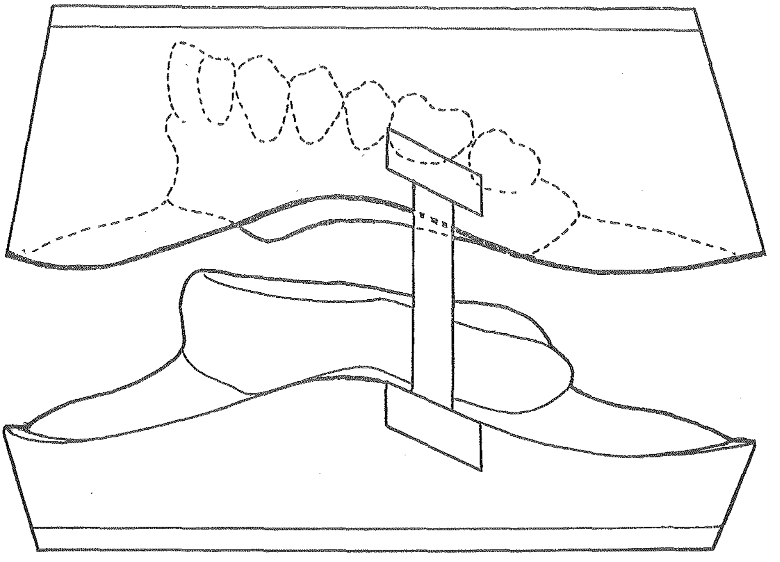


Fig. 434.— Celluloid Flask Designed by Dr. H. C. Miller of Portland, Ore.

gins preventing; hence the necessity for elevating the cast, as suggested.

Coarse plaster should be used for investment purposes, as it withstands high pressure, without perceptible yielding, much better than impression plaster.

CUTTING THE WASTE GATES

Deep and wide waste gates should extend entirely around the matrix, these being cut in the side of the flask containing the cast, for if cut in the opposite, or matrix, side, the walls of the latter would be weakened and probably crushed under the pressure required to force out the excess material. The outer margin of the gate should be at least an eighth of an inch from the inner margin of the flask to prevent any possibility of the surplus celluloid coming in contact with the heated metal. It is a peculiar fact that combustion of celluloid almost invariably occurs when brought in contact with metal heated to 300° F. or above, while if enclosed entirely in plaster the temperature may be raised fifteen to twenty degrees higher before the material will burn. The inner margin of the gate should approach very close to the matrix margin, so that the surplus material may flow out readily after it once passes the matrix periphery. The plaster between the two margins of the gate outline is cut out in V-shaped form, sufficiently deep to afford ample space for any surplus present.

CLEARING THE MATRIX OF WAX AND DEBRIS

The gates having been formed, the wax is removed from the interior of the flask, the latter cleansed with boiling water, the sharp, angular margins of the matrix are trimmed off to prevent them fracturing and mixing with the celluloid in closing the flask.

The face of the cast should be covered with a film of collodion to give smoothness to the surface of the denture pressed against it.

SELECTION OF THE BLANK

Celluloid, as prepared for dental purposes, comes in the form of *blanks,* blocks having the general form of a denture baseplate, but considerably thicker than the finished denture will be, so as to supply the necessary surplus to fill the matrix under pressure.

The blanks come in various sizes and are numbered as follows, beginning with the smallest: No. 2½, 3, 3½, 4, 4½, 5, 5½, 6, 6½. These are sufficiently thick to insure a surplus of material for ordinary cases. When a large amount of absorption has occurred, it is sometimes necessary to use a thicker blank than those mentioned. For such purposes a series of extra-thick blanks are supplied and numbered as follows: 2½a, 3a, 3½a, 4a, 4½a, etc., up to 6½a.

When using upper blanks of this variety it will invariably be necessary to reduce the palatine portion to a reasonable thickness with a lathe burr, shown elsewhere. If not reduced, the matrix, and frequently the cast, is distorted in forcing out the excessive surplus, oftentimes to such an extent as to destroy denture adaptation.

Frequently it will be necessary to modify the form of a blank before introducing and pressing, so that, in a general way, it will conform to the face of the cast. This is done by placing it in boiling water until thoroughly heated, and with pliers bending the outer rim to the required form, or if the vault portion, as in flat-arch cases, needs modifying, lay the blank on a flat surface, and with a round-end wood handle depress the central area until the outer rim settles down over and encloses the labial and buccal surfaces of the cast. It may be necessary to heat the blank three or four times in order to give it the proper form, but time devoted to this preliminary adaptation is well spent, as it reduces the liability of the celluloid folding on itself, of the matrix failing to fill, and also of the latter becoming distorted from the application of unequal pressure.

Usually during this preliminary adaptation the blank will become more or less soiled. This may be corrected by scraping the soiled surfaces and also rubbing the blank with a clean piece of muslin moistened with spirits of camphor. The application of the latter will also prevent the tendency of the celluloid to flake or crack during the pressing process. The blank is now set upon the cast, and the upper half of the flask set in position to engage with the guide-pins of the opposite side, then carefully let down until the matrix margins are in contact with the blank. Care should be taken to see that the latter is not displaced during this step.

PRESSING THE CASE

A dry-chamber press should be used, for reasons previously mentioned. The flask is set on the bedplate of the press, matrix side down, so that in case any of the teeth become loosened in the dry heat, gravity will retain them in position. The three screws which draw the bedplate up against the lid of the press should be tightened evenly, so that the guide-pins may at all times travel in a perpendicular direction and parallel with the screws. No pressure should be put upon the blank until the latter is thoroughly heated to a temperature of at least 300° F., at which point it should be maintained during the pressing process. At least twenty-five minutes should be allowed for raising the temperature in the interior of the press up to this point.

When the proper temperature has been attained, the bolts are gradually tightened, and, as before suggested, care should be taken to keep the bedplate parallel at all times with the top of the press, so that the guide-pins will not be bent. The case should be lifted out of the press from time to time for examination, to determine the progress of the closure, but should be returned to the chamber as quickly as possible to prevent cooling.

Too much pressure should be avoided. Celluloid, even when plastic, is rather sluggish and flows slowly. If forced too rapidly, or faster than the normal flow the material will warrant, distortion of the matrix and face of the cast will occur, and a misfit will result.

When the flask is closed, the source of heat is cut off and the case allowed to cool for ten or fifteen minutes or longer, if time permits. This permits the molecules of the material, under the continued heat and pressure, to adjust themselves to each other, and lessens the danger of warpage which sometimes occurs when pressure is relieved too suddenly. In every case the flask and contents, whether suddenly or quickly chilled, must be perfectly cold before the press bolts are loosened, otherwise distortion may result.

REMOVAL OF THE CASE FROM THE FLASK

In removing a case from the flask it will be found that the plaster is extremely hard and difficult to cut. The desire to pry the flask apart suddenly, or use a hammer to knock the investment out of the flask, is great, but if these methods are employed, some of the teeth will very likley be fractured. It is, therefore, best, even though more tedious, to saturate the case with water, pry off the top and bottom plates, and remove the content of the flask by cutting close to the inner periphery of the flask.

FINISHING

No special directions are necessary for finishing celluloid cases, as this material is susceptible to the same methods of polishing as vulcanite. Should there be a decided odor of camphor present when the case is finished, it may be removed by immersing the denture in a 10 per cent solution of sulphuric acid for a few minutes. If allowed to remain in the acid for a long time, or in a strong solution for a short time, solution of the celluloid will occur.

GENERAL REMARKS

As before stated, celluloid is not as durable a material as vulcanite, but it certainly deserves some consideration as a serviceable and inexpensive base for dentures, as well as for its beauty and close resemblance to the natural gum tissues.

Celluloid is peculiar, and its physical properties must be well understood in order to derive the best results from its use in denture construction. It forms an admirable base for temporary, and under favorable conditions for permanent dentures also. Celluloid does not serve well as a base for partial dentures, for the reason that single or isolated teeth are more readily displaced from a base of this material than from one of vulcanite.

CASTS FOR CELLULOID CASES

Since the principal source of error in celluloid denture adaptation is due to compression and consequent distortion of the cast in pressing the material, and since the pressure applied cannot well be reduced under that usually employed, on account of the sluggishness of the material, even under high temperature and pressure, the remedy lies in the use of a harder substance than plaster for casts. Any of the three materials previously mentioned in connection with *cast construction* are applicable for this purpose, viz., oxy-chloride of magnesium, Spence's plaster, and tin, although when the latter is used great care must be exercised to avoid overheating and consequent combustion of the celluloid.

CHAPTER XXV

REPAIRING VULCANITE DENTURES

The materials of which vulcanite dentures are composed are susceptible to wear and breakage under stress, and since dentures of this, as well as of all types, are subjected to more or less heavy masticatory effort, accidents of various kinds frequently occur to both the vulcanite base and the porcelain teeth. The accidents which are of most frequent occurrence, with methods for repairing such cases, will now be outlined.

Fracture of the Vulcanite Base

Fracture of the baseplate may be caused by the application of sudden or undue stress in handling while cleansing, or from a fall; or, in case unequal absorption of the alveolar process occurs after the denture is introduced, under heavy masticatory stress the baseplate may break from the resulting undue torsional strain, due to lack of support over the absorbed areas.

Under such conditions a fissure usually makes its appearance at some point along the margin of the baseplate, and, unless corrected, extends more deeply into the vulcanite, finally resulting in fracture of the denture into two or more pieces. Occasionally complete fracture of the base plate will occur suddenly from undue strain, as from the sudden crushing of a hard morsel of food, as well as from some of the causes previously mentioned.

Usually the plan of repair of a denture is easily determined. Occasionally, however, the nature of the accident and the causes leading up to it clearly indicate that reconstruction, instead of repair, will prove most serviceable.

It should be noted that the preceding outline covers a common class of accidents, due to two different causes — first, those resulting from sudden undue stress, as in careless handling or from a fall; and, second, those resulting from torsional or bending strain in masticatory effort,

In all cases where, up to the time of the accident, the adaptation of the denture to the tissues has proven satisfactory, repairs are generally indicated. In those cases where the primary cause of the fracture is due to imperfect adaptation of denture to oral tissues, reconstruction of the case is, in most instances, indicated, since by the usual methods of repair the greatest efficiency can not be realized.

Reassembling a Fractured Baseplate

In repairing a fractured denture, the first consideration is to assemble and hold the several parts of the baseplate in correct relation to each other while preparing the joints and splicing the fractured pieces together with new material. This is best accomplished by constructing a *cast,* not in the usual way, by taking an impression of the mouth, but by reassembling the broken pieces of the denture and filling in the maxillary or border side with plaster to serve as a cast.

Technic of Securing a Cast from the Baseplate

The broken parts of the baseplate are pressed together until the fractured surfaces show perfect contact, and, while in this relation, sticky wax is applied to the lingual surfaces on either side of and across the fracture line, but, for obvious reasons, not on the border or palatine areas. The wax should be applied in sufficient bulk, so that when chilled it will hold the several broken pieces firmly and accurately while the cast is being formed.

The border and palatine sides of the denture are now coated with a thin film of oil, and the material of which the cast is to be constructed is applied in the same manner as in an impression and allowed to harden.

Sometimes the relation of the several parts of the denture can be best maintained, while securing the cast, by imbedding them to a slight extent in modeling compound, care being taken to maintain the correct relationship of the fractured surfaces until the compound has hardened somewhat. This method is especially applicable for holding in correct relation the two halves of a full lower denture, fractured in the incisor region. When sticky wax alone is used in such cases, slight pressure on the outer sides of the denture while handling is liable to disturb the correct relation of the fractured surfaces before the cast is secured. This danger can be obviated, in most cases, by laying a small piece of wood, as a match or a rigid wire, between the distal ends of the baseplate and attaching each end firmly to the plate or teeth with wax before forming the cast.

The method frequently followed of assembling the fractured parts of a baseplate on a cast derived directly from an impression of the mouth is objectionable, because it is inaccurate. The cast, being hard and unyielding, will not permit the baseplate to settle in position, as it does on the soft and yielding areas of the mouth, and when the repair is accomplished with the several parts thus sustaining an incorrect relation to each other, even though the distortion may

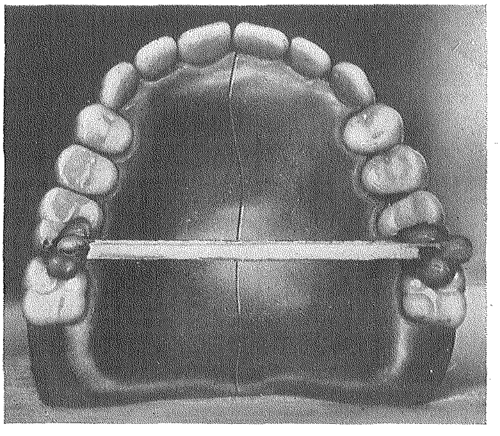


Fig. 435.— A Fractured Baseplate Held Together with a Match, Waxed to Molars

be slight, a misfit usually results, or the occlusion of the teeth is impaired.

Repairs occasionally present, usually in partial dentures, however, where the broken pieces can be placed in the mouth and an impression secured which will give a more accurate relation of the parts to each other than is possible to obtain by adjusting the fractured surfaces together and applying wax, as outlined.

Method of Joining the Fractured Pieces

A long bevel joint, if properly formed, will present the best appearance and prove the strongest and most satisfactory manner of repairing a fractured vulcanite base of any of the methods in vogue. The practice of cutting a series of dovetailed spaces on either side of the fracture line for the reception of the new material, in most cases, tends to weaken the old vulcanite, and when the base is composed of other than black, basic material, the repair, when completed, will present a very unsightly — or, at least, noticeable — appearance, because of the variation in the color of new and old vulcanite, as well as on account of the irregular outline margins of the patch.

A cabinetmaker who desires to produce the strongest possible union between two pieces of wood — a joint that will resist both torsional strain and end pull — will make a long

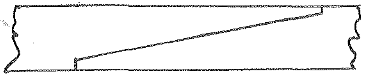


Fig. 436.— Lap or Bevel Joint of Two Pieces of Timber

bevel joint instead of *halving* each piece and abutting each halved end against the corresponding shoulder of the opposite piece. Tests show that the bevel joint is the strongest of the two methods outlined, not only in wood, but in vulcanite as well.

The dovetailed method of repairing a simple fracture is based upon the principle that some positive form of mechanical anchorage is essential, even though it be gained at the expense of weakening the old vulcanite, and in areas not previously involved in the break; it accords too much value to the dovetail, a joint calculated to resist end pull and not torsional strain, and not enough in the lap joint, which, with practically perfect union of surfaces between new and old vulcanite, will resist both torsional strain as well as end pull. The fact does not seem to be generally well understood that under proper conditions new rubber will unite firmly and permanently with old vulcanite. The necessary requisites for serviceable union between the old and new vulcanite are as follows: Fresh, clean surfaces to the old base, produced by filing, scraping or burring; the covering of these surfaces with a thin film of rubber cement before adding the new rubber, and the maintenance of pressure upon the newly added material during vulcanization; also freedom of the joint from wax, grease or dirt.

The rubber cement should correspond in color with the vulcanite or the fresh rubber between the surfaces of which it is interposed, to avoid imparting a variegated appearance to the joint.

The commercial rubber-tire cement, which is nearly invisible when applied to, or used in connection with any color of vulcanite may be used, or a cement may be made by dissolving red, pink or black rubber in any solvent, such as benzine, bisulphide of carbon or chloroform. When the latter is used the solution is called "chloro-rubber." The three colors should be kept in stock, in the laboratory, in tightly

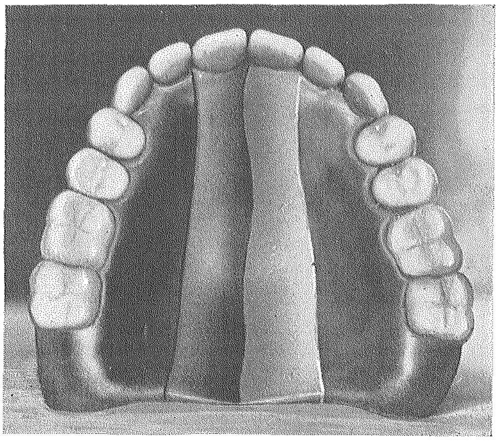


Fig. 437.— Fractured Baseplate, Showing Beveled Areas on Either Side of the Break

stoppered bottles, for use as occasion requires. Excessive application of cement to a joint, without removal of the surplus, will result in porosity of the newly added material.

FORMING THE BEVEL JOINT

Two shallow grooves, about one-sixth the thickness of the baseplate in depth, are cut, one on either side of the frac-

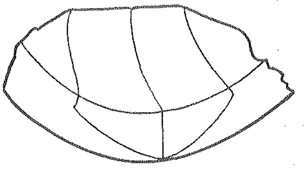


Fig. 438.— Sectional View of Baseplate, Showing Outline of Bevel of Old Vulcanite. The Central Beveled Portion Is to Be Removed

ture line, and approximately parellel with it on the lingual side of the baseplate. These grooves limit the area of the old base to be covered by the new vulcanite and determine the outline of the patch, as it might be called. When the fracture line is very irregular, the position of the limiting marginal lines may be varied, if by so doing a more symmetrical balancing of the new with the old vulcanite can be secured.

The relative position of these lines to the fracture line may be modified by increasing or diminishing their distance from the latter uniformly; or, if the conditions of the case require, they may be laid in curved or diagonal directions. The result of varying the position of the marginal lines will be to vary the length and pitch of the bevel, but this will in no way interfere with the strength of the repair. The main object of varying the outline margins of the freshened area, as before stated, is to give a symmetrical form to the newly added vulcanite, and when good judgment is displayed in planning the repair, very presentable, and at times quite artistic, results are realized. In most instances the average repair is an unsightly, and often an unsatisfactory, operation, when in practically every instance where a repair is indicated, both satisfactory and esthetic results are possible when proper steps are taken.

Summary of the Technical Steps Followed in Repairing a Median Line Fracture, Full Denture

Assemble and unite the fractured pieces firmly, as previously outlined; secure the cast; with a pencil, sketch on the

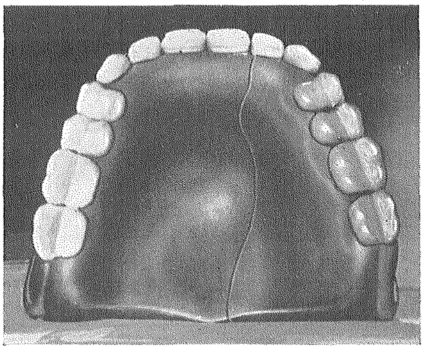


Fig. 439.— Denture with Complete Fracture, Extending Entirely Through Palatine and Labial Gum Portions

lingual surface of the baseplate, as symmetrically as possible, the position of the marginal lines which limit the area to be covered by the new vulcanite; cut the grooves along these lines to the depth previously indicated; bevel off the old vulcanite from the bottom of these grooves to the opposite or palatal surface of the baseplate, terminating the bevel in a feather-edge along the fracture line. This entirely removes the inner wall of each groove and converts the outer wall into a shoulder against which the new vulcanite finishes.

When the break extends through the labial portion of the denture, the outer surface of the pink gum should be beveled in a similar manner to the alveolar border joint surface. In all cases of pink vulcanite gum repairs, where the fracture occurs anteriorly, or anywhere between the cuspids, the marginal lines of the repair should be laid back of the cuspids, so as to render invisible, if possible, the line of junction of the old with the new vulcanite. This is imperative on account of the unsightly discoloration noticeable in joint areas on pink gum after vulcanization.

In preparing the joint, the beveling is most easily accomplished by applying those areas of the baseplate to be reduced

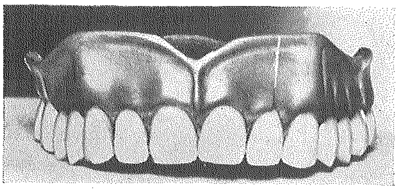


Fig. 440.— Labial View of Preceding Case

against the emery band on the lathe mandrel. Constricted areas that cannot be reached by this means can be reduced with large fissure or round burs in the engine.

After beveling, the fractured pieces are returned to the cast, a piece of sheet wax is applied to the freshened areas on the lingual surface of the denture, and with a hot spatula burnished, but not melted, down to the required contour of the finished case.

METHOD OF FLASKING A REPAIR CASE

It is seldom possible to flask a full denture so that the matrix side of the flask can be withdrawn from that containing the baseplate, to which the teeth have previously been permanently attached, without injuring the matrix, especially those portions of it which fill the embrasures. Therefore, in repairs involving the labial or buccal gum surfaces, as well as lingual portions of a denture, provision must be made for placing the rubber on the gum surfaces in such manner as not to be disturbed in the final closing of the flask.

This may be accomplished in two ways. First, by covering the prepared and waxed portion of gum repair with the plaster in the first half of the flask, and by means of one or more suitably located connecting gates removing the wax from the gum surface, packing the matrix through these openings, and with an excess of rubber in the gates condense that forming the gum repair in the partially enclosed matrix in the final closing of the flask.

Second, the following method, when carefully carried out, involves less time and is quite as effective as the first and can, in most cases, be followed. The details are as here outlined:

When the beveling of the several surfaces involved in the repair is completed and the parts are adjusted to the cast, the lingual surface is waxed as before described. Instead of waxing the gum areas they are coated with a thin film of rubber cement, well rubbed into the freshened surfaces with a pellet of cotton.

A strip of pink, or granular, rubber, large enough to neatly cover the entire area of removed old gum, is applied, and with a large, hot burnishing spatula is pressed firmly against the freshened areas until perfect contact and firm adhesion is developed. Smaller pieces are added and burnished against that already placed until the required gum contour is developed and a compact homogeneous mass results.

When the pink gum restoration has been built up as described, the case is ready for flasking, and herein lies the

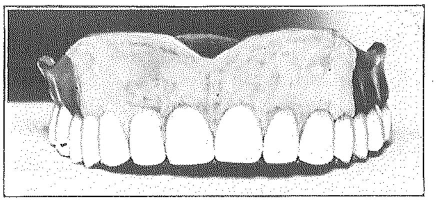


Fig. 441.— Gum Facing Applied to Freshened Labial Areas

advantage of packing the gum repair as outlined, since complications in flasking and subsequent packing are avoided.

A mix of plaster is made and the case invested in the lower half of the flask just as though no gum surfaces were involved; that is to say, the entire labial and buccal portions, including the gum surfaces just packed, the teeth and the lingual surface of the baseplate not included in the repair area in this location, are covered or entirely enclosed within the plaster investment in the first half of the flask. The pink gum, packed as above described, is thus entirely enclosed within a matrix. No provision need be made for producing pressure on the pink rubber, for, if properly packed, the expansion of the mass of pink rubber in vulcanizing is sufficient to hold it firmly in contact with the old vulcanite and cause it to unite perfectly with the latter.

When the plaster in the lower half of the flask is smoothed up and varnished, the upper half of the flask is adjusted, filled, and when hardened, separated, the wax removed with hot water, the surfaces of freshened rubber covered with a film of rubber cement, well rubbed in, some basic rubber of appropriate shade is applied to the cut-out area, slightly in excess of the actual bulk required, so as to insure pressure in vulcanizing, the two halves of the flask are adjusted, and while cold the bolts are tightened with finger power only, the case is warmed with dry heat and finally closed in the usual manner. Vulcanization is carried out as for ordinary cases.

Replacing a Displaced Tooth

When a tooth has been forced from the denture base, its pins having pulled out of the vulcanite, or as sometimes occurs, when a small section of vulcanite enclosing the pins fractures and comes away with the tooth without injuring or in any way impairing the usefulness of the latter, replacement of the same tooth can in most cases be effected by very simple methods. The following means for replacing bicuspids and molars are both simple and serviceable.

First, adjust and wax the tooth in its correct position in the vulcanite base, enlarging the old pin holes, if necessary, to let the tooth in place. The periphery of the vulcanite socket in which the tooth rested before displacement should be disturbed to the least possible extent at this time, as it guides the tooth to proper place.

Second, oil the labial or buccal surfaces of the teeth and gums, including the displaced tooth and extending a short distance mesially and distally from it.

Third, make a matrix of plaster by building it against these oiled surfaces. This is necessary in order that the displaced tooth can be returned to correct position after the supporting vulcanite on the lingual side is removed preparatory to adding new vulcanite for the repair.

Fourth, remove the matrix and the tooth, and with a vulcanite file or a large engine bur form a dovetail space in the baseplate, to the lingual of the tooth displaced, as wide as the latter and deep enough to entirely obliterate the old pin holes.

Fifth, return and hold the tooth in correct position on the baseplate by means of the matrix, and apply wax in the dovetailed space around the pins and against the porcelain, building it out to the required contour of the finished denture.

Sixth, remove the matrix, invest the case in the lower half of the flask, entirely enclosing the denture in plaster except a

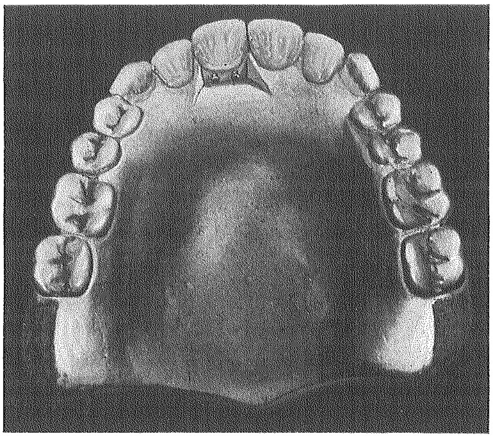


Fig. 442.— Denture Base Prepared for Replacement of One Tooth, Showing Formation of Dovetail Space

small surface immediately surrounding and including the waxed repair area. The tooth itself should remain in position in the baseplate, and be covered sufficiently with plaster to obviate its being raised on forcing the rubber into the dovetailed space and underneath the tooth in closing the flask. Smooth the upper surfaces of plaster, tapering the margin around the repair area so that the plaster in the upper section may separate readily, varnish, complete the investment in the upper half of the flask, and allow time for plaster to set.

Seventh, separate flask; pick out as much wax as possible and use hot water for the removal of the last traces of it.

Eighth, apply a thin film of rubber cement, being very careful to avoid excess, since as before stated a surplus will cause porosity in the newly added rubber in vulcanizing. Cut and apply some small pieces of basic rubber of appropriate shade, usually slightly darker than the denture base, as the latter will darken somewhat with each vulcanization. With a warm, round end rubber packing instrument the pieces should be fairly well condensed in the dovetailed space and around the pins, and a little surplus added to insure slight pressure on the mass when the flask is closed and during vulcanization.

Ninth, close the flask, vulcanize and finish in the usual manner. When the pink gum margin has been fractured and requires restoration, the surfaces are freshened and small pieces of pink rubber are built up to the required contour, condensing them with a hot instrument. This should be done before flasking the case, the pink rubber being enclosed in the first half of the investment as previously outlined in repairing a fractured baseplate. Usually, however, as previously stated, on account of the unsightly discoloration at the line of junction of the new with the old pink vulcanite, visible areas needing repairs should be extended to such point that the discolored joints are invisible, and only new pink vulcanite will show. This often necessitates carrying the beveling back as far as the second bicuspid on each side.

Replacing a Displaced Tooth by the Casting Method

When the displaced tooth is situated between two proximating teeth as in a full denture, and rests in a vulcanite socket or matrix having a complete periphery, attachment of a new tooth may be made by casting. The advantage of this method is that vulcanization is obviated, a process which, when resorted to as is usual in repair cases, while the plaster is "green," soft and yielding, often results in warpage and consequent loss of adaptation of the denture to the oral tissues.

The steps are as follows:

The vulcanite which enclosed the pins is freely cut away and in addition a cavity, having a decided undercut, is formed in the sides and bottom of the vulcanite matrix in which the tooth rests. Care must be taken not to disturb the peripheral outline of the matrix, or if unavoidably disturbed, to restore in wax the lost portion after the tooth is finally set in place. A positive connection of the wax so applied with the interior of the matrix is esssential so that the metal, when cast, will flow from the interior outwardly and take the place of the wax.

Now at a point well within one of the lingual embrasures drill a hole connecting with the undercut cavity, as nearly parallel with the long axis of the tooth as possible. A broken engine bur converted into a drill of the full diameter of the shank produces a hole of convenient size. Later on the bur, by reversing, will assist in forming the sprue.

The tooth is now returned to position in its matrix and waxed externally, if necessary, to hold it in place, thus leaving the undercut space free from wax or debris.

A .093 wire (the diameter of an engine bur shank) is now passed into the sprue previously drilled in the baseplate, or

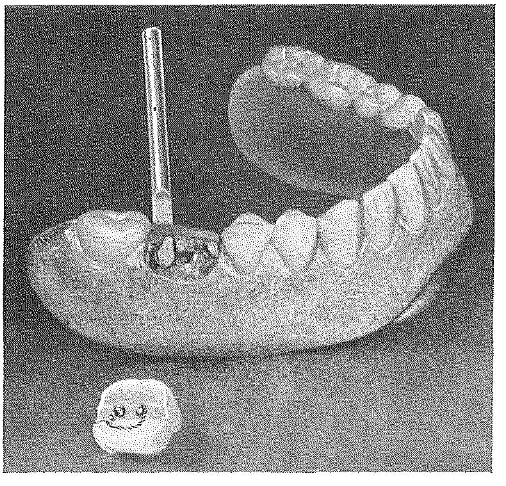


Fig. 443.— Replacing a Tooth by the Casting Method

the drill may be reversed and used for this purpose, a mix of investment or plaster is made, filled in the palatine or border side of the denture, to form a base to prevent the denture tipping, carried out against the buccal or labial surface, over the occlusal or incisal surfaces, and down on the lingual surface of the denture surrounding the sprue wire.

While the plaster is yet soft, a small cup, similar to or made from a common thimble, having a hole drilled in the bottom, is slipped over the sprue wire and pressed down into the plaster sufficiently deep to support it when the wire is withdrawn, and to insure its stability under the pressure of casting.

When the plaster has hardened, the sprue wire is withdrawn, thus forming a sprue connecting the thimble with the undercut space under the tooth. Fusible metal is melted and poured into the thimble, from which it is forced into the space by means of Melotte's moldine, confined within a ring or cup somewhat larger than the diameter of the thimble. Forcing the metal in the undercut under pressure causes it to fill the

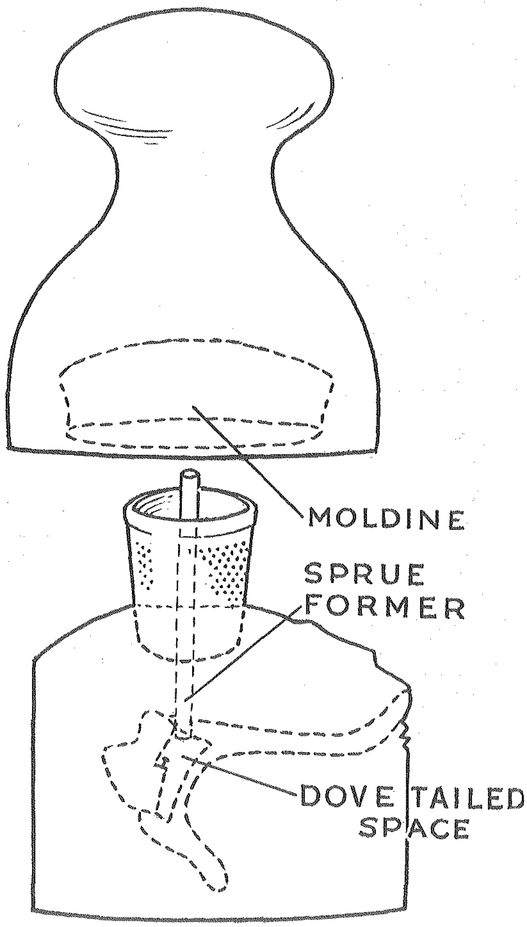


Fig. 444.— Diagrammatic View of the Invested Case, Thimble in Position, and Moldine Carrier. Sprue Former Not Yet Removed

entire space and enclose the heads of the pins perfectly, thus making a very serviceable repair. When finished, the only metal showing is that which fills the sprue, which, when dressed down and polished, is scarcely noticeable.

Dr. A. C. Alexander of Kahoka, Mo., first called the writer's attention to this method of repair two years ago, and since that time it has been applied satisfactorily in many practical cases. In general, the principle is similar to the method suggested by Dr. J. B. Bean in 1869 for attaching gum sections to cast aluminum bases by forming an undercut in

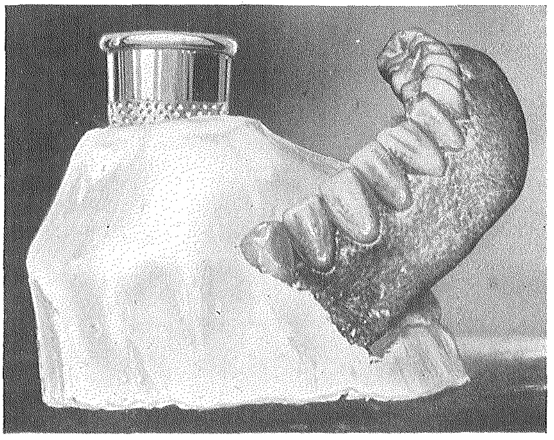


Fig. 445.— Cut of a Practical Case Invested Ready for Reception of Fusible Metal

the baseplate and casting tin into the space so formed and around the pins of the section; described in Harris, Ed. 1870.

Another Method of Repair by Means of Fusible Metal

Cut a decided dovetail in the lingual surface of the denture, as for an ordinary vulcanite repair, but greater care must be exercised in developing positive mechanical anchorage in the space in repairs of this type than where vulcanite is employed, since in the latter case the union is an adhesion of molecular material and not merely a mechanical anchorage, while in the repair under consideration the union of the metal with the base is mechanical.

Fill the palatine or border surface of the denture with plaster to form a base, extending it out over the outer surfaces of the gums and teeth to serve as a matrix for holding the displaced tooth in position.

The case should be set at such an angle in the investment that gravity will assist in filling the undercut space when the molten metal is poured.

The case being properly invested as described, some Mellotte's or other easily fusible metal is melted in a small ladle and poured into the dovetailed space. As it begins to congeal, a little surplus is added, and with a pad of blotting paper folded three or four times, pressure is made on the mushy or semi-hardened metal to force it into all parts of the space and around the pins of the tooth. When hardened, the excess is trimmed off and the surface polished to proper contour.

Repairing by Means of Amalgam

A very common method of attaching a displaced tooth is to form the dovetailed space as just described, adjust the tooth in position and form a matrix in such manner that it will not become displaced nor allow the tooth to be forced out of position under the pressure of packing the amalgam. A mix of amalgam of moderate consistency is made and quickly forced into the space prepared for it and around the tooth pins, using small-pointed pluggers to pack it into the deeper portions of the dovetail.

Repairs made in this manner, although at times quite satisfactory, are usually temporary in character, the amalgam around the pins fracturing under masticatory stress and allowing the tooth to be dislodged.

By forming a loop of fine, tinned iron wire, such as is used for root measurement, twisting it around the pins and weaving it back and forth between the two, three or four times, additional anchorage of the tooth to the denture will be gained over that afforded by the pin heads alone. This method is very applicable in amalgam or fusible metal repairs, where the tendency of the pin heads to pull out or the amalgam to readily fracture under stress is very marked. The loop should be well embedded in the amalgam. It can readily be seen that if a little tension is placed on the loop to take up the slack, and it is well surrounded with metal, that the tooth or pins will most likely fracture before displacement will occur. (See wire loop on tooth pins, page 572.)

Still another method of increasing anchorage is by soldering to the pins a small loop of wire of suitable form to fit within the dovetailed space and be entirely enclosed within the metal.

Repair Involving the Substitution of Another Tooth

When in addition to being forced from the baseplate the tooth is fractured and rendered useless as well, another tooth must be selected for the repair. Since the chance is slight of finding a substitute of the same size, mold and occlusal form as the fractured tooth, the steps just outlined, although in the main applicable, must be varied somewhat to insure correct alignment and satisfactory occlusal conditions in the completed repair.

In the methods previously outlined, the position for and occlusion of the displaced tooth was found by returning it to the vulcanite socket in which it rested before displacement and of holding it there with wax, if necessary, while a satisfactory matrix was secured. This plan is not applicable in case a new tooth is used, because it will seldom fit in the old socket. In full denture cases, and in some partials as well, the denture is returned to the patient's mouth and a wax or modeling compound *mash* bite is secured, involving the space to be filled, the proximating and occluding teeth.

In case of complicated occlusion, the denture and bite should be transferred from the mouth to the occluding frame with the face bow, mounted, and the bite filled with plaster to develop the occluding teeth, after which the bite material is removed.

In uncomplicated cases the bite may be filled in with plaster and an extension at the same time be made lingually so as to cover definite areas on the lingual surface of the denture, or it may even extend across the entire baseplate, the point of importance being to have a sufficient number of guides to bring the occluding plaster teeth into normal relation with those of the denture when the bite material is removed.

The old socket is now burred out in its interior, and the lingual side cut away to receive the new tooth. Care should be taken not to disturb the gum margin and further complicate the repair. In fitting the substitute tooth in place the procelain itself can, in many cases, be ground to fit the socket on the gum side of the denture. Usually, however, a little careful trimming of the vulcanite socket, together with a little grinding of the tooth, will develop a satisfactory joint, that will not require the addition of new gum material.

Preliminary Dovetailing of a Denture Base

In partial dentures, where an isolated tooth is to be replaced, it is frequently advisable to prepare the dovetail form on the baseplate for the reception of the new rubber before taking the bite. By so doing the danger of mutilating or breaking the proximating plaster teeth when the cast is run up will be obviated.

A small wax bite is now taken, involving the space to be filled, the proximating teeth and the opposite occluding teeth. The denture and bite should be removed together, if possible, to obviate danger of distorting the latter. If for any reason the bite and denture are separated in removal, they should be carefully fitted together and held firmly by melting some of the bite wax at various points against the denture.

The cast is now formed in the united denture and wax, and when hardened, the opposite side is run up. The occlusion cast should extend over onto the palatal surfaces of the denture so that it may be guided to place when the wax bite is removed.

On removal of the wax a suitable tooth is selected, ground, tested for occlusion, waxed in place, and the case flasked, packed and vulcanized in the usual manner.

Sometimes the neck or vulcanite connecting an isolated tooth with the denture base must, on account of the occluding teeth, be so reduced in thickness as to invite ready fracture

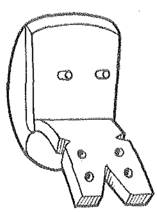


Fig. 446.—A Plate Tooth Backed with Gold, to Which a Clasp Metal Extension Is Applied for Enclosure Within the Vulcanite

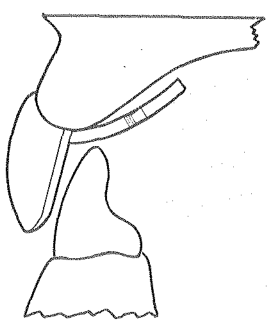


Fig. 447.—Side View of a Backed Plate Tooth in Position

under stress, an accident which frequently occurs, in partial dentures carrying upper anterior teeth. To repair such a case, one of two methods must be adopted, either the opposing tooth must be shortened to make room for greater bulk of vulcanite, or a plate tooth must be selected, ground to position, backed with gold and a strip of heavy clasp metal abutted against the backing to which it is attached with solder. This strip should lie close against the maxillary surface, yet not quite in contact with it, and extend lingually so as to be enclosed in the vulcanite. Two or three holes should be punched in the extension, or its edges should be notched with a file to afford anchorage in the vulcanite which encloses it. The clasp metal strip must be sufficiently broad and thick to withstand heavy masticatory stress without bending, or, if of light gauge, it may be stiffened by flowing solder over it.

This plan of backing a tooth with metal and attaching to it a lingual extension in close bite cases is often resorted to in the initial construction of the denture when the bite is exceptionally close.

Substituting Artificial for Lost Natural Teeth in Partial Cases

It frequently occurs that when a partial denture has been worn for some time, one or more of the remaining natural teeth, through accident or as the result of disease, are lost.

If the adaptation and general requirements of the denture are satisfactory, aside from the conditions noted, re-

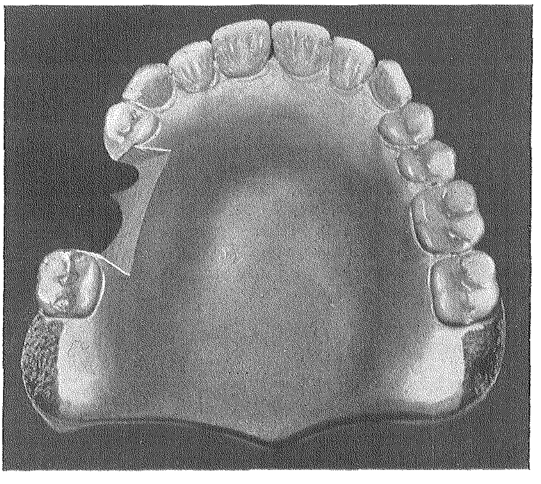


Fig. 448.— Denture Base with Dovetail Prepared for Addition of Two Bicuspids

placement of the lost with artificial teeth may be readily accomplished by the following method:

With a file or engine burs form a dovetail in the baseplate to the lingual of the space to be filled. In case the border in which the natural teeth were situated has absorbed, the baseplate should be cut back to a point where its maxillary surface rests upon the mucous tissues, thus permitting the new vulcanite to join the old baseplate and form a continuous bearing surface over the absorbed area. In such cases a long bevel splice will prove more serviceable than the dovetail method.

The denture, having been cut out as described, is returned to the mouth and a mash bite is taken, being careful to press the wax or compound firmly against the labial or buccal absorbed areas, and to secure an accurate impression of the occluding teeth.

On removal of the bite and denture they should be carefully adjusted and luted together, and the subsequent steps carried out as described under the "repair of partial dentures."

Repairing Gum Section Cases

When one of the sections of a gum section denture has been fractured beyond the possibility of further usefulness, a new block must be selected that will conform as perfectly as possible to the broken section in form, size, color, length of bite and curvature of the labial or buccal surface.

Usually this is a difficult matter unless the prosthetist is fortunate in securing a block of the same manufacture, mold and shade. In repairs of this class the vulcanite in which the old pins are enclosed should be freely cut away, the denture introduced in the mouth and a bite taken. The case is then mounted on the occluding frame and the block selected and ground to fit the ends of the proximating sections. The block, if thick, may need grinding or dressing down on the surface that approximates the baseplate, or the vulcanite itself, if of sufficient thickness, can be reduced with burs to permit the block to settle into correct labial or buccal contour position. Special care should be taken in grinding the joints to hold the block in correct alignment when testing.

Subsequent steps are carried out as outlined in the repair of a single tooth.

Substitution of a Baseplate

Although the adaptation of a denture may be satisfactory, and its occlusion correct, yet, because of frequent repairs which have deteriorated the quality of the vulcanite, or because of some peculiar fracture which renders impossible a satisfactory repair, a new baseplate may be substituted for the old vulcanite by the matrix method in much shorter time than is required to reconstruct the case in the usual way. The procedure is as follows:

CONSTRUCTION OF THE MATRIX

The baseplate, if fractured, should be reassembled and the several parts held in proper relation by means previously described, "Repairing a Fractured Baseplate."

Oil the denture with a thin film of vaseline and develop a cast sufficiently deep to raise the peripheral margin of the denture about three-eighths of an inch above the base bottom and smooth its outer surfaces.

Countersink the buccal walls of the cast at two points on each side so that the matrix, when formed and removed, may be returned to proper position again. Varnish the outer surfaces with a separating medium.

Oil the outer surfaces of the teeth and gum restoration; make a mix of and apply plaster to the buccal and anterior walls of the cast and denture surfaces, extending from the median line to the tuberosity on one side and from the base up over the incisal and occlusal surfaces of the teeth. This addition, which, when completed, forms one-half of the matrix, should be about three-eighths of an inch in thickness.

When the plaster forming this portion has set, the mesial end is squared up, a countersunk depression made in the planed surface, the latter varnished, and a second application of plaster is applied in a similar manner extending back to the tuberosity on the opposite side.

When hardened, the outer surfaces of plaster are smoothed up, and with a few light taps of the hammer on the sides and base of the matrix, it will come away in two pieces.

REMOVAL OF THE TEETH FROM OLD BASEPLATE

The teeth are now removed from the old vulcanite, one at a time, being careful to card them on wax in regular order so as to avoid confusion in their arrangement.

Each tooth is now thoroughly cleaned, the old vulcanite, if any remains, is removed from around the pins and the tooth returned to its position in the matrix.

Should any tooth become disturbed or fall out of place in raising the matrix to an upright position, a little liquid silex touched to the labial or buccal surfaces will, on returning the tooth, under pressure, retain it firmly in place.

FORMING THE WAX BASEPLATE

A sheet of wax is now applied to the cast surfaces and trimmed peripherally so as not to interfere with the plaster matrix being carried to exact position against the cast surfaces.

Each half matrix is then returned to position against the sides of the cast and brought in contact anteriorly, being guided and held in place by the projections of the matrix fitting into the countersunk holes of the cast. Usually a string is wound several times around the matrix and cast and tied tightly to hold all firmly together, or a heavy rubber band applied peripherally will be more convenient to apply and serve the purpose equally well.

The teeth, each one in its individual matrix, and the two halves of the matrix in correct position against the cast, now bear the exact relation to the cast surfaces that they did before removal of the vulcanite.

Softened wax is pressed into the space between the teeth and cast, and the general contour of the case developed as it was before the removal of the old base.

A heated spatula is now passed under the pins and along the ridge lap of each tooth, as well as into the interproximal spaces and embrasures, to firmly cement the teeth to the wax base, so that they will not be disturbed or come away with the matrix when the latter is removed.

Care should be taken not to touch the matrix walls with the heated spatula, or in any manner melt the wax against these surfaces. Should this occur not only the adherent wax, but some of the teeth are liable to come away with the matrix.

To obviate the union of the wax with the matrix, the latter can be coated with a thin film of oil after the teeth are in place and just before assembling the parts of the matrix to the cast. Care should be taken not to apply any oil to the teeth.

The string or band is now removed and the matrix is gradually and carefully worked free, so as not to disturb the position of the teeth in the wax. Each tooth should now be tested to see that it is still firmly adherent to the wax. A further test can be applied by returning the matrix to its former position.

The wax model denture is now smoothly finished, flasked, packed, vulcanized and finished in the usual manner.

In planning the reconstruction of the case, should it be deemed advisable to test the denture in the mouth, Ideal or some unyielding baseplate should be applied to the cast instead of the ordinary wax.

Modified Methods of Reconstruction

A somewhat simpler, but less accurate, method of substituting a new for an old baseplate frequently resorted to is as follows:

Thoroughly clean the denture, oil the palatine surface and secure a cast.

MOUNTING CAST AND OLD DENTURE ON THE OCCLUDING FRAME

Mount the cast and denture on the occluding frame in as nearly the normal position as possible without the use of the

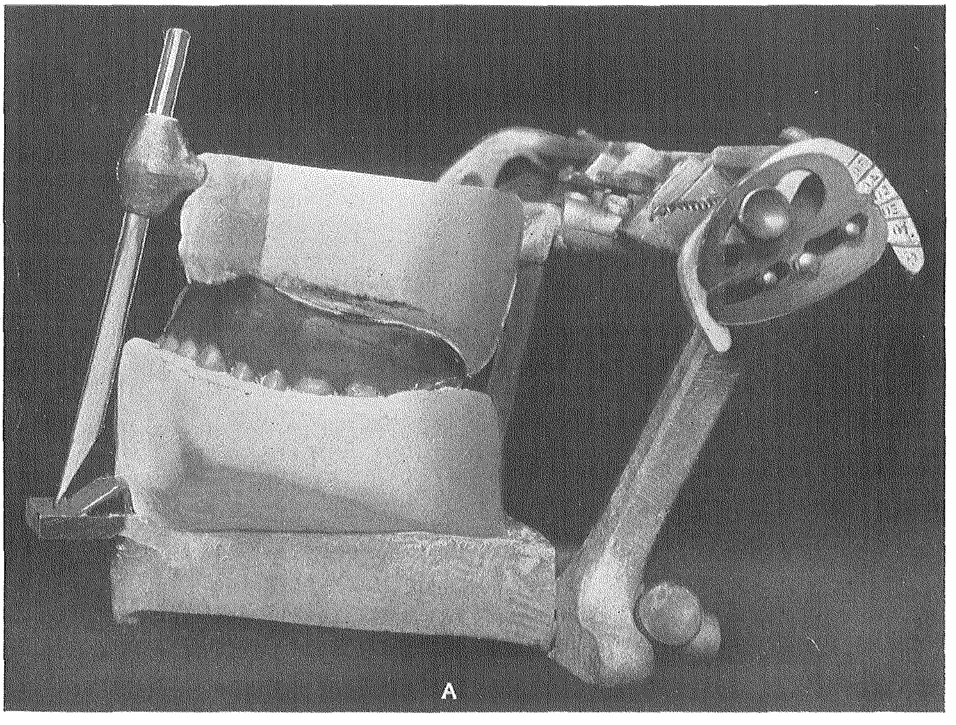


Fig. 449.— Upper Denture Mounted on Occluding Frame. Teeth Embedded in Plaster Matrix

face-bow. An occluding frame with an incisor guide pin is preferable, as such an appliance obviates springing of the bows in the subsequent steps.

FORMING THE MATRIX

Turn back the upper bow on which the case is mounted and apply a mix of plaster to the lower bow, building it up sufficiently high for the teeth of the denture to enter. (See Fig. 449.)

Drop the upper bow down and press the teeth into the plaster so that all exposed portions of porcelain are covered. It may be further extended against the labial and buccal gum surfaces, although this is not usually necessary. The set

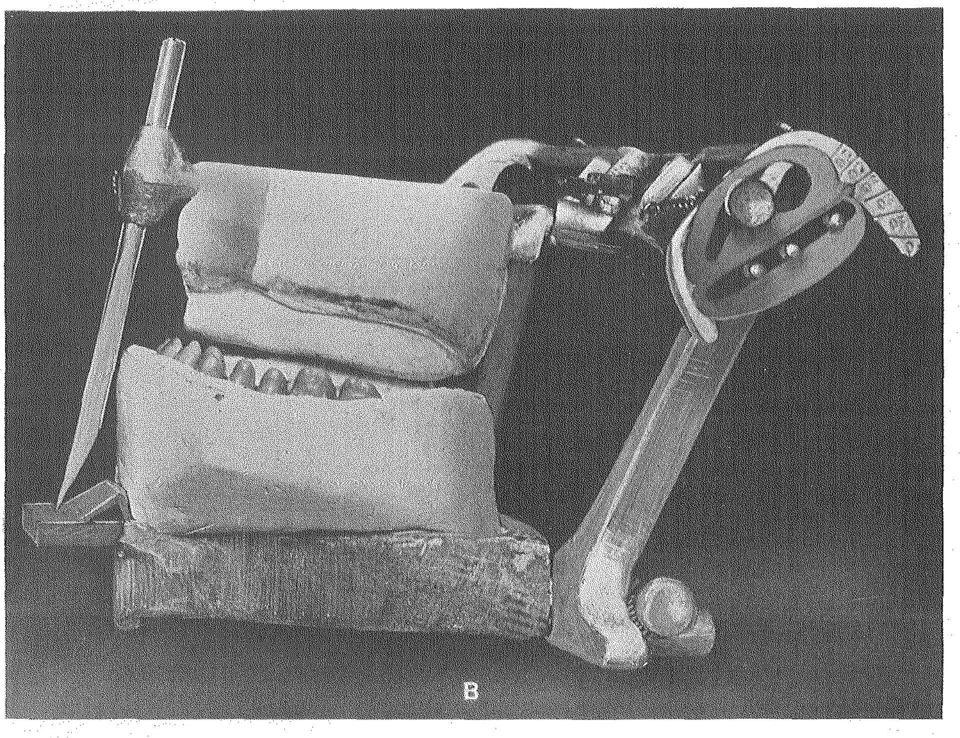


Fig. 450.— Preceding Case with Old Baseplate Removed and Teeth Returned to Their Respective Matrices

screw at the back of the frame, or the incisor guide, should be firmly fixed so as to hold the upper and lower bows a fixed distance apart after removal of the old baseplate.

FORMING THE WAX BASEPLATE

When the plaster has set, carefully separate, remove the teeth from the old baseplate and return them to their respective positions in the matrix. (See Fig. 450.)

A baseplate with roll of wax is adapted to the cast, the wax warmed slightly, and the upper bow of the frame closed so as to force the wax against the teeth in the matrix.

That portion of the matrix enveloping the outer surfaces of the teeth is cut away, so as to allow the teeth now attached to the baseplate to part from the matrix without interference, after which the case is waxed and the subsequent steps are carried out as usual. (See Fig. 451.)

The weak point of this method is in the liability of the frame springing in pressing the teeth into the wax and thus

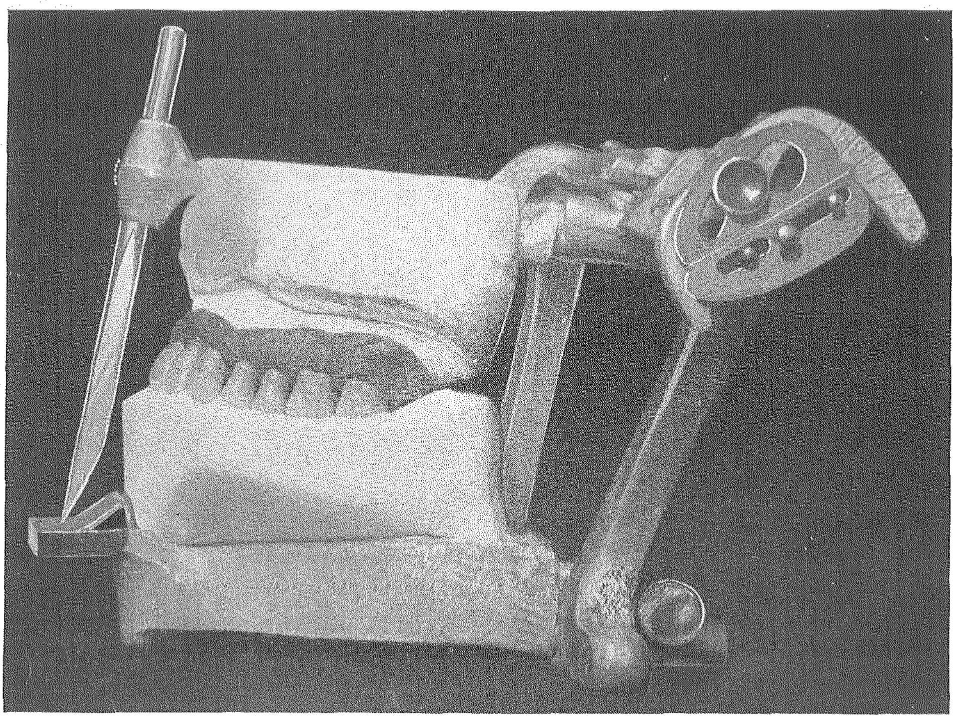


Fig. 451.— Same Case, Showing Teeth Waxed to Cast. Outer Portion of Matrix Cut Away to Release the Teeth

shortening the bite. Such an error cannot well occur when the incisor guide pin is used.

Correcting Imperfect Adaptation by Substitution of a New Base

When the adaptation of a denture has become impaired, but the teeth which it carries occlude and interlock well with those in the opposite arch, adaptation may be restored by several methods, the first of which is as follows:

Thoroughly clean the denture with a stiff brush wheel and pumice stone. Remove from the entire palatine and border surfaces a thin layer of the old vulcanite by means of a small lathe bur or a large surgical bur in the engine.

Apply a thin layer of well-mixed, but rather thin, impression plaster over the entire interior of the vault and border surfaces.

Introduce in the mouth and instruct patient to bite intermittently at first, then with steady, maintained pressure to compress the tissues, bring the denture into correct occlusion and force out all excess plaster.

When hardened, trim off peripheral excess, relieve pressure over hard areas by scraping, coat impression with separating medium, secure a cast and mount it on the occluding frame in the usual manner.

Either one of the methods previously described may be adopted for securing the correct relation between the teeth and cast, so that on removal of the old vulcanite the alignment and occlusion of the teeth in the wax model may be correctly established.

When the matrix for the teeth is formed, the denture is first removed from the latter, then from the cast, the surfaces of which are then cleared from any remaining portions of the plaster impression.

The steps from this point forward are the same as those already outlined under the head of "Substitution of a Baseplate," page 579.

Correcting Adaptation by Addition of New Rubber to Old Base

When the impression has been secured in the manner described above and the cast secured, the case may be flasked immediately; when the investment plaster has set, the flask is separated, the plaster is removed from the impressed areas, and the exposed palatine and border surfaces of the denture thoroughly freed from all debris.

All exposed areas of the baseplate not previously already freshened, and to which new vulcanite is to be added, should be renewed by scraping, these areas covered with a thin film of rubber cement; a sheet of new rubber is cut to correct size and carefully pressed against the old baseplate, being careful not to confine the air between the two surfaces.

The two halves of the flask are now adjusted, the screws tightened slightly and the flask contents heated to about 200 degrees F., dry heat, when gradual, but not excessive pressure is applied to force out the excess rubber.

When closed the flask is separated, the muslin removed and the result of the work so far accomplished noted. Should there be an insufficient amount of rubber, more is added and the flask finally closed and vulcanized and the case finished as usual.

Previous to the application of the rubber cement, an ample waste gate should be cut close to and around the entire periphery of the denture, but not connected with the margin of the matrix at any point, to receive the excess rubber.

Correcting Adaptation by Means of Rubber Paste

Bur out and freshen the surfaces of the baseplate as above outlined and apply a film of Bridgeford's rubber paste, a solution of rubber heavily loaded with powdered aluminum. Thickness of the film applied varies, depending on the amount of old vulcanite removed and the extent of absorption of the border that has occurred, but usually from one to one and a half millimeters will be sufficient.

The denture with paste applied is immersed in cold water for an instant to chill it slightly and also to prevent it adhering to the oral tissues.

On introduction into the mouth, the denture is pressed to place for a moment, removed, the excess around the margins brushed off, the case dipped in cold water and again returned to the mouth for further adaptation by closure on the part of the patient, as well as reapplied pressure on the palatine areas by the operator.

These steps are repeated three or four times, or until satisfactory adaptation is secured, when the denture is removed, freed from excess and set aside for a short time to allow the volatile constituents time to evaporate, when the case is flasked in a single investment and vulcanized.

To Renew the Adaptation of a Denture by Means of Furlong's Plastic Rubber

Prepare the palatine and border surfaces of the denture by freshening as outlined in the first method described.

Apply to these surfaces a sheet of Furlong's Plastic Impression Rubber, pressing it well against the old vulcanite, being careful not to confine any air between the surfaces.

The plasticity of this rubber is increased and its impression quality improved by immersing it in warm water for an instant before introducing in the mouth. Apply pressure as when using Bridgeford's paste. When satisfactory adhesion has been developed, the excess is removed and the denture is flasked in a single investment, vulcanized and finished in the usual manner.

To Correct Occlusion When Denture Adaptation Is Satisfactory

It sometimes occurs that a patient may persistently maintain an incorrect bite in trial of the contour models and of the wax model denture in the mouth, and the error only be discovered when the cases are finished.

The result is that the occlusion is incorrect, the teeth of one of the dentures occupying a position a little forward in upper and backward in lower cases, or to one side of the normal alignment.

The best plan, as a rule, is to reconstruct one or both dentures, beginning with a new impression and carrying out the usual steps in such cases.

When, however, the adaptation of the denture to be reconstructed is in every way satisfactory, equally good results may be attained, with minimum inconvenience to both patient and operator by adopting the following method:

With a small engine bur cut the vulcanite from around the pins and remove the teeth.

By means of a vulcanite file and the emery cloth band on the lathe, sufficient vulcanite is removed to permit the shifting of the teeth to proper position without interference. The entire outer gum surfaces should be removed so that in the completed case no joints or lines of junction will be visible, a layer of new material having replaced the old.

The case now presents the same conditions as does the one in which the double vulcanization method is followed, the old base, denuded of teeth and surrounding vulcanite, serving as a foundation on which to construct the wax contour model. On this base the teeth are waxed and occluded and the subsequent steps carried out in the usual manner.

CHAPTER XXVI

CONTINUOUS GUM DENTURES

From an esthetic, as well as hygienic standpoint, continuous gum dentures fulfill most perfectly the requirements of substitutes for the lost natural teeth. They are most strongly indicated in full cases, although at times partial dentures of this type will prove very serviceable.

ADVANTAGES

Continuous gum dentures possess two important advantages over dentures of any other type.

First, they are absolutely impervious to moisture, exempt from chemical action to which dentures are ordinarily subjected when in use, and afford but little opportunity for the lodgment and retention of food; consequently they are easily kept clean and free from decomposing food and from the odors of ptyalin and retained saliva.

Second, the gum surfaces, being composed of glazed porcelain enamel tinged with pink, present an unbroken or *continuous gum* surface free from joints, fissures, or cracks of any character, and which is united to the underlying vitrified porcelain, the teeth, and to the peripheral margins of the baseplate by fusion.

When the denture is properly constructed and the gum enamel artistically applied, it is impossible in most cases to detect the fact that the substitute is artificial.

DISADVANTAGES

The principal objections urged against dentures of this type are as follows:

First, excessive weight, particularly in upper cases where much absorption of the border has occurred.

Second, difficulty in construction, from warpage of the entire denture due to shrinkage of mass in fusing the silicious material around the teeth and to the base; to the formation of fissures in the underlying body and in the enamel in the final baking; to the tendency of the mass of porcelain to become porous at any stage of fusion after the first baking.

Third, dentures of this type are liable to fracture if carelessly handled, because of their excessive weight and the friability of the materials of which composed.

Fourth, the expense of time and material involved place them beyond the reach of persons of limited means.

In regard to the first objection, when good adaptation of the denture is secured and the teeth are arranged anatomically, the weight of the denture is seldom noticeable to the patient.

The second objection can be overcome by patient attention to details on the part of the prosthetist.

The third objection more especially concerns the patient, who, however, if properly instructed, can usually avoid accidents.

The fourth disadvantage is an important one to both patient and prosthetist. The patient must of course decide whether a denture of this type is within his means. The prosthetist, on the other hand, must exact such fee as will cover the cost of the materials and recompense him well for all possible time involved in constructing the case. Oversight in this particular is responsible for many failures in the class of work under consideration, the tendency being to rush the constructive details to their detriment, or turn the case over to someone who may prove incompetent.

In no department of prosthetics is there an opportunity for the display of greater skill, or the realization of finer esthetic results, than in the planning and construction of dentures of this type. There is first, the development of a well trussed, yet light, platinum baseplate; second, the arrangement of the teeth anatomically, as well as esthetically; third, their attachment to the baseplate by soldering, and bracing when necessary, in such manner as to remain unchanged during the contraction of the porcelain in fusing; and finally, the application of the porcelain body, and subsequently, the enamel so disposed as to represent nature's best efforts in contour gum effects and vault irregularities.

Formerly dentures of porcelain were constructed without metallic bases, but on account of the shrinkage which invariably occurred in baking, adaptation was seriously interfered with, or entirely destroyed. As a result corrections had to be made by the method mentioned elsewhere of securing a new cast of the mouth, pigmenting its surface, and by repeated trials of the denture to the cast, locating the high points, which were then ground away until close adaptation was secured. The grinding of the glazed surfaces exposed many minute spaces, and left the porcelain more or less rough and porous.

A further objection to the all-porcelain denture was that unless formed thick and somewhat bulky, it was liable to fracture with usage in the mouth.

About 1855 Dr. John Allen of New York, introduced the method of attaching the teeth to a platinum base and fusing the porcelain around them. By this means warpage of the denture during baking was to a large extent obviated. This is essentially the method in vogue today, the constructive details of which are as follows:

FORMING THE PLATINUM BASEPLATE

From an impression of the mouth a model is secured. A die and counterdie are formed in the manner elsewhere de-

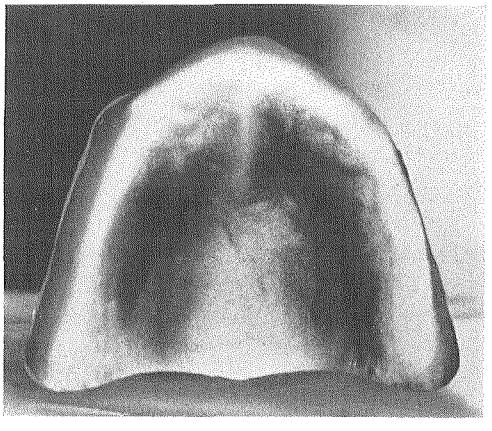


Fig. 452.— Platinum Baseplate, Swaged and Trimmed to Approximately Correct Peripheral Outline

scribed, and a pattern of the baseplate obtained. Usually pure platinum, No. 28 gauge, is used, since a thinner plate, unless heavily reinforced, will not furnish a sufficiently rigid foundation to prevent warpage of the porcelain during baking, or obviate fracture of the finished denture under stress.

In the swaging of a platinum baseplate special care should be taken to avoid the formation of folds in any location, since if subsequently corrected by flowing solder into them, and reducing the excess by grinding, an unsightly area is left due to difference in color of solder and baseplate.

FITTING THE BASEPLATE IN THE MOUTH

When swaged and trimmed peripherally, the base should be introduced in the mouth and tested as to general adaptation and stability. All margins which impinge on the muscles or frenum should be corrected, and the peripheral outline of the baseplate trimmed to as nearly the exact outline of the finished denture as possible. This is necessary in order to avoid the unsightly appearance caused by grinding away the metal rim, often into the porcelain, to relieve impingement when the finished denture is introduced — a condition frequently seen in cases where proper care has not been exercised in peripheral trimming of the baseplate.

REINFORCING THE BASEPLATE

Since porcelain in thin layers is easily fractured, the metal framework of dentures and bridges which are to be overlaid with this material should have sufficient inherent strength,

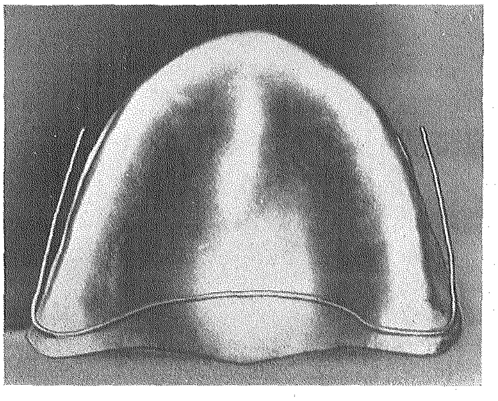


Fig. 453.— Distal Shoulder Wire Adapted to Platinum Baseplate. This Wire Should Be 20 to 22 Gauge, and Terminate About the Center of Each Tuberosity

exclusive of the added porcelain, to withstand all stress to which they may be subjected.

A platinum base may be strengthened in several ways, the most common methods of which will now be given:

First, to strengthen an upper baseplate, a platinum wire of 22 to 24 gauge is adapted and soldered to the lingual side of the baseplate near its distal margin. It should be laid in a symmetrical curve, and advanced further forward in the vault portion than at either side. The object in placing the two ends near the margins at their terminal points on the tuberosities is to afford some space for a graceful curve to the porcelain in its extension distally from the second molars.

Over this wire a second strip of platinum, usually 31 or 32 gauge, is swaged to the plate. The anterior margin of this strip should overlap the wire anteriorly, and the posterior margin extend slightly beyond the distal margin of the baseplate, to afford a shoulder on which to lay the solder. When

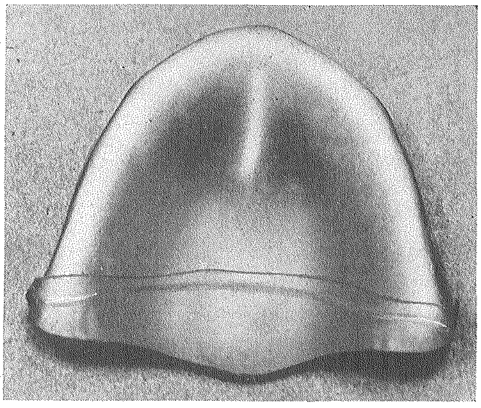


Fig. 454.— Doubler of 30 or 31 Gauge Conformed to Baseplate and Wire

swaged, the anterior margin of the strip is trimmed to the anterior surface of the wire and the two ends cut so as to terminate on the tuberosities and even with the underlying wire.

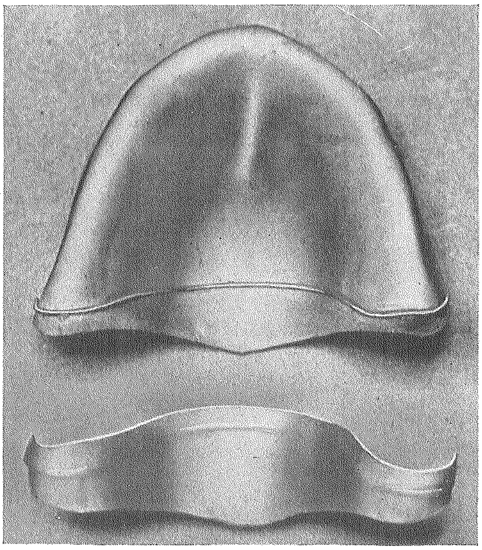


Fig. 455.— Doubler Removed from Baseplate for Final Trimming

In addition to the doubler just described, a second doubler is sometimes swaged and trimmed as illustrated, to overlay the border and extend into the palatine area. It should not extend much beyond the crest of the border either labially or incisally; first, because it is not necessary for strength; second, the space it would occupy if extended can be best conserved for increasing bulk of porcelain; third, unnecessary metal adds to the weight of the denture. (See Fig. 457, page 594.)

Instead of the doubler just described, some prefer to adapt and solder a piece of 16 or 14 gauge iridio-platinum wire

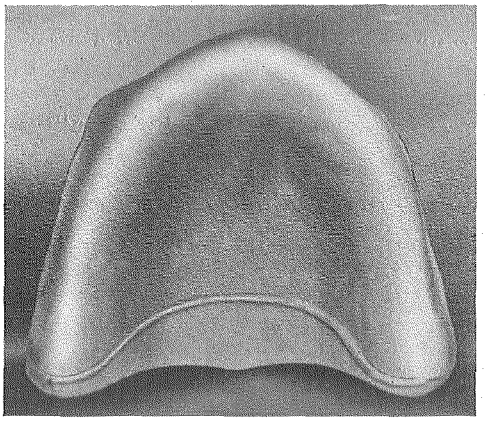


Fig. 456.— Doubler Trimmed and Soldered to Baseplate

along the crest of the border in such position as not to interfere with correct tooth alignment.

The doublers, of whatever form, should be firmly attached to the baseplate with high-grade platinum solder, and the base reswaged to correct any warpage that may have occurred.

FORMING THE FINISHING SHOULDER FOR THE PORCELAIN

It is necessary in order to avoid fracture, to form a right-angle shoulder around the entire periphery of the base, against which the porcelain may settle in fusing. The anterior margin of the doubler and underlying wire, when squared out with small stones and burs, constitute the distal shoulder, while that on the labial and buccal periphery is formed on these surfaces by soldering a wire of about 18 gauge to the baseplate.

One end of the peripheral wire should abut the doubler and wire on one tuberosity, and be bent to lie in contact with the baseplate rim for a distance of about an inch anteriorly. It is then clamped in position and attached with solder throughout a portion of this distance, and the plate cooled. The adaptation of the wire and attachment with solder should proceed in sections, rather than to attempt to adapt and clamp it around the entire periphery at the start.

The wire should be parallel with the periphery of the baseplate rim, but be placed about one-sixteenth of an inch from it, so that subsequent trimming, if necessary to relieve muscular impingement, may be accomplished without encroaching on the porcelain.

Extensive contouring of the solder in the space on the peripheral side of the wire should not be attempted, as pits are liable to develop in bulky masses of platinum solder during the fusing of the porcelain. The angle, however, should

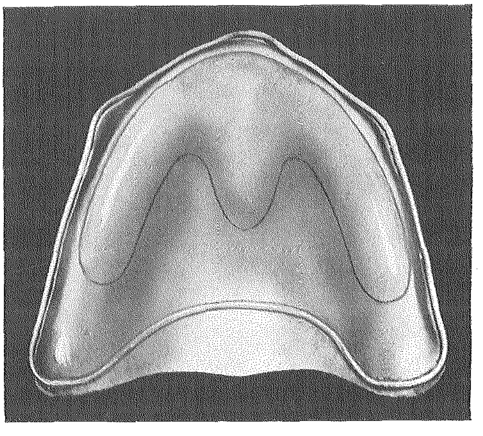


Fig. 457.— Baseplate with Peripheral Wire Attached. Also a Strengthener Adapted to Border Areas

be filled in to develop a uniform, but slightly tapering or concave surface.

The angle between wire and baseplate presenting toward the crest of the border should not be filled to any extent with solder, since this surface of the wire must subsequently be squared out in forming the shoulder.

Small square-edged carborundum stones are now applied to the wire to develop a square shoulder against which the porcelain may be fused. Plug-finishing burs are also useful for this purpose. The shoulder should present a definite angle around the entire periphery of the base, for if left round at any point a crease may form by the contraction of the porcelain, or the latter may overlap the rounded surface of the wire forming a thin edge and be fractured in handling.

The soldering is best accomplished by means of nitrous oxid and gas blow-pipe, or when pure gold is used as a solder the ordinary gas blow-pipe may be employed. Platinum solder is preferable to pure gold, as it is not dissipated during the several bakings of the porcelain as is pure gold, the latter being absorbed by the platinum at high temperatures. Frequently joints united with pure gold as a solder pull apart during baking, or under slight stress when the finished piece is introduced in the mouth.

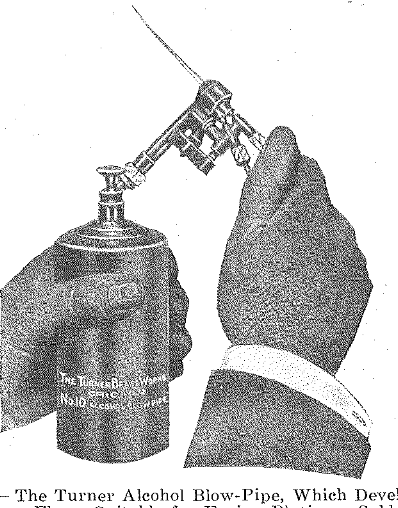


Fig. 458.— The Turner Alcohol Blow-Pipe, Which Develops an Intense Flame Suitable for Fusing Platinum Solder

RESWAGING AND CLEANSING THE BASEPLATE

The doubler and peripheral shoulder wire having been attached by soldering, the baseplate should be reswaged to correct the warpage that may have occurred during this operation.

To prevent the baseplate from becoming lodged in the counterdie in swaging, due to the peripheral shoulder wire being driven into the sides of the latter, a few layers of damp newspaper can be interposed between the two. The die and counterdie should at all times be kept oiled to prevent contamination of the platinum by the base metals. In addition to this precautionary measure the baseplate should be boiled in dilute acid and thoroughly polished on the lathe with a stiff brush wheel and pumice stone, to prevent any possible danger from this source.

DEVELOPING THE OCCLUSION AND CONTOUR MODEL

The baseplate is now in condition to receive the rim of wax, by means of which the occlusion and facial contour is established. The steps from now on are exactly similar to those described under the head of *Full Denture Construction* up to that of permanently attaching the teeth to the baseplate, with the exceptions resulting from the use of a special type of tooth for these cases.

CONTINUOUS GUM TEETH

Teeth intended for continuous gum work differ from vulcanite teeth in having gingival extensions resembling roots.

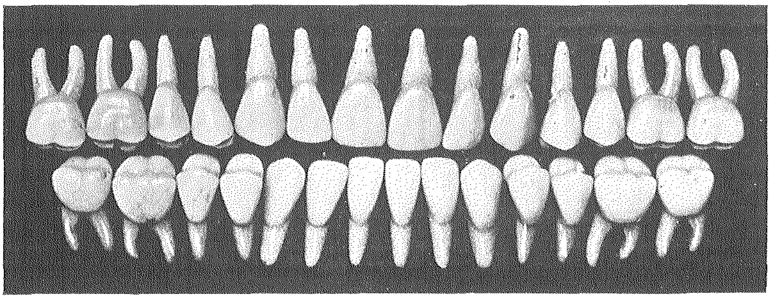


Fig. 459.— A Set of No. 28, Continuous Gum Teeth (Justi)

These extensions are flattened somewhat on their lingual surfaces to obviate excessive grinding in aligning the teeth on the baseplate.

These root extensions serve two very useful purposes; first, being composed of high-fusing porcelain which is unaf-

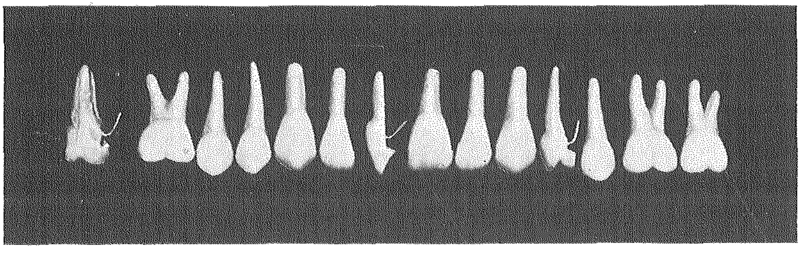


Fig. 460.— A Set of No. 14, Continuous Gum Teeth, Molar, Central, and Bicuspid, Turned to Show Long, Single Pins. (S. S. W.)

fected by contractile changes during vitrification of the continuous gum body, the bulk of the latter required for the case is materially lessened, and shrinkage of the denture mass is proportionately reduced; second, in addition to the long pin attachment of the tooth to the baseplate, the extension serves to increase stability by resting upon the baseplate, thus obviating the danger of displacement due to contraction of the body during baking.

When but slight absorption of the ridge has occurred, it is frequently necessary to grind away a portion or all of the extension, thus bringing the body of the tooth directly in contact with the baseplate, much as the ridge lap of an ordinary vulcanite tooth is frequently set in contact with its baseplate, or sometimes upon the cast itself.

In other cases when excessive absorption of the ridge has occurred and the correct labial, buccal and occlusal alignment of the teeth have been secured, these extensions may fail to touch the baseplate at any point. It then becomes necessary to interpose blocks of high-fusing porcelain, as pieces

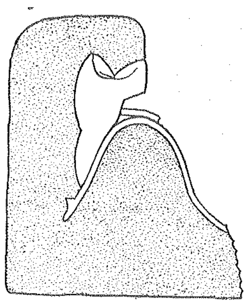


Fig. 461.— Case Requiring Considerable Reduction of Lingual Side of Root

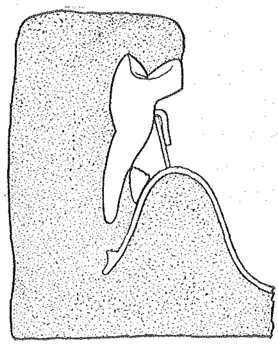


Fig. 462.— Case Requiring Adjustment of Broken Pieces of Porcelain Between Teeth and Baseplate

of broken teeth, between the baseplate and the extensions not in contact, or to truss them in proper position with platinum wire or plate. In addition to the difference in form noted, continuous gum teeth are supplied with single platinum pins, larger and longer than those ordinarily used in other types of teeth.

SELECTION AND ARRANGEMENT OF TEETH

Teeth of suitable form, size and shade to meet the requirements of the case having been selected, they are let within the wax rim by successively cutting out sections of the latter of sufficient depth to permit each tooth, with its extension, to assume proper alignment. No attention need be given the relation of the extension end of the tooth to the baseplate during arrangement, except when its length or lingual surface interferes with correct placing of the tooth, when it may be reduced by grinding, or entirely excised, as conditions require.

The steps of arrangement and occlusion of full upper and lower cases of this type are carried out in other respects the same as for full dentures in general. When the teeth are occluded the denture should be waxed up labially and buccally to represent the natural gums, with such added contour as may be required for facial restoration. This step is seldom carried out, but more esthetic results can be produced by following this plan than by developing the contour without definite guidance.

TRIAL OF THE WAX MODEL DENTURE IN THE MOUTH

When properly contoured, the denture is tested in the mouth, first as to normal occlusion; second, as to clearance paths in lateral movements; third, balancing contact; and fourth, general esthetic results. When corrections have been made, if necessary, and the prosthetist is satisfied that all required conditions have been fulfilled up to this stage of construction, the next step is to prepare a guide for testing the labial and buccal contour of the case at various stages of construction.

DEVELOPING THE CONTOUR MATRIX

The entire labial, buccal and palatine surfaces of the wax model denture are now coated with a thin film of oil, a mix of plaster made, and a cast of ordinary form developed by

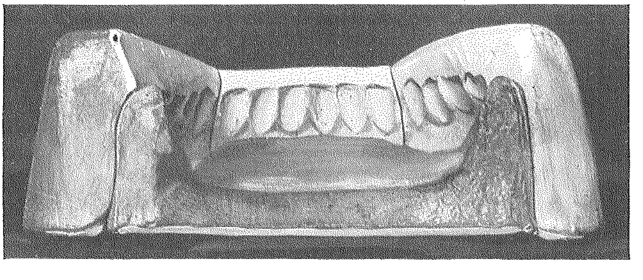


Fig. 463.— Four-Piece Matrix for Lower Denture. All Parts in Correct Apposition, the Denture Having Been Removed

filling in the palatine and border surfaces of the baseplate. This cast should be about $3/8$ inch thick in the vault region, or sufficiently deep to raise the peripheral margins of the baseplate about one-fourth inch above the base of the cast. The sides of the cast should be trimmed smooth, converging slightly from the base upward, to the outer peripheral line of the wax. At several points on the labial and buccal surfaces of the cast, shallow countersunk depressions are made to develop projections on the several sections of the labial and buccal matrix. This is necessary in order that any section of the matrix may be returned to position independently of the other pieces. The side of the base is varnished with shellac, which, when dry, is coated with a thin film of oil.

Plaster is now applied to one of the buccal surfaces and built against the base of the cast, the wax and outer surfaces of the teeth. It should not extend over the buccal marginal ridges or incisal edges of the teeth. This first section includes the area from the tuberosity back of the second molar to the middle of the cuspid tooth. It should be about three-eighths

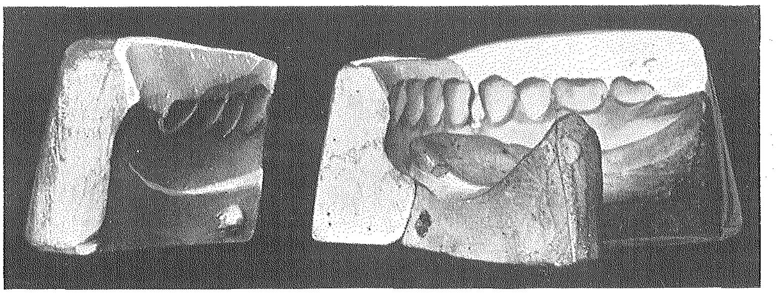


Fig. 464.— Four-Piece Matrix for Lower Case, Used for Testing Contour of Case During Construction Stages, Partially Separated

of an inch in thickness, its outer surface parallel with the buccal surface of the cast base and denture. When hardened the anterior end of this first section is squared up, varnished and oiled.

Another mix of plaster is now applied to the incisal area, building against the squared end of the first section and extending to the opposite cuspid tooth. When set, this section of plaster is trimmed, varnished, oiled, and the third piece corresponding to the first on the opposite side is constructed.

When the plaster has set the three sections are tapped slightly to loosen, then removed, and the wax model denture is detached from the cast. These are now set aside until after the application of the body in the second baking, when the baseplate is returned to the cast and the several labial and buccal areas are tested as to required fullness, or excess of applied body, by returning each section to position against the cast base. By sawing partly through any section at one or more points, cutting from without inward, it may be cleanly fractured into any number of required pieces, any one of which may be used for test purposes over its own particular area.

It is possible by calipering a number of prominent areas of the waxed case, and recording the same, to arrive at comparatively accurate results in the disposition of the gum body. The time required for measuring, recording, and later for reference, usually aggregates more than that required for forming a matrix, while the latter when suitably fractured will determine quickly the accuracy of many gingivo-peripheral surface contour lines.

These various steps having been completed, the case is now ready for investment, preparatory to attaching the teeth to the baseplate.

INVESTMENT OF THE WAX MODEL DENTURE

In continuous gum cases the teeth must be rigidly attached to the baseplate by soldering and trussing to prevent their relation, as established in the wax rim and by trial in the mouth, from becoming distorted by the contraction of the porcelain while fusing the latter. The steps are carried out as follows:

The wax representing the labial and buccal surfaces of the gums is removed from these areas and from between the embrasures and root extensions as well, so as to permit the investment to partially surround and hold the teeth when lingual support is removed. A mix is made of some standard investment material which possesses considerable hardness when set. A portion of the investment, about one-half inch

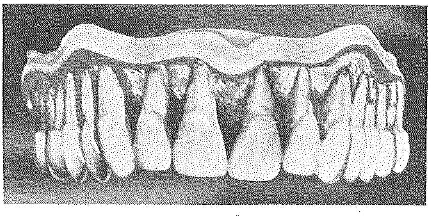


Fig. 465.— Continuous Gum Teeth Arranged on Platinum Baseplate. Wax Removed from Embrasures to Allow Investment Material to Enter These Spaces

thick and a little larger than the area of the baseplate, is placed on a sheet of paper on the bench. Another portion is filled in the palatine side of the platinum base and the latter pressed down upon that resting on the paper, until it approaches within three-eighths of an inch of the bench. The investment is then worked into the embrasures and over the occlusal and incisal surfaces of the teeth. To resist the more or less rough usage it will receive in applying the truss bars and soldering, the investment should be about three-eighths of an inch thick through the side walls. All overhanging portions should be removed from the occlusal and incisal surfaces,

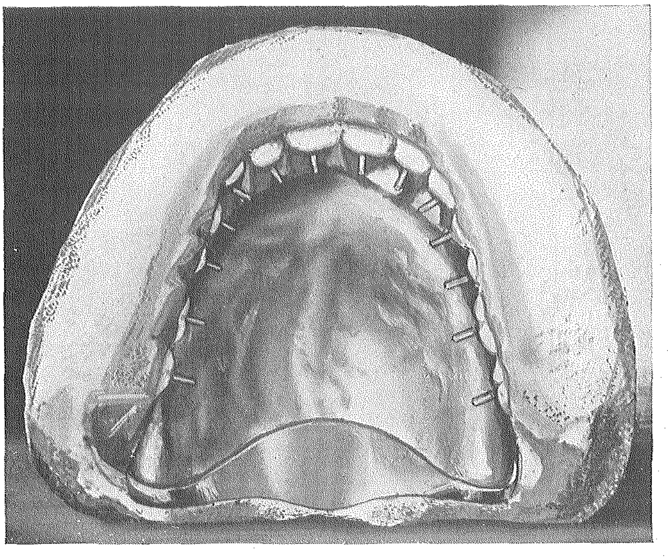


Fig. 466.— Teeth and Baseplate Invested. Wax Removed from Lingual Areas

to permit of ready access in bending the pins and soldering them to the truss or baseplate.

When hardened the rough excess of investment is trimmed away, the wax surrounding the lingual surfaces of the teeth in which the pins are imbedded is thoroughly warmed and removed — care being taken not to dislodge the teeth — the final trimming of all excess investment accomplished and the case thoroughly cleansed with a stream of hot water.

FITTING AND APPLICATION OF THE METAL SUPPORT TO THE TEETH

Occasionally cases present where the long pins of the continuous gum teeth can be directly applied and soldered to the platinum baseplate in such manner as to give all necessary support to the teeth. More frequently, when much absorption of the border has occurred, it is necessary to extend some kind of metal support from the border crest to the angle of junction of the pins with the porcelain. The Allen method, although not the best, is most frequently resorted to, and is as follows:

The platinum pins are straightened out at right angles to the long axes of the teeth. A strip of cardboard about four inches long is cut like the illustrated pattern, subject of course, to such modifications of form as the slant from the

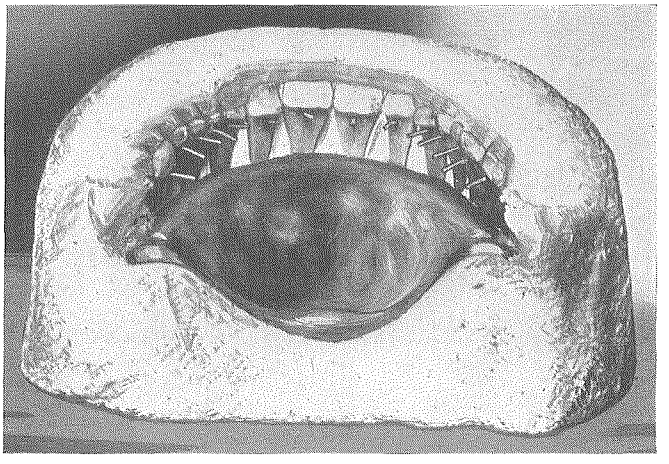


Fig. 467.— Invested Case Showing Pins Raised So Supporting Truss May Be Fitted

border to the pins and to the varying width of the space between the same at different points. (See cut on page 603.)

This cardboard pattern is corrected by trial, and reconstructed if necessary, until when finally fitted it exactly repre-

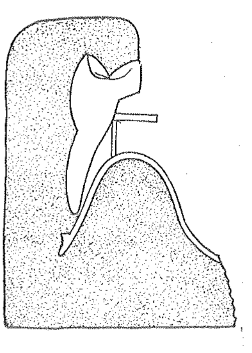


Fig. 468.— Sectional View of Tooth, Baseplate Metal Support and Investment

sents the form of metal strip to cut for the proper support of the teeth. The pattern as shown usually represents the segment of an ellipse. A metal duplicate of 30 or 31 gauge iridio-platinum plate is now made and bent to place. Marks are now made at various points on its lingual surface between the teeth, to indicate the position for punching the holes, the idea being to so place the holes that the pins when bent and soldered to the strip will not close them. The holes, usually about ten or twelve in number, should be located about midway between the border crest and the pin margin of the strip and

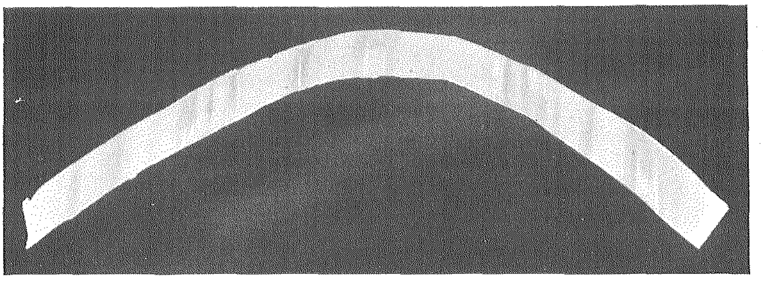


Fig. 469.— Paper Pattern of Metal Support for the Teeth

should be about one-sixteenth of an inch in diameter. At various points along the margin which rests on the border, crescent-shaped notches are cut in the strip. Through these various openings the labial and buccal portions of porcelain become more or less firmly united and under stress of masti-

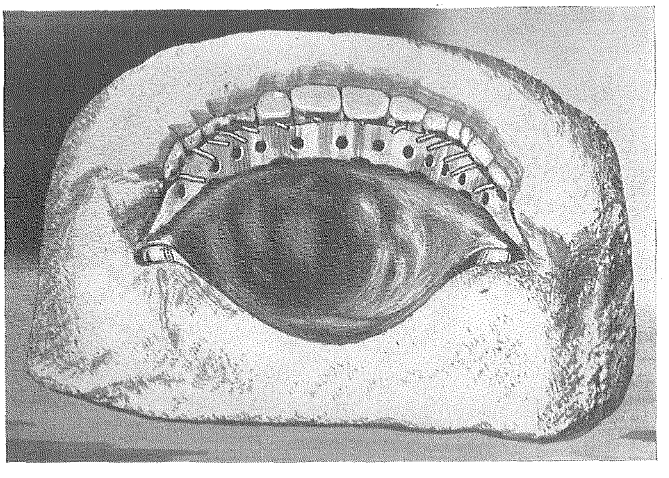


Fig. 470.— Metal Support, Trimmed to Fit, Adapted and with Holes Perforated

cation splitting of the denture is not so liable to occur as is the case when the openings are omitted.

It will readily be seen that a support so formed mechanically divides the denture into two portions, and is therefore a source of weakness, which after construction of the case, cannot be overcome. More recent and better methods will be shown for trussing and holding the teeth in position.

The holes having been punched and the notches cut as described, the strip is returned to position and the pins bent

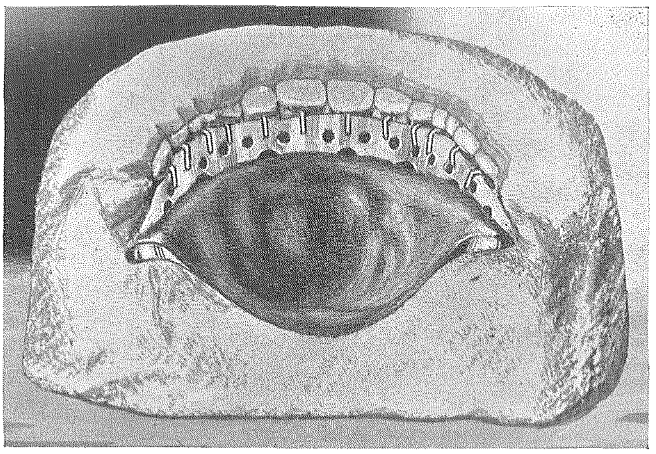


Fig. 471.— Pins Bent Closely to Metal Support. Case Ready for Soldering

down in contact with it, and the baseplate also if the space is not too wide.

The invested case is now placed on a Bunsen stove to thoroughly dry and become heated. Medium fusing platinum

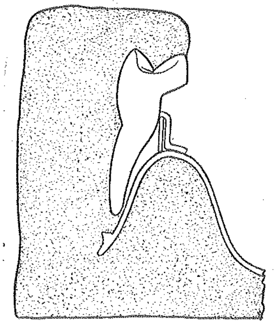


Fig. 472.— Section Showing Pin Adapted to Metal Support, and, in This Case, to the Baseplate as Well

solder is cut in small pieces preparatory to the final union of the many parts. When thoroughly heated, the invested case is placed on a solder block in such position that gravity will retain the solder in position in certain areas to which it is now applied. The nitrous oxid and gas blow-pipe previously mentioned is now directed on the solder placed, and when fused the position of the case is changed. The process is repeated until all of the teeth are firmly united to the strip and the latter to the baseplate. The use of excessive amounts of solder should be avoided, as it only increases the weight of the denture without materially adding strength.

Pure gold is often used as a solder in this class of work, and while commonly safe, there is danger of it being absorbed by the platinum and the joints becoming disconnected.

In all soldering operations of the class under consideration, certain essentials should be kept in mind. These may be summarized as follows:

Close, clean joints.

Strong, yet not too bulky, investment.

Plenty of preliminary, as well as blow-pipe, heat.

Small pieces of platinum solder laid just where they are needed.

Avoid the use of too concentrated or long-continued flame on any one tooth.

Depend on gravity for retaining and carrying the solder in position when fused.

Avoid the use of flux, since the metals do not oxidize and its presence, if allowed to come in contact with the porcelain at high temperatures, is certain to check the latter.

SUPPORTING THE TEETH WITH WIRE

When the distance between the border crest and the pin-porcelain junction of the teeth does not exceed one-fourth of an inch, a No. 18 gauge iridio-platinum wire can be bent as shown in the illustration (see Fig. 473, page 606), to afford a comparatively rigid support for the teeth, while the tendency to divide the porcelain into an outer and inner portion is obviated, or at least greatly reduced. The technic of application, fitting and trying is so simple that it need not be here detailed.

When the amount of border absorption is excessive and the teeth must of necessity be raised a considerable distance from the baseplate, the following plan can be adopted.

Two wires of 16-gauge iridio-platinum are bent to conform to the arch. One is laid on the border crest, not necessarily in close contact, but touching, the baseplate at the distal extremities and at several intermediate points. The other wire is bent to lie in close contact with the pins and porcelain at their junction. The extremities of this wire are carried from the pins of the second molar in a sloping direction, down alongside of, and in contact with, the wire on the border crest.

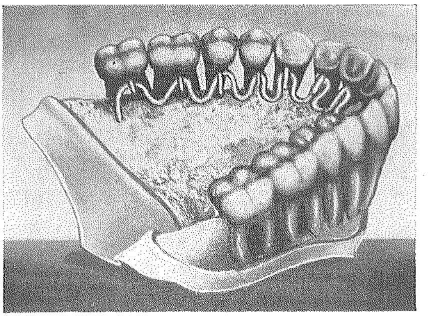


Fig. 473.— Wire Truss, Corrugated to Support Teeth

Five or six iridio-platinum posts are now cut and fitted so as to reach from the baseplate to the wire under the pins. They should also touch the wire on the border crest. The pins are now bent around the upper wire and the frame-work when soldered forms a rigid truss, capable of withstanding all ordinary strains.

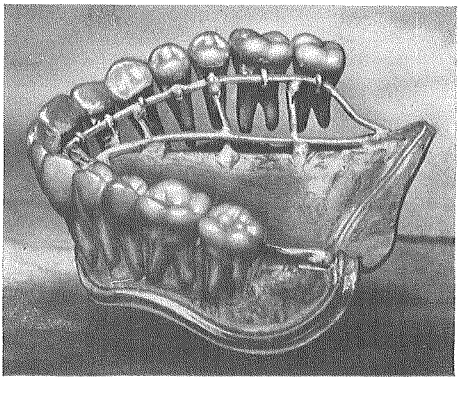


Fig. 474.— Extensive Truss Built to Support Teeth When Border Is Badly Absorbed

In these cases of excessive absorption, the teeth are frequently so placed that their cervical extensions do not touch the baseplate, nor can the border wire of the truss at all times be bent in such manner as to afford them necessary support without reducing the efficiency of the truss.

By blocking in the space between the baseplate and the porcelain roots with broken pieces of old porcelain teeth, or even whole teeth, so placed as not to interfere with proper contouring of the gum body, the danger of distortion in fusing is obviated. The presence of the blocks of high-fusing porce-

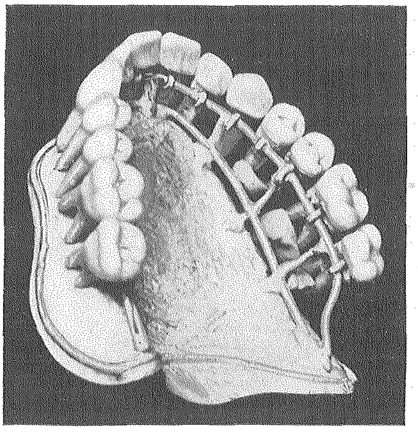


Fig. 475.— Case of Trussed and Blocked Teeth, Ready for Application of Body

lain is not in the least objectionable, but rather an advantage, since the bulk of gum body required will be proportionally reduced. The soldering of the wires is carried out in a manner similar to that followed in attaching the teeth by means of the metal strip. (See Figs. 462 and 475.)

When the teeth, by whatever method adopted, are attached to the baseplate, the investment is allowed to cool. It is then

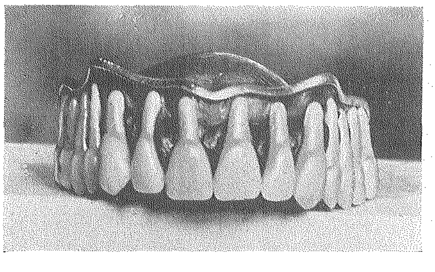


Fig. 476.— Case Soldered Ready for Application of Continuous Gum Body

placed in water to soften and finally carefully removed so as not to disturb the position of the teeth. The latter, although firmly fixed to the truss bar or strip by the pins, can be rotated or bent under stress until rigidly fixed by fusion of the first application of body.

In some cases it may be advisable after soldering to try the skeleton denture in the mouth to test the occlusal relations of the teeth. Frequently some slight change, as rotating a tooth or modifying its axial alignment at this time will obviate what might later on prove a glaring defect.

The skeleton denture is now boiled in dilute HCl, thoroughly washed and the palatine and outer surfaces of the platinum base roughened by passing a sharp-pointed blade over them in various directions to afford some slight hold for the porcelain. The case is now ready for the application of the continuous gum body.

Continuous Gum Body and Enamel

Under the description of porcelain on page 904 will be found the general formulæ of *continuous gum body,* and *gum enamel.* These materials, supplied by the manufacturers for denture construction, come in powder form, usually in one-ounce packages. They are commonly referred to as *body* and *enamel.* The body is almost white in powder form; during fusion it assumes a yellowish tint much resembling dentin.

The enamel is a delicate pink, which on fusing assumes varying shades ranging from almost imperceptible pink to a pinkish purple, depending on the thickness of the layer and the amount of heat applied.

The body supplies the necessary bulk and contour to the case, and is usually applied and fused two times. The enamel supplies the color and is fused once, although at times two applications are necessary.

PREPARATION OF THE BODY

As a preliminary requirement in successful porcelain work the strictest care as to cleanliness must be observed. This includes clean hands, instruments, materials and a room free from dust.

About one-half the contents of the box of body is placed upon a flat glass or porcelain slab four inches square, or even larger. With a drop tube sufficient distilled water is added to the powder to make a medium plastic mass.

The specific gravity of titanium oxid is 4.2; of silex, 2.66; and of kaolin, 2.6. It is apparent that in a thinly-fluid mix of body the coloring matter will gravitate below the other ingredients if much time elapses before taking up the surplus moisture. While the quality of such mass when fused may not be impaired it will not be of exactly uniform color. To avoid separation of the constituents mentioned the pasty mass should be thoroughly spatulated and the excess moisture absorbed by immediately pressing a clean linen towel or napkin over it.

APPLICATION OF THE BODY TO THE TEETH AND BASEPLATE

With a moderately broad spatula the body is applied to the lingual surfaces of the teeth, and vibrated to position by

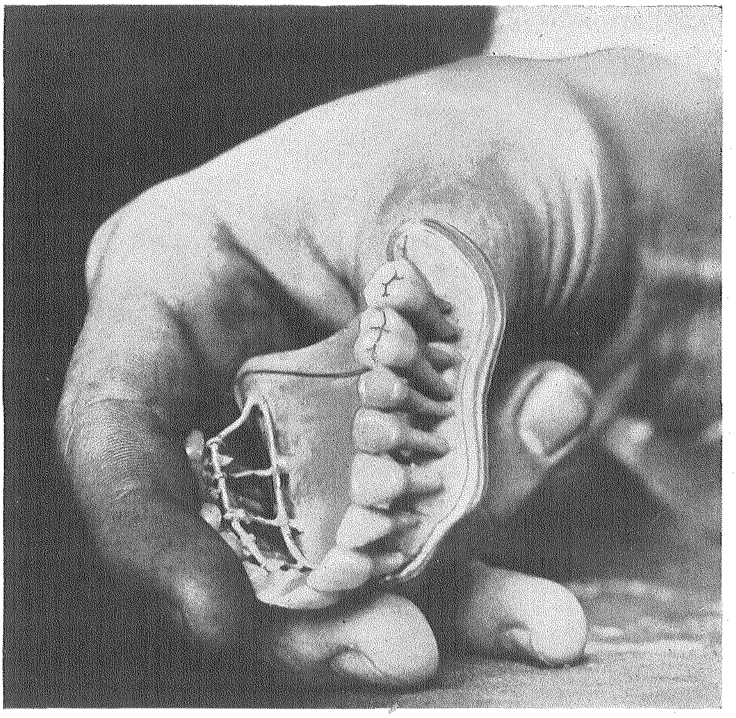


Fig. 477.— Manner of Holding Case to Prevent Porcelain Paste Flowing Through Interproximate Space When Applying It to Base

drawing a knurled instrument against the side or back of the baseplate.

The skeleton denture should be held by placing the thumb against the peripheral rim or within the maxillary portion of the baseplate and the index finger on the occlusal surfaces of the teeth. Now, by applying the middle finger against the buccal surfaces of the teeth and extensions and holding the baseplate edgewise the body will be prevented from dropping through the open spaces. The excess moisture which is forced out by the settling of the granules together is taken up with the napkin and another mass of body applied in like manner until the greater bulk of lingual contour required is developed.

It will be found most convenient to apply the bulk of body to the lingual space in three sections; first, from the cuspid to the tuberosity on one side, vibrating and absorbing the moisture; second, from cuspid to cuspid incisally; third, from cuspid to tuberosity on the opposite side. Each addition as it is applied and vibrated to place should be relieved of the surface moisture. In dentures requiring excessive restoration, it sometimes becomes necessary to further elim-

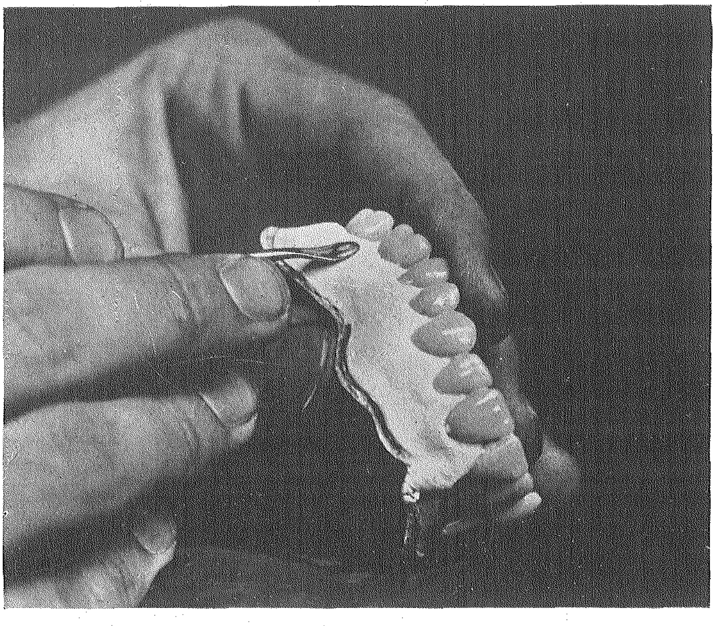


Fig. 478.— Condensing the Body with Carving Tool

inate the moisture by passing the case a few times rapidly through the Bunsen flame, to prevent the flowing of the adapted body while vibrating subsequent additions to place. Should further additions of body to areas which have been rendered comparatively dry be necessary, such areas should be moistened before making the addition, so that the two will intimately unite. When this precaution is neglected, the comparatively dry body will absorb the moisture from the mass last added so rapidly that the latter cannot be vibrated into a dense, compact state.

The lingual contour is developed roughly to approximately the required thickness of the finished case, as are the labial and buccal surfaces also. Care should be taken to avoid excess of material in any area, for if present in excess, removal by grinding would be necessary, while any deficiency may be corrected in the second application of the body.

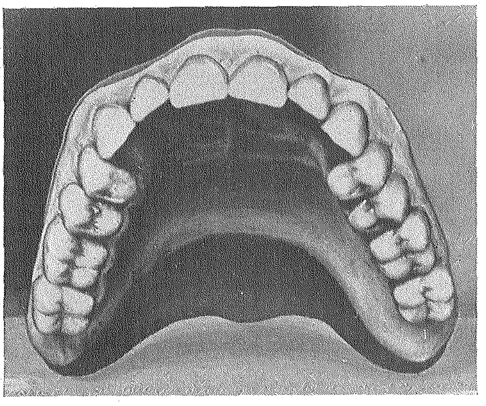


Fig. 479.— Body Applied Ready for Division Before Baking

The denture should be brushed free from all particles of the body that may be lodged upon the platinum baseplate or the teeth where not actually required, as during fusion they will become firmly attached to either platinum or teeth and must subsequently be removed with discs.

Special care should be given to the exposed portion of the

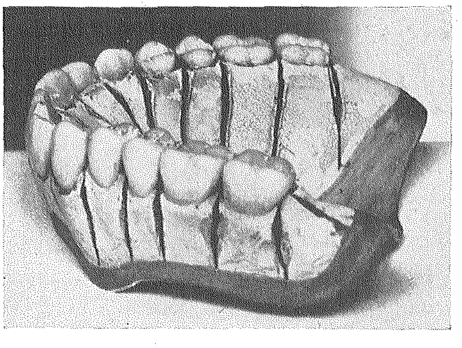


Fig. 480.— The Case Ready for First Baking. Continuous Gum Body Divided with Thin Blade Instrument

teeth to see that proper gum curvature is outlined. Dr. L. P. Haskell recommends for this purpose an ordinary quill toothpick sharpened to a neat, smooth blade-like point. A delicate spatula will answer the same purpose. This step is followed by applying a delicately pointed camel's-hair brush, moistened first, afterward drying and removing every particle of body not required from the gingival curvatures.

Since porcelain contracts from one-sixth to one-fifth its bulk in vitrifying when applied in the manner described, unless preventive measures are used, the teeth are liable to be warped out of position from the contraction of the material between and around the root extensions. To obviate this difficulty, a thin spatula should be passed through the body to the baseplate on both external and vault surfaces. Each tooth previously fixed by its pin to the truss or stay wire thus becomes a fixed center toward which the body composing that section will contract.

The case should finally be inspected to see that all surfaces are free from excess material before introducing in the furnace.

SUPPORTING CONTINUOUS GUM CASES WHILE FUSING

To obviate danger of warpage of the denture during baking, it must be supported at widely divergent points. One of the most convenient methods consists in bending a 16-gauge platinum wire in the form of a V, bending the angled end and

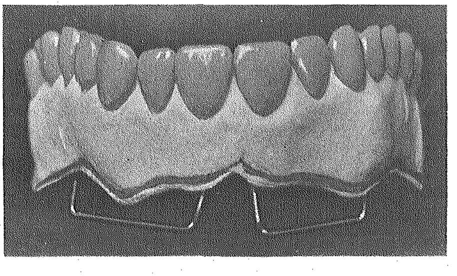


Fig. 481.— Case Ready for Second Bake. Supported on Platinum Wire Tripod

the two terminals upward so as to form three legs of sufficient height to raise the denture clear of the muffle slab. The two terminals support the case at the tuberosities, and the angular leg anteriorly. These three points of contact give uniform support to the case at all times and effectually prevent warpage.

This form of support is also of advantage because it does not absorb the radiated heat as does a support composed of fibre asbestos and investment material commonly employed. In case a support of the latter class is used, it should be reduced to the smallest possible dimensions consistent with strength.

Porcelain Furnaces

Electric furnaces of various types are almost universally used at the present time for the fusing of porcelain in prosthetic procedures. The Custer and the Hammond represent

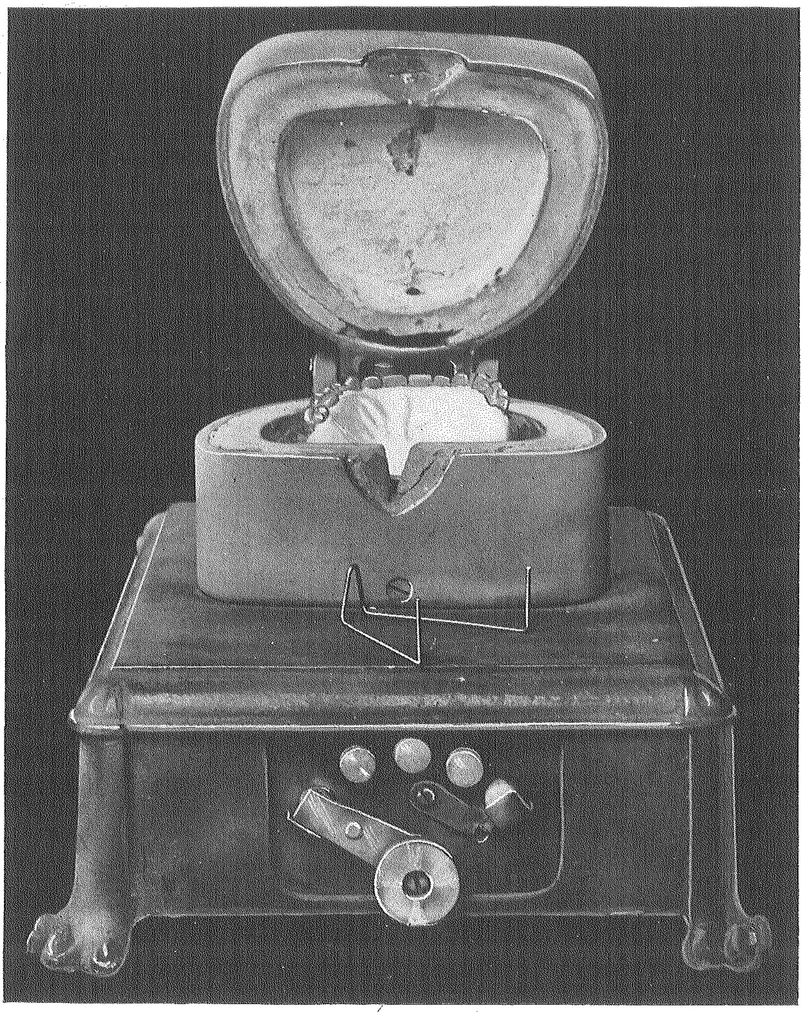


Fig. 482.— Denture in Position. Electric Furnace (Custer Type). Platinum Wire for Supporting Denture on Furnace Table

two of the most serviceable forms, although there are others almost, if not quite, equally as dependable.

The principle involved in the generation of heat depends upon the resistance offered by a fine platinum wire to the passage of a current of electricity. When a 110-v. current of low amperage is passed through a 28-gauge wire the resistance offered to the passage of the current is manifested by the wire becoming heated to high temperature of varying degrees, depending on the length of wire and the time of current flow.

When a conductor offers resistance to the passage of a current to such an extent that heat is manifested, the voltage of the current is reduced. By interposing outside resistance, as a rheostat in which the resistance can be gradually reduced

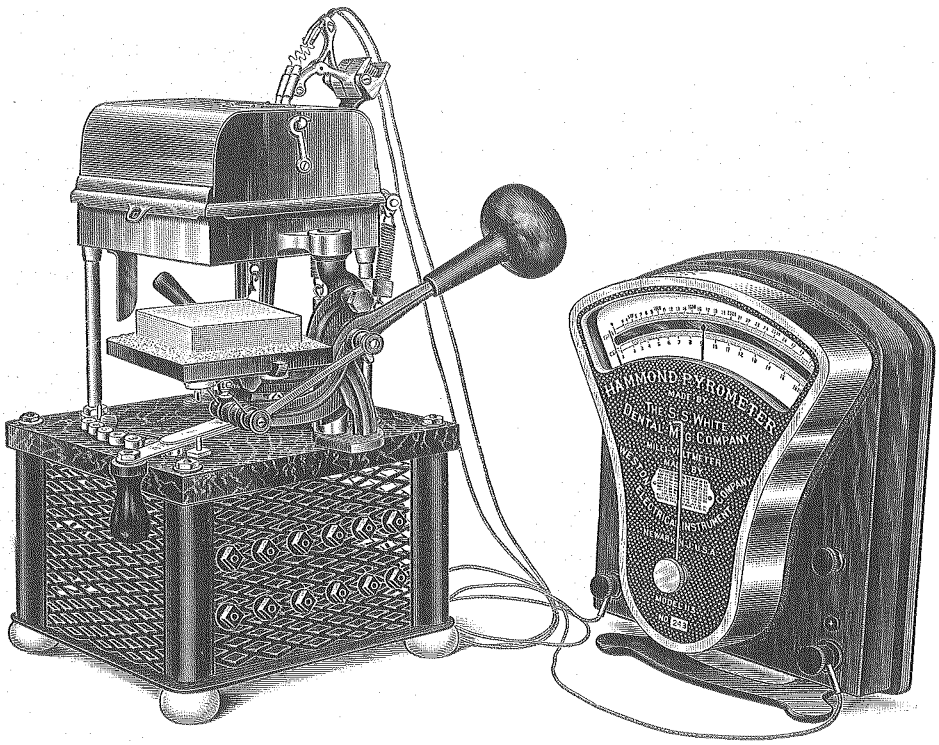


Fig. 483.—Electric Furnace for Continuous Gum Cases. Floor Raises or Lowers by Counterpoised Weight

or entirely cut out, the amount of heat generated within the furnace is easily controlled. This is an important advantage in the fusing of porcelain, for if heated too rapidly, bulky pieces contract unevenly, while the quality of the fused product is impaired.

Time is a most important factor in the fusing of porcelain. Practically all of the high-fusing bodies, with the exception of tooth bodies, can be fused under 2,000 deg. F. if subjected to long continued heat. The quality of porcelain so fused is denser and its color better than when subjected to rapid fusion.

However, very satisfactory results may be secured by adopting the plan of fusing at a temperature about midway between the lowest possible point of vitrification and that required for the shortest time for the particular body used.

FIRST BAKING OF THE CONTINUOUS GUM CASE

The case is now introduced into the furnace, teeth upward, and placed on its support. The latter, whether of wire, as suggested, or composed of investment materials, should rest on a fire-clay slab to afford protection to the slightly imbedded furnace wires. This is necessary to obviate short circuiting of the current, and also to prevent any small flakes of porcelain which might become detached from falling to the furnace floor and there fusing to the fire-clay lining, or over the nearly exposed wires.

The muffle is closed, the rheostat arm set on the first button and allowed to remain there a sufficient time to expel all moisture. This usually requires from 8 to 10 minutes. If this step is crowded too rapidly, the body will flake off as a result of the sudden generation of steam within the mass.

Several methods are in vogue in the baking of porcelain, any one of which will give good results if carefully carried out. The following method, and one preferred by the writer, is to gradually increase the temperature in uniform steps as follows:

When the moisture has been expelled, which can readily be seen by the chalky appearance of the case, the rheostat arm is moved from first to second button, where it is allowed to remain until the maximum heat of that section is developed. This usually requires from 15 to 20 minutes. The arm is now moved on, allowing five-minute interval between each change. In extra-bulky cases each interval may be safely extended one or two minutes longer.

With a new or strange furnace, preliminary tests should always be made to determine the length of time required, and the particular button at which fusion will occur. The time of fusion will vary somewhat with the intensity of the current and various other conditions. If in a position where a strong draft of air strikes the furnace fusion is retarded.

The body should not be glazed during the first baking, but carried to the point of fusing the most fusible ingredients, yet stopped before the granular surface is entirely lost. This stage is called "biscuit bake." It presents a semi-granular, yet partially glazed appearance, while the porcelain is dense and darkened.

When the fusing stage is reached the interior of the furnace and contents present a bright red appearance, so that it is sometimes difficult at first to distinguish the outlines of the case. By carefully viewing the buccal surfaces of the denture in line with the back of the furnace, the roughly granular surface can be seen to gradually disappear. The fusion should be stopped at this stage by reversing the rheostat arm, opening the switch and allowing the case to cool. If removed and cooled suddenly, fracture of the porcelain is almost certain to occur.

SECOND BAKING

The gum body should now be freshly spatulated, adding water and absorbing it as previously described. The case is first dipped in cold water, the surplus shaken out, fresh body applied to the fissures purposely formed before the first baking and all others that may have developed in any location from contraction in baking. The body should be actually compressed in these fissures, when possible, to reduce to the minimum the slightly greater contraction that must occur over these areas than will be noticeable where the freshly added material is thinner.

The case should now be developed to full contour on all surfaces and the labial and buccal areas tested with the contour matrix previously formed. If deficient, more body should be added, and if too full the amount reduced as required.

Palatine rugæ should be developed somewhat stronger than the natural marking, as some detail will be lost in fusing.

Again, all surplus body must be carefully brushed from the teeth and baseplate, the moisture expelled, and the case returned to the furnace for the second baking. This step is carried out as before, except that less time is required on first button — usually about 10 minutes, and the fusion stopped at the semi-granular stage. Since time of exposure to heat is an important factor in fusing porcelain, care must be taken not to over-fuse the case.

In the second baking the body last applied is not alone affected. That first fused is also advanced from the biscuit to the glazed stage. It also contracts to a very slight extent, although the greatest contraction has previously occurred in the first fusing.

When the second application of body has been biscuited, fusion is stopped as in the first baking and the case allowed to cool, when it is ready for the third bake.

PREPARATION OF THE CASE FOR THE THIRD BAKING

The case should now be thoroughly inspected for fissures that may have formed during the last baking. These usually are found at the junction of the body with the lingual surfaces of the teeth, and around the periphery of the base, although they may occur in any location. When not extensive they may be filled with another mix of the gum body and the case enameled. The overlying enamel, although not requiring a temperature for fusion sufficiently high to fuse the body last added, will intermingle and unite with it to form a compact mass.

APPLICATION OF THE GUM ENAMEL

The gum enamel is now mixed with water, spatulated, and the surplus moisture absorbed as in the preparation of the body. It is applied to the case in a thin uniform layer about 1-32 of an inch thick. Since slight variation in shade of the pink enamel is desirable in the finished case, this effect may be produced by varying the thickness of the layer of enamel as it is applied. Care should be taken to distribute it uniformly over the rugæ and avoid filling in the depressions between the ridges, the tendency being for it to settle into depressed areas. By pressure and burnishing, the gum enamel while slightly moist can be distributed and condensed so that when fused it will display a very lifelike color. Since it is almost transparent if not applied in sufficient thickness, the enamel when fused will frequently present an anæmic and unsightly appearance. On the other hand, if applied too thickly, the color will be abnormally dark.

Particular attention should be given the gum festoons to have them of proper curvature and distinctly developed. Every particle of surplus should be swept clear of exposed tooth surfaces, the baseplate, and from the lingual, labial and buccal embrasures, where its presence as a pigment would prove unsightly.

Briefly summed up, the teeth should stand out clean and prominent, the gum festoons and other surface markings should be sharply, or at least plainly, defined, and the baseplate free from all adherent particles.

The moisture is now gradually evaporated by passing the case through a current of heated air above a Bunsen flame, in preference to placing in the furnace to dry, so that if any of the gum enamel flakes off in drying it may be corrected before baking.

FUSING THE ENAMEL

The denture is now introduced into the furnace and heat applied as before. Gum enamel fuses at a considerably lower temperature than gum body, so when the furnace becomes well heated the case should be watched very closely to avoid overfusing and bleaching the color.

The enamel should be perfectly glazed so that it may easily be kept clean, will look well, and not prove irritating to the mucous tissues as a result of roughened surfaces.

Being able to distinguish the outlines of the denture when in the furnace and highly heated, and to determine the instant when the enamel is perfectly glazed, is one of the essen-

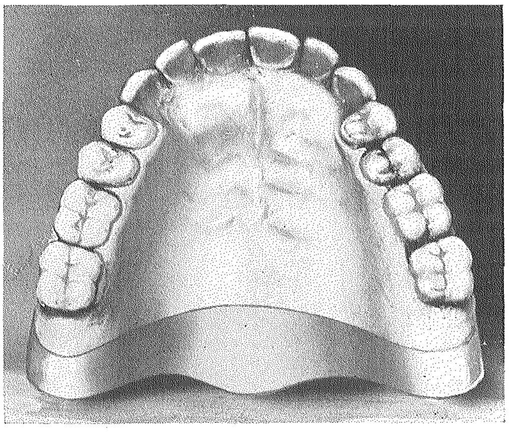


Fig. 484.— Occlusal View of Finished Case. Slight Suggestion of Rugæ

tial points in porcelain technic, and comes only with experience and careful observation.

When fused, the current is shut off, the furnace opened, and the case examined to see that glazing has been accomplished. If satisfactory, the furnace is closed and the denture allowed to remain within until perfectly cold. Sudden chilling or drafts of cold air striking the porcelain when heated will almost certainly check it, sometimes in a very unsightly manner.

FINISHING THE DENTURE

The enamel surfaces, if properly fused, require no finishing. The peripheral margins, palatine vault of the platinum base, and the lingual surface of the doubler are first polished as in gold denture contruction with felt wheels and pumice stone, following with the finer powders.

The fact should be kept in mind that when porcelain bodies are brought to a state of fusion, continued heat, even though the temperature is not elevated, will gradually render

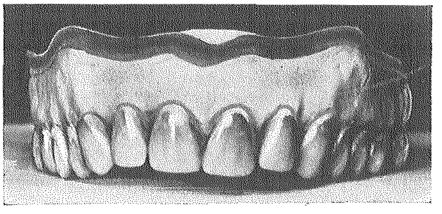


Fig. 485.— Labial View of Finished Denture

them glasslike, friable, porous, bleach the color, and render them weak and devoid of usefulness for prosthetic restorations. Much better and more certain results, therefore, can be attained by subjecting the case to only three bakings — two for the body and one for the enamel — than are possible when a greater number of bakings are required.

Special Uses of Porcelain

Oftentimes in the construction of dentures for partial cases some of the spaces to be supplied with teeth are in a conspicuous position. When but slight absorption of the ridge has occurred, plain teeth may be neatly fitted against the natural tissues in such manner as to escape detection. This may be done by first grinding the ridge lap of each tooth to conform to the irregularities of the ridge, and afterward paring away on the cast the area on which it rests. This step advances the teeth slightly beyond the palatine and border surfaces of the baseplate, so that with use they become slightly imbedded in the tissues and thus present about the same appearance as do natural teeth surrounded with their gingivæ.

INTERSTITIAL BLOCKS OF PORCELAIN

When two or more contiguous teeth are missing and they are replaced by plain teeth without gum restoration, it is frequently difficult to obviate the display of vulcanite in the embrasures of the artificial teeth.

Recently there has been placed on the market Fogg's interstitial porcelain blocks, which, when properly applied, overcome the difficulty mentioned. These pieces of porcelain are

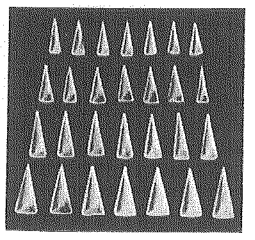


Fig. 486.— Fogg's Interstitial Gum Blocks

wedge-shape in form and slightly concaved on their mesial and distal areas to embrace the proximating surfaces of the teeth. Their exposed surfaces are overlaid with pink gum enamel.

By selecting blocks of suitable length and grinding their proximating surfaces, as well as those of the teeth, these points may be so nicely adjusted that they have the appear-

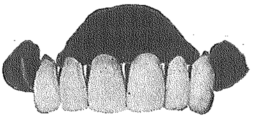


Fig. 487.— Fogg's Interstitial Blocks Applied in Embrasures

ance of natural gum tissue in the embrasures. They are ground and fitted in position before flasking the case, invested as though a part of the teeth, and become firmly attached by means of the flowing of the vulcanite in closing the packed flask.

GUM SECTIONS

Gum section teeth, either single or in blocks, can often be used to advantage in partial cases, particularly when border absorption is marked.

By grinding the margins of the block to a thin edge where it joins the gum tissue, very natural restoration of the lost gum tissue can be accomplished. The block should be reduced at the expense of the lingual or border side, since if reduced from the labial or buccal margins the pink enameled surface is destroyed and a light colored line of demarcation shows at the junction of the block with the soft tissues.

Gum section teeth are used to a limited extent only, at the present time, in full cases because of the difficulty in developing anatomic relations. Oftentimes when care is used in constructive steps and the condyle path pitch is not excessively steep, most esthetic results may be secured with gum section teeth combined with vulcanite or gold and vulcanite bases.

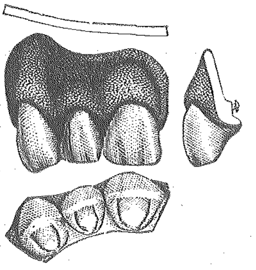


Fig. 488.— Gum Block of Three Teeth

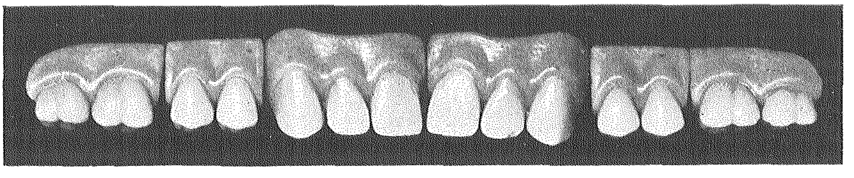


Fig. 489.— Set of Fourteen Gum Section Teeth Before Grinding. (Justi)

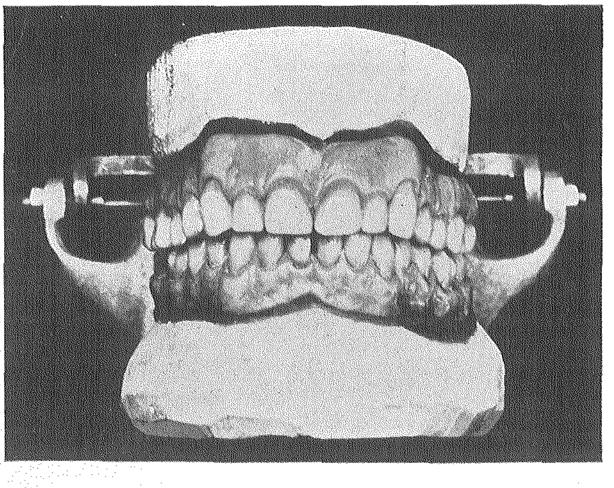


Fig. 490.— Set of Twenty-Eight Gum Section Teeth. Joints Ground and Teeth Occluded. (S. S. W.)

They are very useful in partial cases in the replacement of teeth in conspicuous positions.

It is sometimes difficult to secure porcelain sections for special cases other than the usual three-tooth anterior and two-tooth posterior stock blocks. Stock blocks are frequently applicable when the number of teeth they include corresponds to, or is greater than, the number of teeth to be replaced in the space, the extra teeth being easily cut away, but unfortunately the loss of teeth does not occur with regularity. For example, two centrals and a lateral may be missing, or a cuspid and two bicuspids. In these and many other cases, stock blocks will not fulfill the requirements without the use of two blocks and the grinding of a joint.

Construction of Gum Blocks for Special Cases

Various methods have been suggested for baking single blocks to meet the requirements of unusual cases, but because of the friability of blocks so formed, few undertake their construction. Dr. Walter M. Bartlett of St. Louis has produced some very artistic work in this line, and by a comparatively simple method of technic. His method is practically as follows:

An impression is secured from which a plaster cast is derived. Plain vulcanite or ordinary long pin facings are

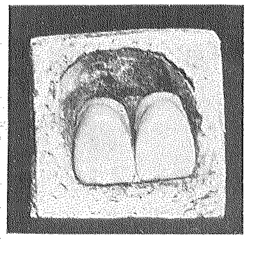


Fig. 491.— Two Plain Teeth Adapted to Platinum Foil-Covered Cast Ready for Application of Gum Body

selected and ground, when necessary, to bring them in proper alignment in the usual manner. The teeth are now removed and a piece of platinum foil is burnished to the cast over the area to be covered by the block. The foil base should be so formed as to be easily released from the cast without distortion. When properly adapted and trimmed to suitable outline, it is retained on the cast until the model block is formed.

The teeth are now returned to the cast and wax flowed between them and the foil to hold them in position. The future block is now modeled in wax to the exact outline desired, and when hardened, the teeth, wax and foil are removed as one piece. Care should be taken to avoid covering the pins of the teeth with the wax, since in introducing the porcelain paste it will fill all spaces caused by the removal of the wax, and the pins would thus be obscured.

The block is now invested, pins and border side down, in tenax. The investment should be as small as possible to be consistent with strength. When set, the wax is thoroughly removed with hot water, and continuous gum body, or the regular high fusing crown and bridge porcelain, is filled into the space between the foil and the teeth. The gum is now carved to the desired contour and the entire case carefully dried, when it is ready for fusing.

In simple cases one application and baking of the body will be all that is required, the slight shrinkage which occurs being compensated for and covered over by the layer of enamel which follows.

When fused, if much contraction of the body has occurred, a second application should be made and fused, followed by the application and fusing of the gum enamel.

By scraping the cast slightly around the periphery of the gum block, so that the latter may fit the tissues closely, and

Fig. 492.—Case Baked. Labial View. Block Constructed for Special Case. (Dr. G. W. Schwartz)

by bringing the body and enamel to a gradual rather than an abrupt termination around the margins, the block when fitted in place in the mouth can be scarcely distinguished from the natural teeth and tissues.

The platinum foil is now peeled off and the sharp margins of the periphery removed with fine discs, when the block is ready for use.

Another method consists in swaging a thin plate of platinum in the form of a saddle, to cover the ridge and serve as a foundation for the back of the gum portion. To this saddle, long pin facings are soldered and additional attachments

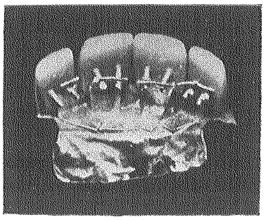


Fig. 493.— Platinum Base with Long Pin Teeth Attached for Reception of Porcelain Body

added for vulcanite anchorage, when advisable. The porcelain is applied and baked as in the previous case. By this method the platinum is not removed, but becomes a part of the section.

CHAPTER XXVII

CROWN WORK

Preliminary Considerations

When through accident, or as the result of caries, the crown of a natural tooth has been impaired so that operative procedures will not fully restore it to usefulness, an artificial crown, when conditions are favorable, can be constructed to replace it. Oftentimes the perfectly formed natural crown of a healthy tooth is reduced in size, or entirely removed, and an artificial substitute placed over it or on the root, to serve as an abutment or pier for a bridge.

Such a procedure, when necessary, is considered good practice and justifiable in well-selected cases, the benefits in improved masticatory function and esthetic appearance resulting from the replacement of missing teeth, more than compensating for the sacrifice of the natural tooth crown.

The successful crowning of teeth requires a thorough knowledge of several correlated subjects, viz., histological and physiological structures of the teeth and tissues involved; oral pathological conditions; therapeutic methods of treatment of diseased conditions; anatomic and esthetic forms of the teeth; hygienic requirements of crowns; technical procedures.

Structures of the Teeth and Investing Tissues

The grosser structures of which a tooth is composed are as follows:

Dentine, which constitutes the larger portion of both crown and root, and within which the pulp chamber is situated.

Enamel, which envelops the crown portion of dentine, and gives the crown its anatomic form.

Cementum, which covers the root portion of dentine, and furnishes attachment to the fibres of the peridental membrane. The cementum at the cervix of a tooth comes to the enamel margin and, in some cases, slightly overlaps the latter.

The Peridental Membrane, composed of fibrous tissue, is interposed between the root of a tooth and its bony socket or alveolus. The fibres of this membrane extend from the socket walls to the cementum covering the root, most of them running in an apical direction as well as tangentally. The tooth is retained in position principally by the network of fibres which pass in various directions through the gingival tissue.

The attachment of the peridental fibres to the tooth terminates with the gingival termination of the cementum. They do not, however, terminate at the margin of the alveolus, but continue on incisally or occlusally into the gingivus, forming a sort of fibrous network or band which holds the gum tissues firmly in contact with the axial surfaces of the tooth. By passing through the interproximate spaces and across the embrasures from tooth to tooth, they unite the lingual with the labial gingivi and buccal, and form what is termed the dental ligament.

Now, since the cementum comes to, or slightly overlaps, the gingival margin of enamel, and since the peridental fibres are attached to the extreme gingival margin of the cementum, extending outward from this point and interlacing to form the dental ligament, in those cases where the peripheral ring of enamel is entirely removed for the reception of a crown band, more or less cutting and laceration of the peridental fibres in this region occurs from the use of the cleavers, files, discs and stones. These severed fibres may, or may never, again re-unite with the cementum, depending on the extent of injury done, the general tonicity of the parts and the character of the joint between the crown band and the root periphery.

In line with this idea, Dr. F. B. Noyes in his Dental Histiology, page 189, says: "That the tissues (peridental membrane) may be re-attached to the surface of a root is both theoretically possible and clinically demonstrable, but for it to occur, biological laws must be observed and the conditions are very difficult to control, especially with the old methods involving the excessive use of strong antiseptics. It is well to remember that a dentist can never cure a suppurating pocket along the side of a tooth root, but if the conditions can be controlled the cells of the tissue may form a new layer of cementum, re-attaching the tissues, and so close the pocket. It is a biological problem, not a matter of drugs, except as they are a means of producing a cellular reaction. In view of its function, therefore, the cementum becomes not the least but the most important of the dental tissues, for no matter how perfect the crown may be, without firm attachment the tooth becomes useless and is soon lost."

One of the gravest dangers resulting from traumatic injury to the peridental fibres and their failure to again reattach themselves to the root, is in the loss of tension of the dental ligament at or near the site of injury. In such cases the formation of a pocket is almost certain to occur, and into this food finds its way, is difficult to remove, decomposes, and pathological conditions arise, which in many cases from inducing infection eventually result in chronic suppurative pericementitis or other troubles.

It will thus be seen that while a crown may restore the function of mastication, accomplish desired esthetic results, and, by wedging, maintain proximate contact which has been lost previous to its application, yet pathological conditions may be induced through improper technic and an imperfectly adapted band.

Many prosthetists, either through carelessness or to avoid traumatic injury to the peridental membrane, fail to remove all of the peripheral enamel ring from the root when preparing it for a band, with the result that the latter, when applied, presents a shoulder which not only invites the lodgment of food, but proves a constant mechanical irritant to the gingival tissues as well. The greatest care should, therefore, be observed to remove all of the enamel in cases where indicated, and yet avoid excessive injury to the peridental membrane and gingival tissues in general.

Physiological Relations

The pulp of a tooth occupies the central chamber, or what is termed the pulp chamber and root canal. It is largely composed of embryonal connective tissue in which very few connective tissue fibres are present. It contains nerve filaments and minute blood vessels which enter through the apical foramen of the root.

The primary function of the pulp is a dentine builder, the outer layer of columnar cells, called odontoblasts, receiving from the blood and depositing from without, inward, the calcific materials of which the dentine is composed. The dentinal fibrils, occupying the dentinal tubuli, are the remnants of the odontoblastic cells which have become reduced in diameter and withdraw inward as calcific dentinal deposit progresses.

The secondary function of the pulp is that of a sensory organ, as it is very responsive to thermal changes, to chemical action on, and traumatic injury to the tooth.

In the preparation of a vital tooth for the reception of a crown, the friction caused by engine stones and discs is often exceedingly painful, even though the site of the operation is far removed from the pulp. Since the dentinal fibrils are devoid of nerve filaments, external irritation when noticeable, is, without doubt, conveyed to the pulp by molecular vibration of the contents of the tubuli, and the heat caused by friction as well.

Usually it is customary to devitalize a tooth before adapting a shell crown, for two reasons: first, so as to reduce to the minimum the pain resulting from the use of stones and cleaners in the root preparation, and second, to avert possible pathological conditions subsequently arising from death of the pulp, either from the shock of denuding the crown of its enamel, or from thermal variations.

When this practice is resorted to, the pulp removed, and the root apices perfectly filled, it is a most excellent procedure. The danger of following this plan in every case lies in the fact that frequently teeth have multiple roots or multiple canals — more than the normal number — and some of these are liable to be overlooked in the treatment and filling. Again the roots of teeth may be deformed, and the canals so tortuous and minute that by the most patient and conscientious effort it is impossible to clear and fill them. These conditions are frequently met with in peg-shaped lateral incisors, third molars, and occasionally in the lower anterior as well as other teeth. Should indications point to abnormalities, the X-ray will disclose their nature, and the prosthetist can then govern himself accordingly. When pathological conditions are not present and treatment is not called for, the safer plan in these abnormal cases is to crown the tooth without removing the pulp, even though the tooth or root preparation may occasion some pain.

Oral Pathological Conditions

The prosthetist should be able to recognize any abnormal or pathological conditions present in the mouth, and be familiar with recognized and proven methods of treatment.

The most frequently occurring abnormal conditions which present in practice are cases in which one or more of the teeth have lost their crowns, or the teeth themselves are missing. Such loss, if of long standing — usually the result of a substitute crown not having been applied — almost always entails the loss of proximate contact of some, if not all, of the remaining natural teeth. The spaces thus formed invite the lodgment and retention of food. As stated elsewhere, chronic suppurative pericementitis frequently has its origin in such mouths under these and similar conditions, and unless corrective measures are resorted to, the loss of all the teeth will sooner or later occur.

When the axial surfaces of the teeth in general have not suffered from caries, and proximal contact has been lost through loss of the crowns of one or more teeth, the roots of which are in condition to carry substitute crowns, contact may frequently be restored between teeth considerably removed from the space to be supplied, by a slow wedging process. The substitute crowns should be constructed of sufficient dimensions to maintain the space gained in wedging.

Hyperaemic or putrescent pulps should be removed, and the root canals of all pulpless teeth rendered aseptic and their apices filled, before attempting the preparation of roots for crowns. Pus sockets and alveolar abscesses connected with, or located near, the site of operation, must be eradicated. Inflammation of the gingival tissues and peridental membranes should be allayed, and when possible, restored to health, before extensive crowning operations are undertaken. In some cases complete restoration to normal conditions may not be effected, since the irritation occasioned by food wedging on the tissues in unprotected locations — as in the embrasures and interproximal spaces — may continue until afforded protection by suitably formed and well adapted crowns. Special care should be given to the removal of the excess cement, which in setting is forced out at the periphery of a crown. When this is not entirely removed inflammatory conditions frequently develop which may result not only in immediate discomfort to the patient, but later on in the formation of a permanent gingival pocket.

The prosthetist should endeavor by every possible means to temporarily and permanently correct all pathological conditions present, and to so form the substitutes, of whatever class, that they may in no way give rise to a recurrence of diseased conditions, or initiate others of a different character.

Therapeutic Methods of Treatment of Diseased Conditions

It is taken for granted that the student is pursuing the study of, and has access to, textbooks dealing with the therapy of the teeth and oral tisues. Therefore it is unnecessary to recount the various methods of treatment and the many general agents employed, except where they are of special interest to the prosthetist.

LOCAL ANÆSTHETICS

Local anæsthetics in some cases are invaluable, as for instance in the removal of pulps, the excision of hypertrophied gum tissue, the curetting of necrosed process, the scaling of roots in deep-seated alveolar pockets, and at times in the preparation of roots of teeth for the reception of crowns.

Solutions of cocain, eucain, novo-cain and various similar agents, either alone or combined with other drugs, are used for this purpose. Such agents may be applied superficially or injected at or near the site of operation, in which case the peripheral nerve endings are influenced by the anæsthetic. Novo-cain and suprarenin dissolved in Ringer's solution are frequently employed, especially in conductive anæsthesia. By this method the main nerve trunk back of the site of operation is anæsthetized, the anæsthesia being more or less complete along the peripheral branches to the nerve endings, except where the tissues are also supplied with other nerve filaments coming from some other than the trunk anæsthetized. In such case an additional local injection at the site of operation is sometimes resorted to, to complete the anæsthesia.

In the use of anæsthetics of any character, and particularly when used by the injection method, extreme care should be exercised in the sterilization of the instruments, appliances and the agent itself, and in rendering aseptic the tissues to which the anæsthetic is applied, or through which the needle is inserted.

Unless scrupulous care is observed in removing the peripheral ring of enamel from the root of a tooth the adjacent tissues having been anæsthetized, serious traumatic injury to the dental ligament and gingival fibres of the peridental membrane is liable to occur, since the nerves are unresponsive and can give no warning of the extent of injury being inflicted. When possible to do so, the use of anæsthetics in such operations should be avoided for the reason stated.

Low per cent solutions of cocain or similar drugs, combined with pressure, usually produce effective anæsthesia in removal of pulps, when the solution and the unvulcanized rubber, by means of which pressure is usually applied, can be confined, as within a four-walled cavity, or one that may be so formed by means of a matrix.

TREATMENT AFTER SETTING A CROWN

After setting a crown, the excess cement having been removed, the tissues should be massaged, syringed with warm normal salt solution, and where pain is experienced an application of tincture of iodine, or a saturated solution of iodine in beechwood creosote, should be applied under the free margin of the gum around the root crowned. This method of treatment is frequently of value as an aid in relieving tenderness in the peridental tissues.

Hot water alone, when properly applied and continued a sufficient time, will very frequently reduce inflammation or abort an abscess in the incipient stage. The method is as follows:

A surgical tank used for irrigation purposes, holding a gallon or more, should be filled with water heated to about 135 deg. F., or even higher if the patient can tolerate it without scalding the tissues. A nozzle with a very fine opening should be applied to the irrigating tube, the nozzle of the bulb water syringe or a glass dropper tube with curved point being suitable for this purpose, the curvature permitting the water to be directed against the gingiva in the embrasures and interproximate spaces of the teeth affected.

The patient should sit with head inclined over the fountain cuspidor, and usually with a little instruction can, without assistance, irrigate the parts thoroughly. The application should be maintained for fifteen or twenty minutes continuously, the efficiency of the method depending upon the contraction occasioned by heat of the arterioles and capillaries, thus reducing the flow of blood to the parts and enabling the tissues to recover their normal tone.

The tank may require refilling once or twice in severe cases, and the stream of water should be directed not only around the gingivæ of the tooth affected, but along the labial or buccal and lingual surfaces of the border of all of the teeth, so as to control the circulation of blood in the entire arch. The writer has in many instances effectively applied this method of treatment for the relief of conditions mentioned, and in various other forms of painful troubles as well.

Anatomic and Esthetic Forms of Teeth

The anatomic form of an artificial crown is governed by its position in the arch, and usually corresponds with the class of crown carried by the root which will support it.

Variations from this rule occur at times, examples of which are seen in the following instances:

A lateral incisor has been lost and the space it occupied has been nearly, or quite, obliterated by the movement toward each other of the teeth on either side. In case the cuspid root requires crowning, a wide lateral incisor placed upon its roots would in all probability fill the space and be more in harmony with the proximating teeth than would a cuspid crown.

Sometimes it becomes necessary to vary the form and proportions of an artificial crown for hygienic reasons, to raise or lower, omit or add, a cusp to meet occlusal requirements, or to secure contact with proximating teeth.

In many instances a tooth has lost all or a portion of its crown long before the patient presents for a substitute. Frequently proximate contact of the remaining natural teeth has been disturbed by such loss. Before crowning the root, the lost space should, to as great an extent as possible, be regained by wedging, which in turn will frequently restore knuckling contact at other points where spaces have developed from the movement toward each other of the teeth proximating the missing crown. In many instances the wedging operation will not only regain the lost space, but may, with benefit to the other teeth, tighten up all lost contacts, when this can be done without disturbing the occlusion. The crown when constructed to fill the space may, therefore, be somewhat greater in its mesio-distal diameter than was the original one it replaces.

When the root of a tooth, capable of carrying a crown, is slightly out of alignment labio or bucco-lingually, should orthodontic measures be deemed inadvisable for bringing it into position, an *offset* crown may be constructed, and by skillful root preparation and assembling of the several parts, the crown, although not of anatomic form, will present a good appearance and fulfill useful requirements.

In the construction of crowns of any class, variations in form from true anatomic types are frequently necessary. The usual conditions calling for modified forms are excessively wide or narrow spaces, abnormal occlusal surfaces of the opposite teeth, movement of the remaining teeth from their normal position with loss of contact, and various other causes.

A study of the axial surfaces of typical natural teeth should be made, and a reproduction of these surfaces carried out whenever possible in crown construction. The convexity of the buccal and lingual axial surfaces of the bicuspids and molars, aside from the esthetic value of such forms, serves a most useful purpose. The bulging mid-crown forms of these teeth, together with constricted crevices, afford efficient protection to the free margin of the gums against the excursions of food that may be forced beyond the occlusal surfaces of the teeth in masticatory effort.

As crowns are frequently constructed, their buccal and lingual axial surfaces are either parallel with each other, or converge from the gingivæ occlusally, thus preventing inclined planes for directing food toward, instead of away from the gum margin. A crown so formed invites the lodgment of food, the formation of gingival pockets, and inflammatory conditions which will eventually result in loss of the tooth.

FLARE OF THE AXIAL SURFACES OF BICUSPIDS AND MOLARS

An examination of many bicuspids and molars with a view of determining the average flare occlusally of their gingival cones was made as follows:

A strip of No. 60 tin foil was cut about 1-3 of an inch wide, slightly curved to more readily adapt it to this portion of the

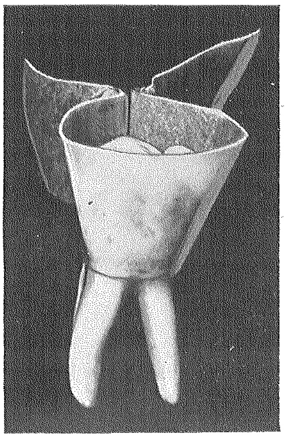


Fig. 494.— Crown of Upper First Molar, with Tin-Foil Band Applied to Gingival Cone

tooth. It was then bent around and burnished to the gingival cone of the tooth, the shorter, or concave, margin of the strip being applied gingivally. The ends were brought squarely together and cut at the angles of junction. The strip was then straightened out, one end laid parallel with the straight edge of a cardboard, and a line drawn along, and parallel with, the opposite end, running toward and intersecting the margin of the cardboard. The angular divergence of the ends was read by means of a protractor. From fifty to one hun-

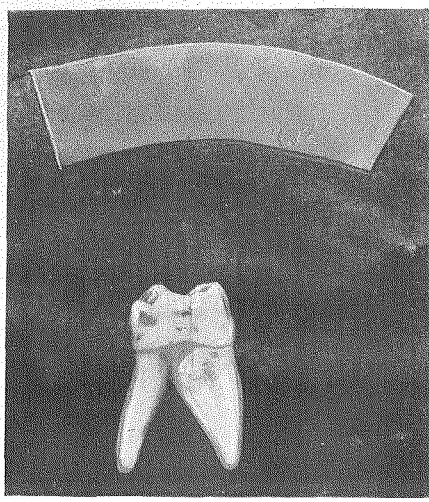


Fig. 495.— Mesial View of Upper First Molar. Tin-Foil Strip Above

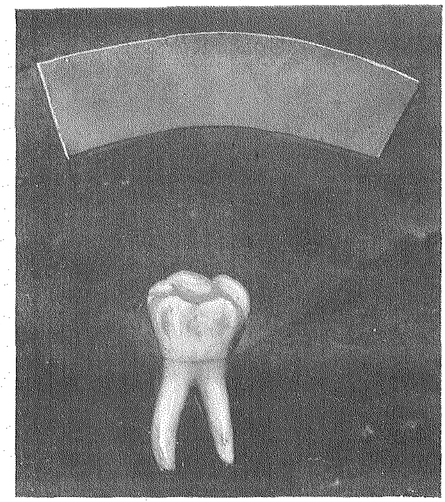


Fig. 496.— Buccal Strip of Upper First Molar. Tin-Foil Strip Removed. Surplus Trimmed from Ends and Occlusal Margin

dred teeth of each class were measured in this manner, the readings of which are as follows:

	Least Divergence Deg.	Greatest Divergence Deg.	Average Deg.
Upper first bicuspids......	21	33	27
Upper second bicuspids....	18	32	27.75
Upper first molars.........	19.4	31	25.5
Upper second molars......	16	28	24
Lower first molars.........	28	40	32
Lower first bicuspids......	24	43	30
Lower second bicuspids....	20	35	32

Valuable assistance has been received in this work from Dr. J. F. Wallace of Canton, Missouri, who made many measurements of teeth by this method. His work, while varying slightly from that of the writer, coincides closely, personal equation accounting for the difference in findings.

CUTTING MOLAR AND BICUSPID CROWN BANDS BY THE CONIC SYSTEM

The practical application to crown work of the measurements seen in the table will now be shown.

When a molar or bicuspid crown band is cut to approximately the form of the tin foil pattern produced as above described, it represents, when the ends are united, a frustum of a cone instead of a cylinder, as would be the case when the ends of the band are parallel. The small end of the cone represents the gingival margin of the band, while the large end, although excessive in peripheral outline, represents the occlusal margin. Reduction of the occlusal cone to correct form can easily and quickly be accomplished with the hawkbill or Benson pliers, using the latter without exerting excessive force, and when properly contoured the axial walls of the band will present a similar appearance to those of the natural tooth. The advantages of this method are that the band walls are not reduced in thickness at any point in contouring, while proximate contact can be secured without the usual narrowing of the band in its mid-crown, bucco-lingual diameter.

The method of diverging the ends of a crown band from gingival to occlusal, has long been followed by careful prosthetists for reasons above given. A few have even cut the band to represent the section of a cone instead of a cylinder, as is most frequently the case, but no definite rule has been evolved capable of application to the development of bicuspid and molar bands in general.

By referring to the table of measurements previously shown, it will be seen that the average flare of a conic crown band of an upper first molar is 25.5 deg., while the average peripheral gingival measurement of this class of teeth is 29.92 m. m.

To cut a conic crown band by this system the only appliance required aside from the regular laboratory equipment is a pair of ordinary 6-inch dividers, a piece of cardboard and a straight edge. The method is as follows:

Measure the prepared root with wire in the usual manner and cut the loop opposite the twist.

Draw a straight perpendicular line on the cardboard parallel with and near the edge, or the edge of the card can be used.

Mark points on line A and B, 3¼ inches apart.

Mark width of band B — C.

Lay a piece of gold plate from which the band is to be cut on the line, the upper corner at C.

Set divider points at A — B, radius.

Hold plate firmly on card and describe arc B D.

Extend divider to reach from A to C.

Describe arc C G.

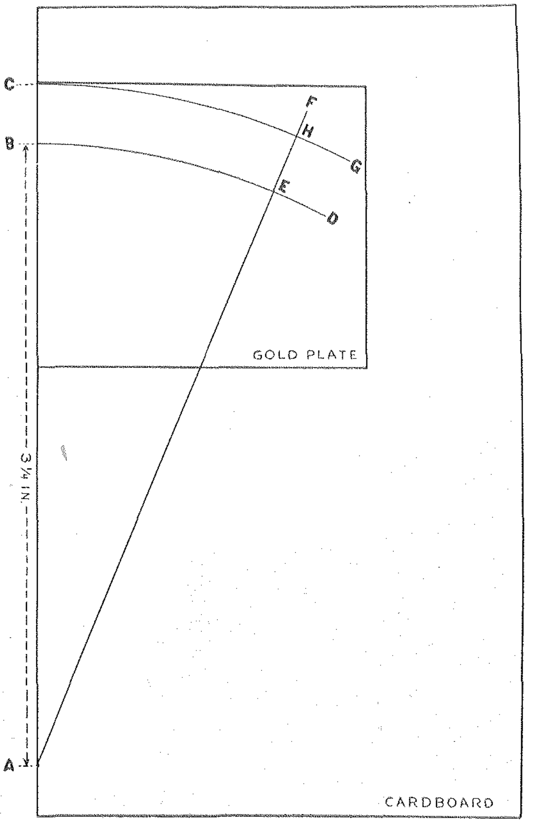


Fig. 497.— Plan of Card, Showing Construction Lines Used in the Development of a Cone Crown Band

Lay root measurement slightly curved along arc B D and mark length of band B E.

Lay ruler edge on points A and E and draw A F.

B C E H represents the band which is cut with the shears. The band when bent around and the ends soldered, in the usual manner, represents the section of a cone instead of a cylinder, the smaller being the gingival end.

In trimming the gingival end of the band to correspond to the gum festoon, the inner diameter of the band is increased as the gingival periphery is sheared away, and consequently is larger than the root. This may be corrected in two ways; first, by reducing the gingival periphery with the pliers, and second, by cutting the band slightly shorter than the wire measurement, when laying it out.

By extending the line along the straight edge to the center, A, and reading the included angle it will usually be found to range from 22 deg. to 28 deg. This reading, however, is unnecessary for practical purposes. The variations noted in a number of readings are due to variations in peripheral root measurements, long measurements showing greater, and short measurements less, divergence of the band ends.

In those cases where, for example, the space in which the crown is to be placed has become constricted by the leaning toward each other of the proximating teeth, the contact points of the remaining teeth in the arch being good, this method, for obvious reasons, is not applicable.

In cases of normal or excessive width of spaces, it is the very best method to follow in the construction of two-piece or band and swaged cusp crowns. Its range of application can be extended to include band and cast cusp, and other varieties of crowns.

The band of a crown cut to represent a cone, when cut gingivally to correspond with the festooning of the gums, is enlarged slightly since the smaller end of the cone is cut away, as before stated. To compensate for such enlargement, the band can be cut from ½ to 1 m. m. shorter than the root measurement. If, when festooned, the band is too small to be driven to place, it can be stretched slightly by placing on a round mandrel and tapping lightly with a riveting hammer. When too large, it can be reduced with contouring pliers.

Any wide crown band, as for a molar or bicuspid, can be tightened gingivally, and its perfect peripheral adaptation insured, the root having been properly prepared, when, after fitting and axial contouring have been accomplished, its gingival margin is reduced as above outlined, after which it can be finally driven to place. A gingival shoulder on the natural tooth or root would preclude this plan of final adaptation.

Badly decayed teeth, to which shell crowns are to be adapted, should in all cases have their axial surfaces restored by means of well anchored amalgam fillings or alloy castings, placed before the final preparation of the tooth or root is accomplished, so as to obliterate all gingival shoulders.

When a tinfoil envelope is adapted to any of the twelve anterior teeth, the ends of the strip cut at their junction, and the strip flattened, the two ends will be approximately parallel, and when again united in band form would form the section of a cylinder. Anatomically, the anterior teeth represent wedges or cylinders flattened at one end to form incisal edges.

STRESS

The amount of stress and the direction of its application are of the greatest importance in crown, bridge and denture construction.

A crown, or a prosthetic appliance of any type, may be anatomical in form, yet when introduced into the mouth may become displaced, or rendered useless, through some abnormal condition present, as elongated cusps of teeth in the opposite arch.

The sloping occlusal surfaces of the various cusps of a tooth, when brought into contact with occluding surfaces of opposite teeth, act as inclined planes, and tend to force the tooth of which they are a part forward or backward, or in or out of alignment, unless such tendency is counterbalanced by proximating teeth or by contact planes of occluding teeth sloping in a contrary direction.

The greatest care, therefore, should be observed in the development of cusps to so form them that displacement from undue force on sloping planes cannot occur. Oftentimes the occlusal surfaces of the opposite teeth must be modified by grinding to meet new occlusal requirements arising from the introduction of prosthetic substitutes. The use of both single and double surface carbon paper will readily disclose points of interference between occluding planes and cusps, and corrections can be made accordingly.

In constructing a crown with porcelain facing, care should be observed to so protect the incisal edge of the facing from direct stress, either by beveling and tipping it with gold as will hereafter be shown, or by avoiding contact with opposing teeth, under any and all conditions, otherwise the pins will be sheared off, or the porcelain itself fractured.

A number of tests conducted by the writer, in which the facings of various manufacturers were employed in the construction of porcelain faced crowns with unprotected, as well as protected, tips, disclosed the following: That 60 pounds' stress will fracture the strongest facings, or shear off the pins, while others will become dislodged at a pressure of 12 pounds. Protected facings were not affected by stress and remained intact until sufficient force was applied to bend the metal structure which constituted the metal tip, after which, with slight additional stress, they were dislodged.

Gnatho-dynamometer tests show that the masticatory muscles can deliver a stress of from 20 to 90 pounds in the incisor, and a much greater amount in the bicuspid and molar region. The necessity for protecting facings from stress in some manner is therefore imperative.

HYGIENIC REQUIREMENTS OF CROWNS

In order that the health of the oral tissues may be maintained, a crown should be so constructed as not to prove an irritant, either by directing food to and under the free margin of the gums and holding it there, or by presenting rough, unfinished surfaces to the tissues, and by this means setting up mechanical irritation. The first of these conditions arises from faulty contour, the second from too large or too wide a band.

In a bandless crown, imperfect peripheral adaptation of the crown base to the root face will result in shoulders on either the root or the crown. Such shoulders may or may not prove mechanical irritants, but in any case they afford lodgment for food, which through decomposition will give rise to chemical irritation, with recession of the gingivæ and frequently recurrent caries of the root.

Correct occlusal forms should be developed in order that the usefulness of substitutes may be realized, that undue side stresses may be obviated, and that the crown may not be subjected to extra heavy direct stress. When possible to do so, firm knuckling contact with the proximating teeth should be established, and between neighboring teeth when such loss of contact is occasioned by movement of the teeth toward the space which the substitute occupies.

These several requirements, although previously mentioned, are again in order under this heading, since, if neglected, the hygiene of the mouth cannot be preserved.

In introducing substitutes of any character into the mouth the dominant idea should be to so form them that with reasonable care on the part of the patient they may be kept clean; that they may not injure the remaining natural teeth or oral tissues; that the function of mastication may be restored; that the esthetic requirements may be fulfilled; and withal, that they may be worn with comfort.

Porcelain-Faced Crowns for the Anterior Teeth

By the common methods in vogue, it is possible and practicable to construct many classes and varieties of porcelain-faced crowns for the anterior teeth. It is not, however, advisable, in a work of this character, to attempt to describe all or even a comparatively limited number of such substitutes in extensive detail.

One type of crown, in which a large number of the constructive steps are based on familiar and accepted methods

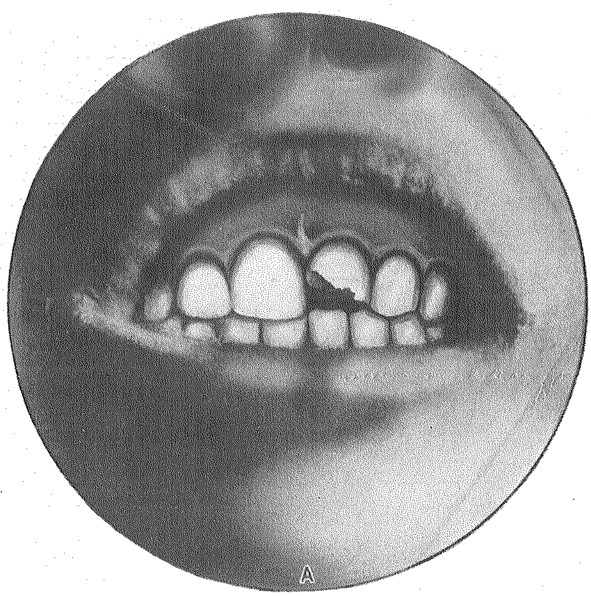


Fig. 498.— Impaired Central Incisor Crown to Be Replaced with a Porcelain Face Crown

of practice, and applicable to many other similar types of crowns, will therefore be described in detail. Consequently, in mentioning variations from the type of crown about to be described, rehearsal of details as here presented need not be repeated.

The crown selected for this description is a left, upper, central incisor, this being one of the most prominent teeth in the mouth, and one for which a substitute crown is frequently required.

The same steps as here detailed are applicable to the crowning of all of the upper anterior teeth, and in most instances, to the corresponding teeth in the lower arch as well.

The student, therefore, is advised to become intimately familiar with every detail as here presented, with the assurance that when he has mastered the technic as outlined, he has laid a substantial foundation for further progress, and has mastered many details applicable to the construction of various other classes of crowns.

Technic of Construction of a Porcelain-Faced Upper, Central Incisor Crown

GENERAL STEPS

Devitalization, treatment and filling of root canal.
Removal of remaining portion of natural crown.
Preparation of root — removal of enamel.
Measurement of root.
Cutting and soldering of band.
Scribing and fitting band to root.
Reducing root face.
Construction of root cap.
Fitting cap to root, and perforating for reception of dowel.
Adapting and soldering dowel to cap.
Taking bite and impression.
Selecting and grinding facing.
Backing the facing.
Assembling and waxing the facing and cap.
Removal and investment of the assembled crown.
Soldering.
Finishing.
Setting.

These steps will now be taken up in order and the various details explained as clearly, yet briefly, as possible.

DEVITALIZATION, TREATMENT AND FILLING OF THE ROOT CANAL

It is assumed that the prosthetist is familiar with the treatment of vital and non-vital teeth, their peridental membranes and adjacent tissues. Therefore, it is unnecessary to dwell extensively on this subject further than to emphasize the importance of adopting correct therapeutic measures and finally in sealing of the apical end of the root with a permanent filling before proceeding with the preparation of the root for the reception of the cap.

REMOVAL OF THE REMAINING PORTION OF THE NATURAL CROWN

To avoid unncessary injury to the dental ligament and soft tissues which surround the tooth cervix while adapting

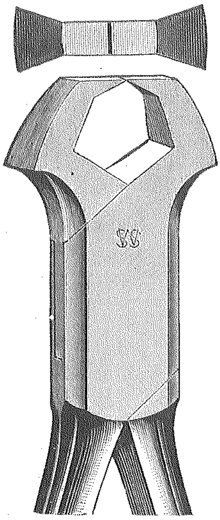


Fig. 499.— Excising Forceps

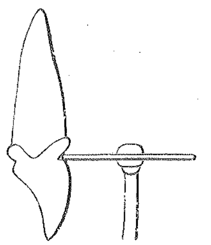


Fig. 500.— Grooving the Enamel of a Crown with Carborundum Stone for Application of Excising Forceps

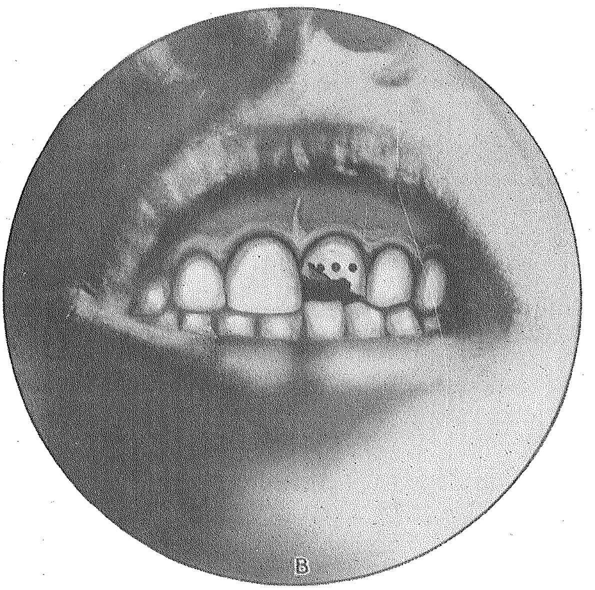


Fig. 501.— Preliminary Step in Removing Crown. Holes Drilled

the band, the remaining portion of the natural crown should not be reduced beneath the gum margin until after the peripheral ring of enamel has been removed, the wire measurement secured, the band scribed and trimmed to correct gingival outline and is finally driven to place on the root.

When a considerable portion of the natural crown re-

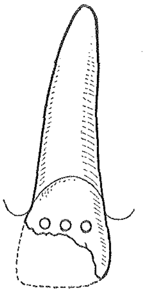


Fig. 502.— Diagrammatic View of Crown Perforated with Drill

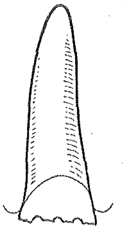


Fig. 503.— Diagrammatic View of Crown Partially Removed

mains, the excising forceps can be used for its removal. Grooves should be cut through the enamel and well into the dentin in the gingival third area, on both labial and lingual surfaces, with a knife-edge carborundum stone. In these

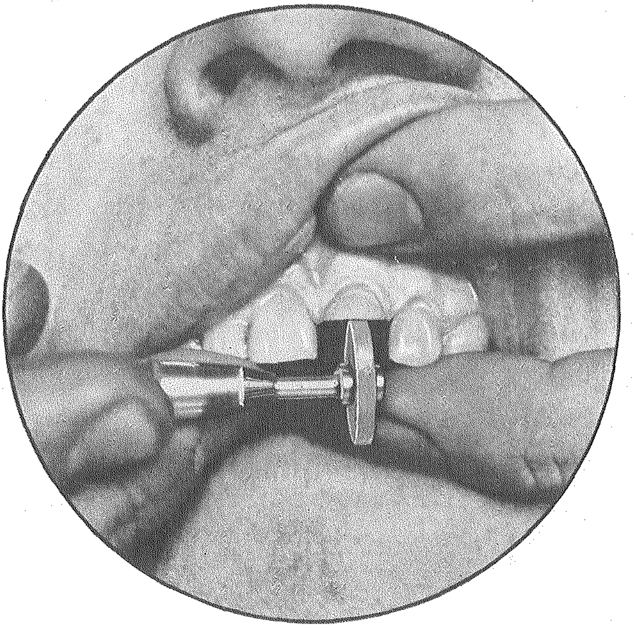


Fig. 504.— Application of Stone in Reduction of Gingival Section of Crown

grooves the beaks or blades of the forceps are set, when, with the application of a little force, the crown can be fractured.

Another method, quite as convenient as that described, consists in drilling several holes through the crown at right angles to the long axis of the tooth and removing the intervening tooth structure between the holes with cross-cut fissure burs. The drill should be introduced in the cavity and the holes cut from within outward, when possible, or the enamel surface can be notched with a carborundum stone as described, and the drill entered in the groove. A bi-level drill made by flattening an inverted cone bur on two sides and beveling the point is most efficient for this purpose.

After the bulk of the crown is thus removed, the remaining stump is reduced with engine stones to within about one-sixteenth of an inch of the gingiva, after which the enamel can be removed.

REMOVAL OF THE ENAMEL

The most effective instrument for removing the enamel is the Case cleaver, or some modification of it of which there

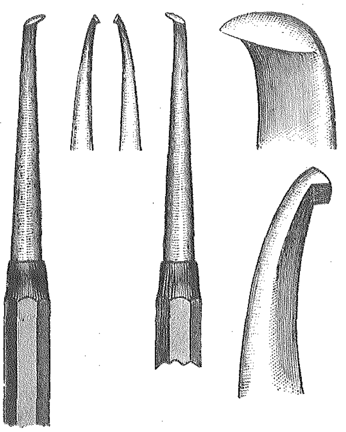


Fig. 505.— Case Enamel Cleavers

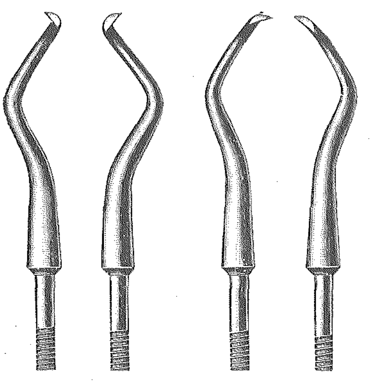


Fig. 506.— Ivory's Contra-Angle Enamel Cleavers

are several on the market, notably the Ivory and the Weaver. A selection of these instruments with both straight and contra-angle shanks should be on hand for this purpose. These

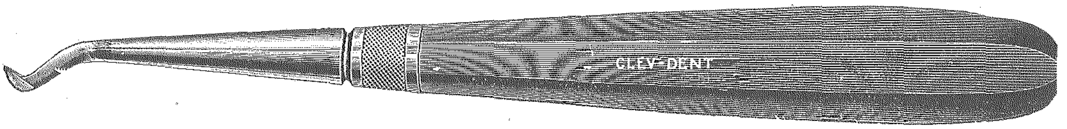


Fig. 507.— Weaver Enamel Cleaver

instruments have a side blade, terminating in a sharp, rather bulky point for strength, and are tempered very hard so as to readily break the enamel.

The point of the instrument is applied to the enamel, under the gum margin, pressure exerted and the point drawn incisally. This step is repeated many times, the position of

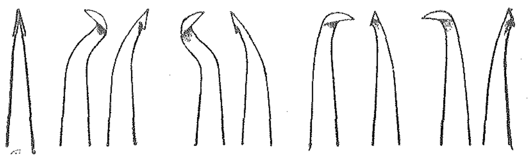


Fig. 508.— Enamel Cleavers of Various Forms

the point being shifted each time, until as much of the peripheral ring as it is possible to reach with the point has been so treated. The enamel will seldom come away as a result of application of the point in this manner, but the cohesion

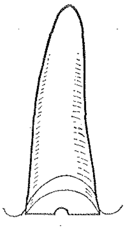


Fig. 509.— Root Showing Peripheral Enamel Ring to Be Removed

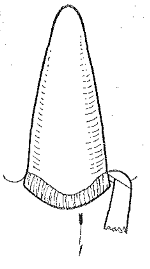


Fig. 510.—Position of Cleaver Point in Fracturing Enamel Surfaces

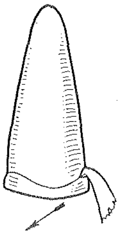


Fig. 511.—Application of Side Blade of Cleaver in Removing Enamel

of the rods will be disturbed by the many fracture lines developed.

The cleaver is now passed beneath the free margin of the gum, the side blade near the point being laid in contact with the enamel. The instrument should be held with the palm grasp, the thumb on the adjacent tooth to serve as a rest, and with a forward and outward movement incisally, the instrument is rotated from beneath the free margin of the gum. With the application of moderate force applied to a great extent in a tangential direction, the enamel can readily be removed from the labial and lingual surfaces and from well into the four embrasures.

When the interproximal spaces are constricted the enamel must be removed by other means, since the cleaver points are too bulky to enter these spaces to any great extent.

A very small fissure bur can frequently be passed into the embrasure, and under proper control will fracture the remaining enamel so that it can be removed with the root files. Care must be taken to avoid injuring the dental ligament, the peridental membrane and the proximating tooth with the bur, also

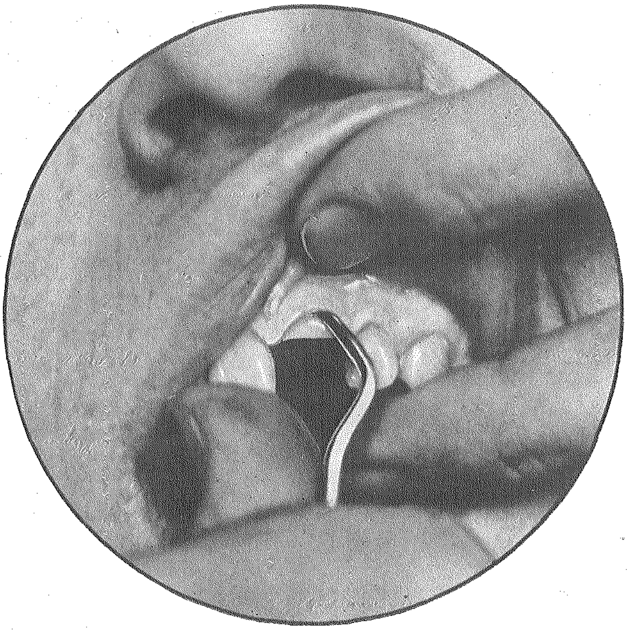


Fig. 512.— Cut Showing Proximating Tooth Used as a Thumb Rest in Cleaving Enamel

to avoid notching the root margin from the bur working beneath the enamel and into the dentin.

SMOOTHING THE ROOT PERIPHERY WITH FILES

A pair of right and left diagonally-cut, thin bladed files, such as designed by the writer, or others of similar type, will be found very useful for planing and smoothing the periphery of the root after the cleavers have removed the bulk of enamel. These files are designed to be used in a tangential direction, much the same as the cleavers, and are held with the palm grasp. They pass without difficulty in constricted embrasures.

The entire periphery of the root, from its face end to as far under the free margin of the gum as the crown band is to extend, must be made smooth and free from all irregularities.

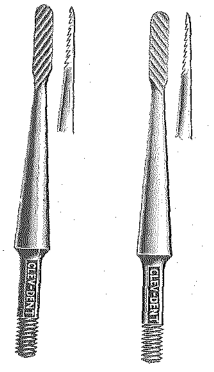


Fig. 513.— Enamel Files for Smoothing Root Periphery. (Prothero)

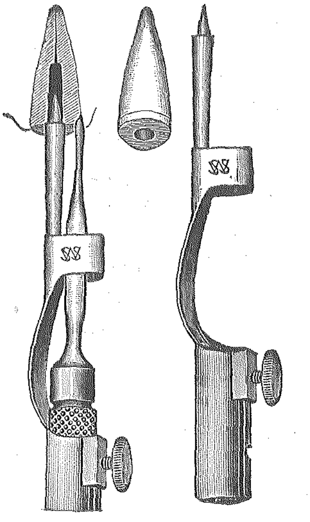


Fig. 514.— Engine Root Trimmer for Peripheral Smoothing of Root

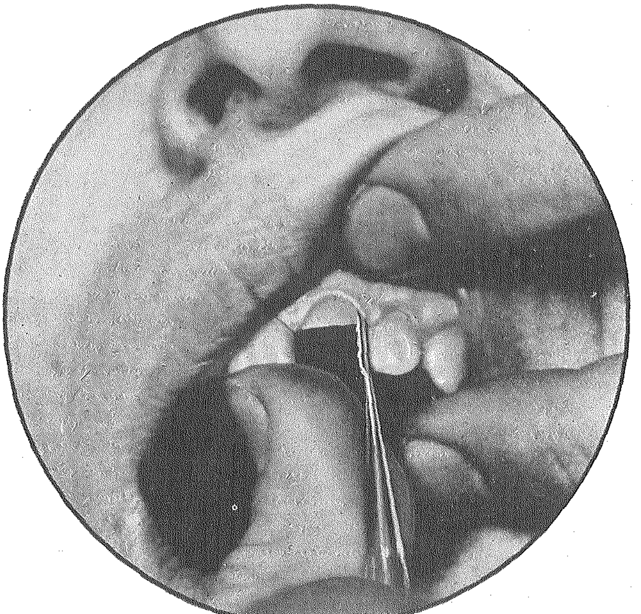


Fig. 515.— Application of the Root Files in Peripheral Trimming of Root

GENERAL FORM OF THE PREPARED ROOT

The peripheral form of a prepared root should be that of the frustum of a cone, the large end situated under the free margin of the gum at the terminal location of the crown band, the smaller end terminating at the face of the root. The flare of the sides of the cone should not be excessive, not

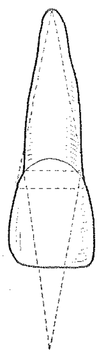


Fig. 516.— Diagram of the Conic Form a Root Should Be Given for Reception of Band. Labial View

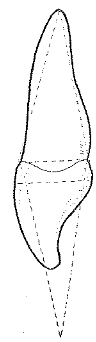


Fig. 517.— Proximate View of Tooth, Showing General Reduction of Root for Band

more than five degrees nor less than two degrees. A root prepared with too much flare affords but little retention for the band in fitting, while if not flared at all, as when the periphery is not given a cone shape, the band when fitted will usually present a gingival shoulder under the free margin of the gum of more or less prominence, depending on the failure

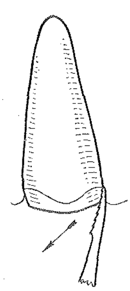


Fig. 518.— Diagrammatic View of File Applied to Root Periphery

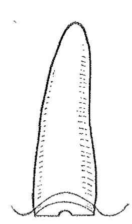


Fig. 519.— Diagrammatic View of Prepared Root

of the prosthetist to produce a true flare or constriction on all surfaces, from gingival toward the incisal area.

The exact fitting of the band of a crown to the root under the free margin of the gum is of vital importance, for regardless of how carefully subsequent steps are carried out, an imperfect form of root preparation will invariably result in the production of a shoulder, either on the root itself or from too large a band.

TESTING THE FLARE OF THE ROOT SURFACES

Since a considerable portion of the root surfaces to which the band will be applied is obscured by the gum tissues, it is sometimes difficult to determine with the eye when proper form is developed. One test that may be applied is to place the point of a delicate instrument, as an explorer, on the side of the root, near the face end, and pass it carefully toward the apex, observing closely the direction it travels, or whether its line of movement changes as would be the case when it passes over a ridge and gradually or suddenly drops into a depression.

By applying the instrument first on one, then on the opposite side of the root, comparing the line of movement each time with the same fixed surface, as the axial surface of a proximating tooth, it can soon be determined whether or not the proper flare to the root sides has been developed.

A second test may be observed in the wire root measurement, which, when tightly twisted, if it can be readily separated from the root without stretching or untwisting, indicates that the gingival portion of the root is the largest. When it becomes necessary to cut or untwist the wire measurement to effect its removal this is positive proof that the sides of the root have not been reduced to a conical form, nor even brought to a parallel relation with each other. Further reduction of the root becomes necessary under such conditions.

In general form, a root should be sufficiently cone-shaped so that as the band is forced apically it tightens.

SECURING THE MEASUREMENT OF THE ROOT

A piece of 36-gauge, annealed iron wire, about three inches long, is bent in the form of a loop, and fixed in a dentimeter

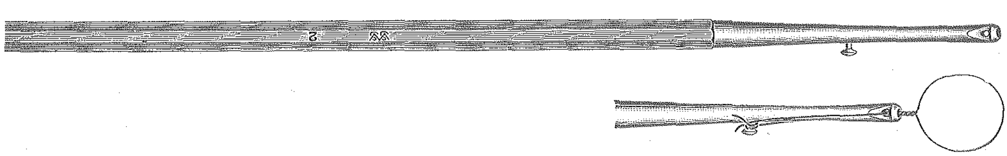


Fig. 520.— A Dentimeter for Holding and Applying the Wire Measurement to Root

or an ordinary broach holder. The loop is then passed over the projecting end of the root, the handle turned until the wire engages loosely with the root surfaces. Careful adjustment of the loop is now made so that it occupies a place even with or slightly under the free margin of the gum. Under no condition should it be carried apically to the extreme limit of the cone base, as such a measurement would usually result

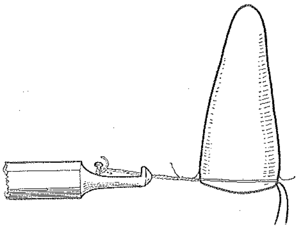


Fig. 521.— Wire Loop Applied and Tightened Around Root

in a loose-fitting band. The fundamental idea to keep in mind is the production of a band slightly smaller than the section of root cone where its apical end will terminate when finally fitted. As the metal is driven under the free margin of the

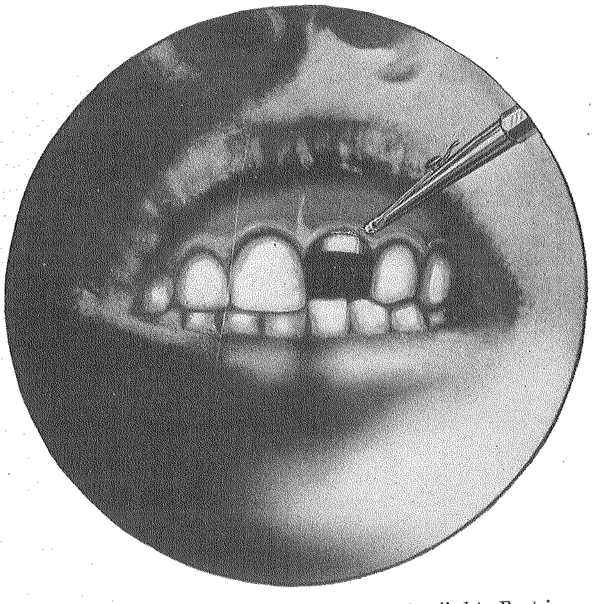


Fig. 522.— View of Wire Measurement as Applied to Root in the Mouth

gum, the conic form of the root will cause it not only to assume correct peripheral adaptation, but stretch it sufficiently to take its proper position. By adopting this method of fitting the band, together with correct root preparation, gingival shoulders are avoided.

MEASURING AND CUTTING THE BAND FOR THE ROOT CAP

After removal of the wire measurement from the root, it is cut opposite the twist and the two halves are straightened out, care being taken not to untwist the wires, as such a mishap would increase the length.

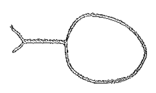


Fig. 523.— Wire Loop Measurement Removed from Root

The straightened measurement is now laid on a piece of gold plate, usually 29 g. and 22 k. The lamina of the gold should run lengthwise of the band for greatest textile strength. One end of the measurement is placed exactly even with the edge of the plate, and with a thin, sharp blade, a

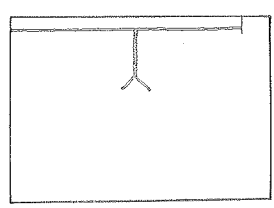


Fig. 524.— Loop Measurement Severed, Straightened, and Laid on Gold Plate for Marking Length of Crown Band

mark is made on the gold exactly even with the other end of the wire. This indicates the length of the band.

The width of the band should be slightly greater than the apico-incisal curvature of the gingiva. Usually one-eighth of an inch in width is ample, but when the curvature is very marked a wider band will be required.

The length and width of the band having been marked, the gold strip is cut with a pair of plate shears, being specially careful to cut it the exact length.

Another method consists in making a lap joint to the band and after soldering reduce the excess thickness, the idea being that such a joint is stronger as well as less liable to become unsoldered in subsequent steps.

When a lap joint is to be formed the measurement is taken as described and the gold marked accordingly. An amount equal to the width of the lap is now added to the original band length as determined by the wire measurement and the band cut that much longer.

In forming the band, one end of the strip overlaps the other an amount equal to the excess length previously marked.

FORMING AND SOLDERING THE BAND

The band is now bent in the form of a ring or ferrule and compressed so that the two ends of the strip pass each other slightly. When later adjusted, the ends will be held in contact by the resiliency of the metal.

The band is now sprung apart and the ends abutted squarely against each other between which there should be absolute contact, otherwise it will be difficult to unite them perfectly with solder. Should either or both ends have been cut irregularly they must be corrected by filing. By observing care in cutting the band the application of the file will be unnecessary.

A piece of 36g., annealed, untinned, iron wire is bent around the band and twisted to form a loop, the twist opposite the joint. This twist serves as a plier grasp for holding the band while soldering, while the loop itself prevents the ends from springing apart. When tinned iron wire is used as a binder, the tin unites with the gold during soldering, to form a low fusing alloy, and frequently as a result the band may be partially melted.

A little flux (pulverized borax and water, or *soldering flux paste*) is applied on the inside of the band along the joint, being careful to place it *only where needed*, since the solder will spread unnecessarily on the band if the flux is applied carelessly or in excess.

When the joint between the two ends of the band is close, as it should be, an almost inconceivably small amount of solder, properly placed and fused, will effect a perfect union. An excess of solder, which, when fused, extends any distance on either side of the joint stiffens the band and renders its perfect adaptation to the root difficult if not impossible.

Usually a piece of solder one m. m. long and one-half m. m. wide, will prove ample for any ordinary band joint.

The piece of solder is now laid on the inside of the band and across the joint, each end of the solder resting on a different end of the band, the joint space being thus bridged over. As the solder fuses, being already in contact with the two ends of the band, gravity causes it to settle to place in the joint.

The twisted ends of the loop are grasped with a pair of soldering pliers and the band is carried close to the Bunsen flame, but not into it, until the moisture has all been driven from the borax. This should be carefully done or the evaporation of the moisture from the paste, and later the driving out of the water of crystallization from the borax, during which the latter swells, will displace the solder before it fuses.

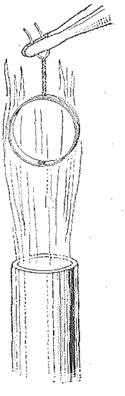


Fig. 525.—Soldering the Band Joint. Notice the Piece of Solder Crosses the Joint and Rests on Both Ends of the Band

The band is now carried into the flame and held in the reducing flame until the solder is fused, when it must be instantly removed, as the gold itself is liable to fuse at the joint if only slightly overheated.

The wire is now removed and the band contoured to the general form of the root. When the convexity of the alveolar border is very marked, the band can be cut out slightly on its mesial and distal sides, from the gingival border, to partially approximate the required curvature, after which the final fitting can best be done on the root. The joint of the band is usually placed to the lingual side of the root, sometimes to the mesial or distal in certain bridge cases, but never to the labial.

SWEATING THE BAND (AUTOGENOUS SOLDERING)

The higher carats of gold can readily be *autogenously* soldered, or, as it is commonly expressed, *sweated*. This process consists in maintaining the parts to be united, as the ends of the band, in intimate contact and bringing the gold along the margins of the joint to such a state of fusion that the molecules of the two pieces will intermingle. Though apparently a difficult process, with a keen vision and a steady hand, it can readily be accomplished.

The essentials to success are a high grade gold that will not readily oxidize, close contact of the surfaces to be united, a limited application of clean flux along the joint, a strong but not large reducing flame, so that the heat may be concentrated along the desired line of union, and finally the removal of the piece from the flame the instant fusion occurs.

This method of joining pieces of gold without the interposition of solder is applicable, not only to the forming of bands, but to the attachment of discs to bands in the production of root caps as well.

SCRIBING THE BAND TO GINGIVAL OUTLINE

In fitting a crown band of any class to the root or remaining portion of the crown of a natural tooth, its cervical end should be so shaped that as it is passed into position it will touch the gingival gum margin at the same time. When trimmed in this manner, this will insure a uniform width of band under the free margin of the gum, when it is finally driven to place.

The most convenient method for marking this *trimming* line on the band is by means of a pair of jeweler's spring dividers. In mechanics, this process is known as *scribing*. The method is carried out as follows:

The band is passed over the root until its mesial and distal margins are in contact with or are carried slightly under

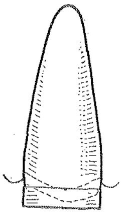


Fig. 526.— Untrimmed Band Applied to Prepared Root

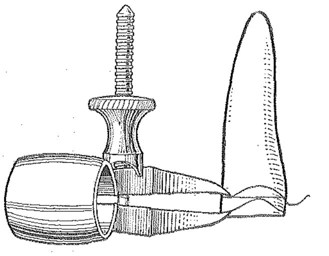


Fig. 527.— Scribing Caliper Applied for Marking Gingival Curvature on Band

the gingival tissues in the interproximate spaces. A space usually shows on the labial view of the root, between the gingival end of the band and the highest curve of the labial gingiva. This space indicates the distance apart at which the points of the dividers must be set, one point being placed in contact with the gum margin, the other just resting on the gingival margin of the band.

The dividers are now drawn along root and gold band from the center of the labial surface, first mesially then distally, the point on the plate marking a line as the other follows the gingival gum curvature.

The dividers should not be rotated as in drawing an arc, but be held so that a line extending from one point to the other is at all times parallel with the long axis of the tooth.

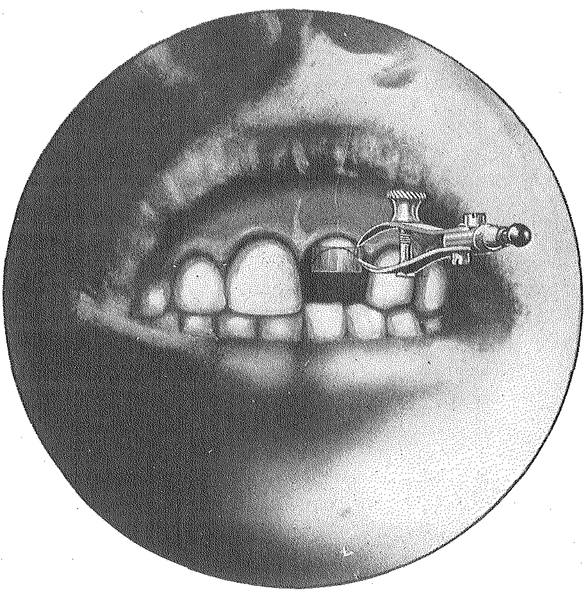


Fig. 528.— Jeweler's Spring Calipers Used for Scribing Band. More Convenient Than the Preceding Instrument

Since the dividers cannot conveniently be used within the oral cavity, for marking the lingual *trimming line,* an explorer can be used for this purpose, keeping its point as far removed from the lingual, gingival curvature as the divider point which rested on the gold was removed from the labial gum margin while marking the labial surface of the band.

When both labial and lingual trimming lines are thus marked, the band is removed, and with a pair of small, curved beak, crown shears, trimmed accordingly. The margins are now smoothed with a half round, fine cut file, so that they will not irritate the soft tissues in the subsequent steps of fitting to the root.

FITTING SCRIBED BAND TO THE ROOT

The band, with its gingival end modified as described, is returned to the root and pressed cervically until about in contact with but not quite beneath the free gum margin. A close examination is now made to see whether the gingival margin of the band is parallel with that of the gum tissue. If not, the band margin should be corrected by reducing with a file, the points which first touch the tissues, until the paralleling or approximation of the two margins is accomplished. There are cases where it is necessary to carry the gingival band margin farther beneath the gum at one point than another, as

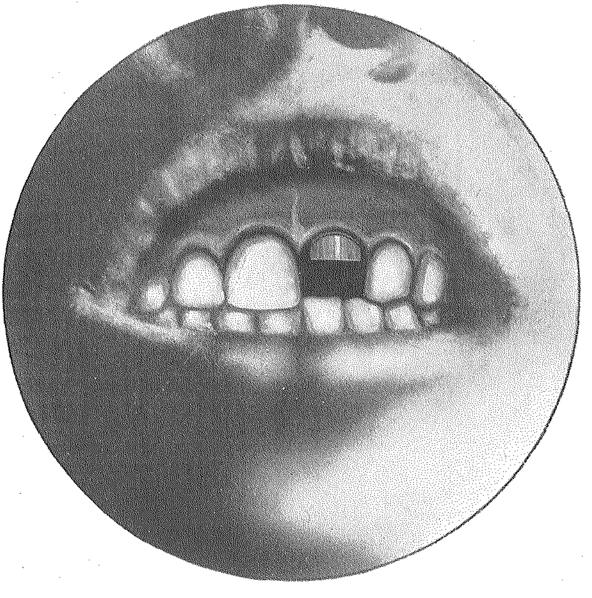


Fig. 529.— Band Scribed, Trimmed and Returned to Root. Notice Its Gingival Margin Coincides with Curve of the Gums

where the free flap of the gum tissues varies in its width, or because of hypertrophy or some previous injury it is not of normal curvature or depth, or where a pocket may be present, and it is considered best to extend the band to line of attachment of the peridental fibers to the root. Such conditions should be noted and the band formed at this time to meet the requirements of the case.

The band is now carefully and lightly driven beneath the free margin of the gum, usually to the depth of one to one and one-half millimeters when conditions are normal. The cervical margin of the band should *approach*, but never *encroach* on the attachment of the peridental fibers to the root, nor should it ever pass beyond the base of the root cone developed by the cleavers and files. Should this occur, the result will be the formation of a shoulder under the free margin of the gum, which will prove a mechanical irritant to the soft tissues from the moment the crown is permanently set. Later, when food finds its way beneath the tissues and lodges on the shoulder, as decomposition sets in, chemical irritation augments the mechanical, and loss of the root will eventually occur. The most painstaking and conscientious effort should be bestowed not only upon the preparation of the root, but in the fitting of the band as well, in order that the substitute crown may prove permanent and comfortable when set.

TRIMMING BAND TO PROPER WIDTH

The band being driven to place as described, its cervical margin in close contact with the sides of the cone base and the proper distance under the free margin of the gum, is still

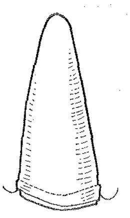


Fig. 530.— Cervical and Incisal Ends of Band Reduced to Proper Outline. Band Driven to Place Under Free Gum Margin

only partially formed. The opposite end of the band or that portion which projects beyond the free margin of the gum must be reduced to such length that when the root cap, of which it forms a part, and on which the porcelain facing rests, is completed, no gold will be visible on the labial surface.

With a sharp pointed instrument a line is marked on the band close to and following the gingival curvature of the gums, around its entire periphery, labially, lingually and in the embrasures as well.

The band is then removed from the root and with a pair of curved shears cut to the line marked on labial, mesial and distal surfaces, but not necessarily on the lingual surface, since a wide band in this area is desirable, affording greater resistance to outward stress than a narrow band.

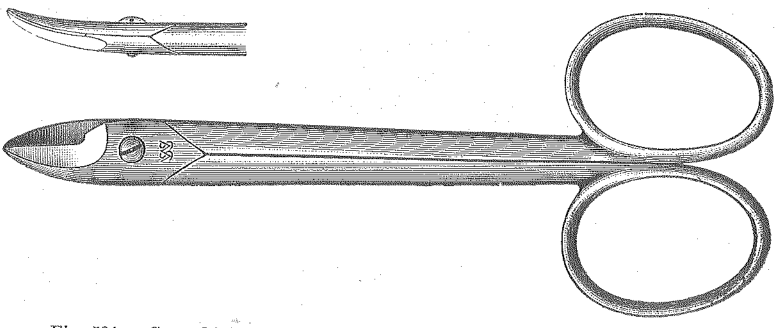


Fig. 531.— Curved Blade Crown Shears Suitable for Trimming Band Margins

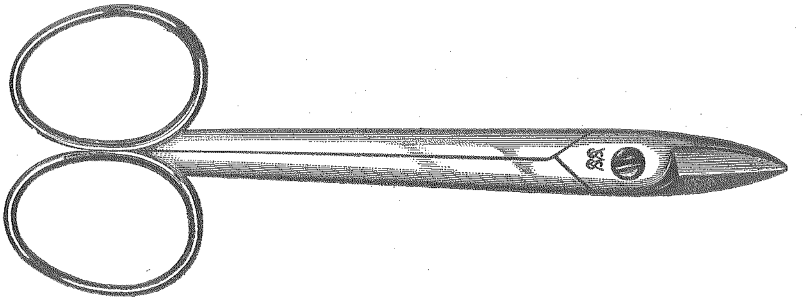


Fig. 532.— Straight Blade Crown Shears for General Use

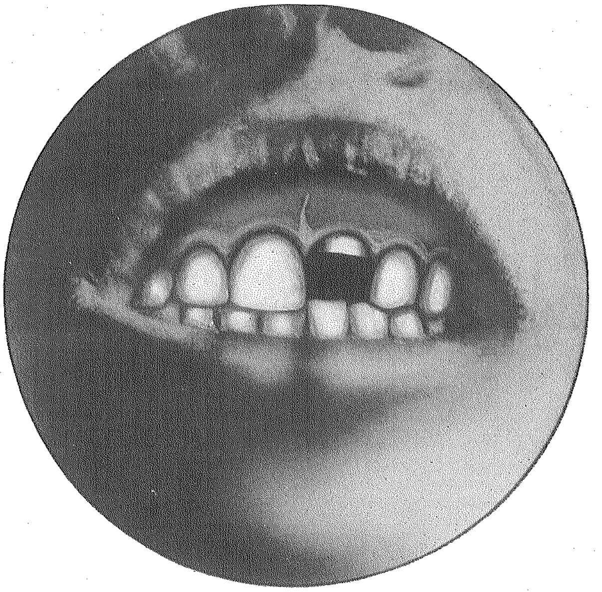


Fig. 533.— Trimmed Band Fitted to Root. View Obscured by Gum Margin

The band is returned to the root, driven to place and the projecting end of the root reduced to the gum margin on the mesial and distal, slightly beneath on the labial and near to but not beneath on the lingual surface in order, as before

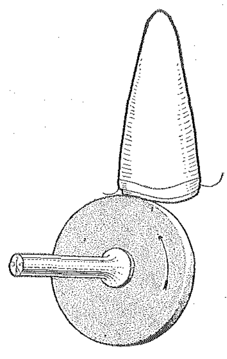


Fig. 534.— Stone Applied for Final Reduction of Root Face. Arrow Indicates Direction Stone Should Revolve to Avoid Injury to Free Gum Margin

stated, that the band may be wider to better resist the stress of the opposing teeth.

The general form of the face end of the root should be convex from labial to lingual and straight or slightly concave from side to side, depending on the depth of the labial curvature of the gingiva. The root may also be ground to present two planes, one sloping from the pulp chamber labially, the other from the pulp chamber lingually. This form

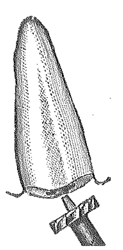


Fig. 535.— Ottolengui Root Facer as Applied in Reducing Excess of Root

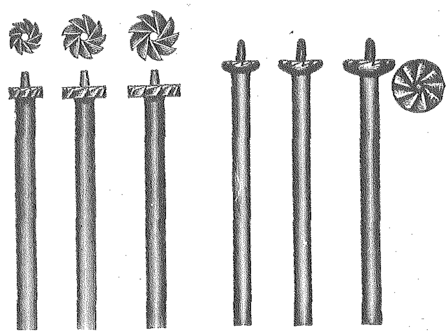


Fig. 536.— Various Sizes of Forms of Ottolengui Root Facers

of preparation, which is common, will usually require less grinding of the ridge lap of the facing than when the root face is decidedly convex.

The root may be faced with an engine stone about three-fourths of an inch in diameter and one-eighth inch face, or with the Ottolengui root facers, the various sizes of which afford the selection of one suitable to different sizes of roots.

The Roach root facer can be used to advantage in reducing the projecting end of the root. This appliance has a central loose pin which keeps it within the root periphery.

In facing the root with the stone it should revolve from the root toward the free margin of the gum to avoid laceration of the soft tissues.

The root should be faced even with but not shorter than the band, for when the disc which forms the end of the cap is attached it should rest directly upon the root end. Care

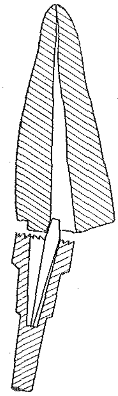


Fig. 537.— The Roach Root Facer, with Movable Center Guide Pin

should be taken, therefore, in facing the root, not to reduce it below the band margin or in driving the finished cap to place, the cervical end of the band will be forced too far apically.

CONSTRUCTING THE ROOT CAP

The root cap consists of the band formed as described, to which is attached a disc of metal, designed to rest upon the root face and which forms the foundation for the crown. The constructive steps are as follows:

The band is removed from the root and a disc of 24 k. or 22 k. 30 g. gold, slightly larger in diameter than the band, is adapted to its incisal end. General adaptation may be secured by placing the cervical end of the band on the ball of the thumb, adjusting the disc correctly against the other end and with the ball of the finger forcing it in contact with the band margins. While pressure is thus maintained, a thin blade burnisher is applied between the ball of the finger and the disc to conform it accurately at all points to the band edge. By scratching the side of the band and adjacent surface of

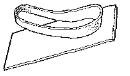


Fig. 538.— First Step in Adapting Gold Plate to Completed Band in Forming Root Cap

Fig. 539.— Plate Adapted to Band Periphery

the disc at two or three points, the two parts may later be re-adjusted in exact relation as they must be when soldering.

When closely adapted, which means positive contact of the disc with the band around its entire peripheral edge, the two are separated, a thin film of flux is applied to the disc surface on which the band will rest, a little to the band edge also, and the outer margin of the disc is caught in the beaks of a pair of self-locking soldering pliers. A very small piece

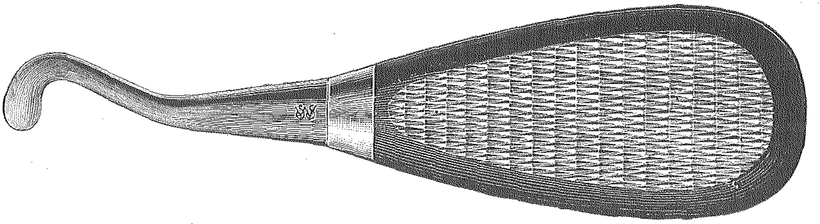


Fig. 540.— Plate Burnisher for Adapting Backing to Facing (Prothero)

of solder is cut and set endwise, one end resting on the disc, the other against the outside of the band, care being taken to see that the band and disc are in exact relation to each other, as previously marked.

SOLDERING THE BAND TO THE DISC

The disc with band and solder in place is quickly passed back and forth through the flame a few times to gradually expel the moisture and water of crystallization from the flux and thus obviate displacement of the band, after which it is held in the reducing flame until the solder fuses, when it is quickly withdrawn. When the adaptation between disc and band is perfect, the solder should flow around the entire joint periphery. Frequently, however, the solder will fail to flow along the joint immediately in front of the plier beaks because the conduction of heat by the latter, away from the gold in that particular area, lowers the temperature below the fusing point of the solder. By grasping the opposite side of the disc

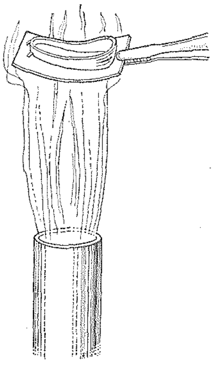


Fig. 541.— Soldering the Band and Disc. Notice Two Small Pieces of Solder on Opposite Side from Plier Beaks. One Piece Is Usually Sufficient

with the pliers and again introducing in the flame, complete union of band and disc can usually be effected without addition of more solder.

TRIMMING OFF THE PERIPHERAL EXCESS OF THE DISC

The flat side of the shear blade is applied against the side of the band, and the excess margin of the disc removed. Further reduction should be made with the file, care being taken to avoid rounding the disc margin, but leave it square and

Fig. 542.— Cap Completed. Excessive Surplus Margins Removed

flush with the band. In some cases it is advisable to allow it to extend slightly beyond the outer surface of the band, particularly on the labial surface, when proper alignment of the facing requires that it be set to the labial of the band surface.

CONSTRUCTING CAP BY THE INDIRECT METHOD

In making a cap by the indirect method, the excising of the crown, removal of the enamel and smoothing up of the root cone is the same as by the direct method, in which the cap is constructed of two pieces, as described. The steps vary, however, from this point on.

In the indirect method, the root must be faced to the final form desired, the labial portion being reduced beneath the free margin of the gums the full extent before the impression is secured. Counter-sinking the canal orifice should also be done so that this depression may be reproduced on the die.

TAKING IMPRESSION OF ROOT

A seamless copper band, slightly larger than the root, is contoured to its general peripheral outline, and the contoured end trimmed to approximate the curve of the gingiva. The band should be slightly longer than the proximating teeth for convenience in handling.

The band is filled slightly in excess with softened modeling compound, then introduced between the proximating teeth,

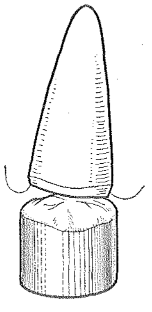


Fig. 543.— Band Filled with Modeling Compound Preparatory to Taking Impression of Root Face and Periphery

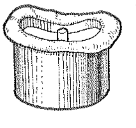


Fig. 544.— Impression of Root in Modeling Compound

and evenly centered over the root. Pressure is now applied to force the compound against the root face and at the same time telescope the band over the root periphery so as to confine the compound and press it closely against the sides of the root. The thumb or finger should be placed over the outer or open end of the band to prevent the compound escaping in this direction. The Ivory impression cups, a number of varying sizes of which are supplied, which fit into a universal handle, are well adapted to this work.

When properly carried out, the gum margin is pressed apically and an impression of the face end of the root and of the sides as well can be secured. Because of the limited compressibility of the gum tissues, an impression of the root sides, as far apically as the band will eventually extend, can seldom be secured, but sufficient of the root surfaces can be embraced so that the die when developed can be filed away to represent a longer root. When this plan is followed care should be taken to preserve the original flare of the root cone.

CONSTRUCTING THE ROOT DIE

Any excess impression material that may have been forced out beyond the periphery of the impression band is removed. A section of rubber tubing which neatly fits the outside of the band is slipped over it and allowed to project about one-eighth inch beyond the impression, to confine the amalgam or cement and thus increase the depth of the die.

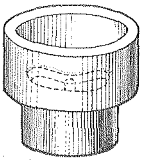


Fig. 545.— Rubber Band Applied to Impression Periphery to Confine the Amalgam

A mix of amalgam, such as is used for die purposes, is made and carefully worked into all inequalities of the impression, being careful while doing so not to mar any of the surfaces. Not only the impression, but the rubber ring is filled to give sufficient base to the die to resist the stress of swaging and that it may be well anchored in the swaging ring.

IMBEDDING THE DIE IN THE SWAGING RING

The die, when hardened, is removed from the impression by warming the latter, and set in a base of modeling compound in the swaging ring, placing it well above the margin

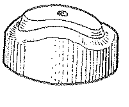


Fig. 546.— Amalgam Die After Impression Is Removed

of the ring, so that the counterdie material may press the gold against the sides of the root.

Should any change of form of the die be indicated, as increasing the length of the root apically, it can be made at this time. In practically all cases such change should be made, even to the extent of increasing the length of the root *beyond* what is required. The band of the cap when swaged will naturally be wider than necessary, but in fitting to the root it

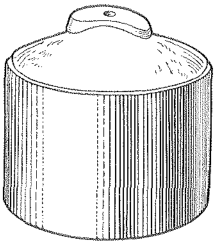


Fig. 547.— Die of Root End Adjusted in Swaging Ring

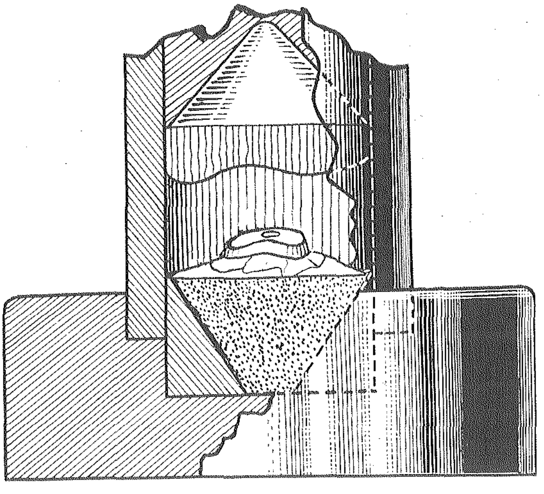


Fig. 548.— Die Imbedded in Ring within Swager

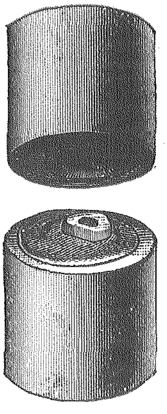


Fig. 549.— A Two-Ring Swaging Device

can readily be reduced to correct width, while if too narrow the form of the die must be changed as outlined and the cap reconstructed.

SWAGING THE ROOT CAP

The swaging ring is now placed in the base of the swager, a disc of pure gold, of 34 or 36 gauge, slightly larger than will be required to form the face and sides of the cap, is oiled on both sides and adapted by finger pressure and burnishing, to the die. The general outline of the cap can thus be definitely determined and the surplus gold removed practically to the band margins.

The swager is set in position, unvulcanized rubber or moldine being interposed between the plunger and the root cap, and with two or three heavy blows of the swaging hammer the cap is swaged.

The band margins are now trimmed to as nearly the correct width as possible before trial in the mouth, and the cap reswaged to correct the distortion from trimming. Since a die formed in the manner described shows distinctly the en-

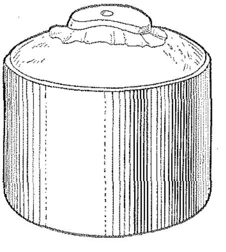


Fig. 550.— Swaged Cap, in Position on Die. Surplus Not Yet Removed

trance to the root canal, and this is indicated by a depression in the cap, the hole for the dowel may be punched before the last reswaging.

The cap is boiled in acid to remove any adherent amalgam and cleanse the surfaces, then washed to remove the acid, when it is ready for fitting to the root.

FITTING THE CAP TO THE ROOT

The principal fitting to the root consists in trimming the band to proper width. The cap is placed on the root and light pressure applied. If any obstruction is met the location and cause are ascertained and correction made. The usual change necessary is to shorten the cervical end of the band so that it will not encroach on the tissues around the root cervix. When the cap can be firmly seated without impingement on the tissues, a thin, flat burnisher is applied under the gum margin and the band burnished into close contact with the root periphery. While doing so the cap must be held in close contact with the root face.

From now on, the steps are similar to those described for the two-piece crown, the next step being securing the relation between cap and dowel and attaching them as previously described. In flowing the solder which unites cap and dowel, the entire cap and band as well should be covered at the same time with a thin layer of solder to give it rigidity.

ENLARGING ROOT CANAL FOR RECEPTION OF THE DOWEL

If the root canal has not already been prepared to receive the dowel, it must be at this time, since the following steps relate to the fitting and adjustment of the dowel to the root and cap.

The reaming out of a root canal is a comparatively simple step when the prosthetist himself has treated the root and filled the apex. When, however, the case presents, the root having previously been filled by another operator, an effort should be made to determine the probable length of the root and its position in the border. If any doubt exists as to its anatomic form, its position, or the thoroughness of the root filling, a skiagraph should be secured to determine as accurately as possible the existing conditions.

Examination of the labial tissues overlying the root will frequently disclose a slight elevation of the mucous membrane and underlying alveolar plate, which will indicate the position of the root in the process. If no visible evidence is present, pressure with the ball of the finger, particularly in the apical region, will frequently locate the direction of the root. It is of the utmost importance that the general trend of the root be known before attempting to ream out and enlarge the canal. When for any reason it is impossible to determine it, the greatest care should be observed in keeping the cutting instrument within the canal and pointed in the right direction or serious injury is liable to occur.

A rigid, inflexible *drill, bur* or *root reamer,* having a *cutting point,* is a dangerous instrument in the hands of an unskilled or careless operator. Perforation of the side of the root is very liable to occur as a result of the instrument point leaving the canal and boring its way through the dentin and into the alveolus. The tissues injured as a result of such accident seldom ever recover their normal tone, the root having a feeling of chronic soreness, while frequently its extraction in a short time becomes necessary.

The safest method of removing a root filling and enlarging the canal to the required diameter, or to such size that a reamer may with safety be used, is by means of various sizes of round engine burs. The technic is as follows:

Determine, if possible, the general direction of the root, and keep this constantly in mind at all times until the initial reaming of the canal to proper depth has been accomplished.

Place a No. ½ round bur in the handpiece and introduce the point in the entrance to the canal.

Line the handpiece up to conform to the general direction of the root, holding it loosely with the pen grasp.

Start the engine and apply light pressure with the point of the bur, removing it frequently to bring out the gutta-percha cuttings and keep the canal clear.

Do not attempt to guide the point; it will follow the canal if the handpiece is held loosely and in proper alignment, and the cuttings are removed frequently.

Since a dowel should extend as far apically as the crown extends incisally, it will be necessary to ream out the canal to this depth when the length of root will permit.

As soon as the bur begins to bind, and the *feel* or vibration of the handpiece indicates that the bur is cutting dentin instead of root filling, an examination should be made with a straight explorer to determine whether the bur is leaving the canal and if so, the cause.

Should the tapering shank of the small bur jam against the sides of the canal before the latter has been opened to required depth, a No. 3 round bur can be substituted and the canal slightly enlarged from without inward for a short distance, thus making room for the shank of the smaller bur with which the opening of the canal can be completed to the required depth.

The No. 3 bur is now used in the manner as described for No. ½ bur, holding the handpiece loosely and allowing the bur to make its own way in the now open canal as far as the latter has been opened by No. ½.

The canal can now safely be enlarged to the required size for the reception of the dowel with either Nos. 4 or 5 round burs, depending on the diameter of the dowel to be used. Any of the ordinary forms of reamers can also with safety be used, since there is little danger, except when grossest carelessness is displayed, of perforating the side of the root.

Great care should be taken to avoid passing the small round bur through the apical end of the root, or of disturbing that portion of the filling which closes the terminal of the canal. Pressure on the bur must be extremely light at all times, but particularly so in the final steps of removing the root filling.

COUNTERSINKING THE CANAL OPENING

To give rigidity to the cap and a firmer attachment to it of the dowel when soldered, the entrance to the root canal should be slightly countersunk with a No. 10 round bur, and into this depression the cap disc is depressed.

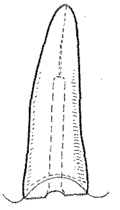


Fig. 551.— Labial View of Root, Showing Canal Entrance Slightly Enlarged

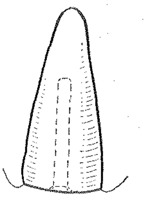


Fig. 552.— Proximate View of Root, Showing Enlarged Canal Entrance

INDENTING THE CAP IN COUNTERSUNK AREA

The cap is now returned to position on the root and the small end of the large egg burnisher is applied to its central area with sufficient force to press it into the depressed area.

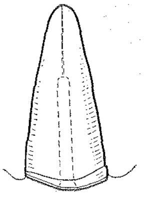


Fig. 553.— Root Cap in Position, Notice That Labially the Band Is Beneath Gum Margin, While Lingually It Projects Slightly Beyond

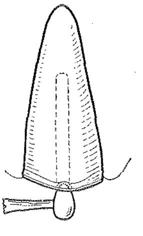


Fig. 554.— Forcing the Cap Into the Root Canal Entrance

Usually, when the burnisher is somewhat pointed, the gold will be forced slightly beyond the countersunk area and into the entrance of the root canal itself, thus giving the exact location of the hole in the cap for the dowel.

PERFORATING THE ROOT CAP FOR THE DOWEL

A heavy instrument, with a sharp point, the diameter of which is slightly less than the dowel, is now forced against the cap directly over the opening in the root, and the gold punctured. A small engine drill may be used for the same purpose, or the cap can be removed and the hole punched with the plate punch. The opening, as before stated, should be smaller than the dowel, so that when the latter is forced through it the margins of the disc may fit tightly against and hold the dowel firmly in position.

FORCING THE DOWEL THROUGH THE CAP INTO THE ROOT

The dowel, usually of 16 or 15 g. iridio-platinum, or clasp metal wire, is cut slightly longer than the actual depth of the reamed canal, so that it may project beyond the root cap and be surrounded by the solder which forms the lingual contour of the crown. Its apical end should be slightly reduced so as to readily enter the hole in the root cap. Better retention,

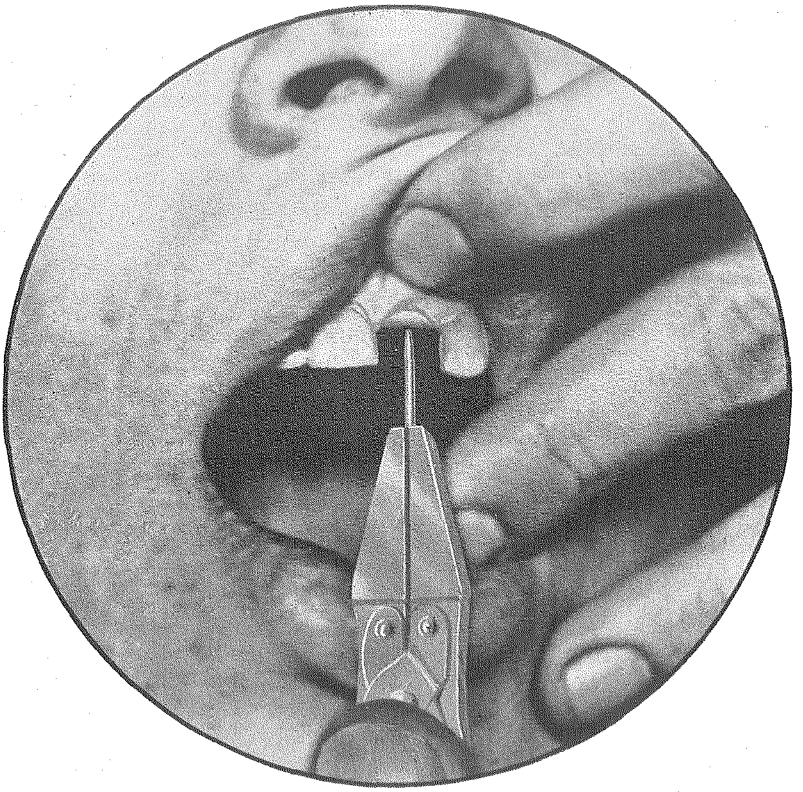


Fig. 555.— Forcing the Dowel Into Canal Through Root Cap

however, will be afforded the crown if the sides of the dowel are not tapered as is the common practice.

With a pair of parallel jaw pliers, the dowel is grasped firmly, the reduced apical end outward. This end is entered in the opening in the root cap, the dowel brought in alignment with the root canal, and forced through the cap and into the root, the full depth of the reamed out portion.

As the dowel is forced into the root through the constricted opening in the cap, the margins of the latter will be enlarged and carried into the entrance of the canal, and the bearing of the gold against the dowel be much increased.

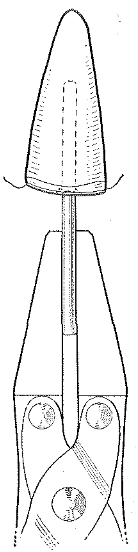


Fig. 556.— Diagram of Introduction of Dowel Through Cap, with Parallel Jaw Pliers

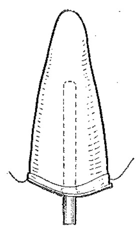


Fig. 557.— Root Cap with Attached Dowel in Position on Root

MAINTAINING CORRECT RELATION BETWEEN DOWEL AND CAP WHILE REMOVING FROM ROOT

The cap and dowel are now ready for attaching together with solder. To preserve the exact relationship which they now sustain to each other, on the root, during the soldering process, a piece of wax or modeling compound which will enter the space of the missing crown, is softened, pressed against the projecting dowel and root cap and chilled. A small 6-2-23 hoe, or instrument of similar shape, is carefully passed under the free margin of the gum, labially or lingually, hooked over the cervical margin of the band and the cap loosened.

Should the cap and dowel cling to the root and fail to come away with the impression as it is removed, they can be released and set in position without difficulty.

Frequently, when the dowel fits tightly in the cap opening, and the cap and dowel release easily from the root, they can be removed from position, a little sticky wax applied to and melted on the cap and against the dowel, after which they are returned to the root to correct any disturbance of alignment of the dowel that may have occurred in removal. The wax is now chilled and the two, now firmly held together in correct relation, are removed and invested for soldering.

At times the dowel may be held so firmly by the cap that the two may be removed and soldered without investment.

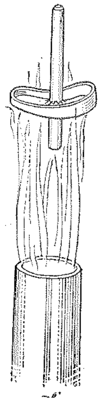


Fig. 558.— Soldering Cap and Dowel without Investment. Perpendicular Position of Dowel. Notice Reflected Margin of Disc Around Dowel

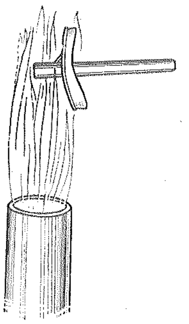


Fig. 559.— Soldering Cap and Dowel without Investment. Horizontal Position of Dowel

Although requiring a little longer time than by the method just mentioned, it is much the safest plan to take the small impression and invest the two for soldering.

INVESTING THE CAP AND DOWEL FOR SOLDERING

A small mix of investment material or plaster alone, because of its greater rapidity in setting, is prepared and applied to the root side of the cap and around the dowel, building it up the full length of the latter and squaring it off to form a base on which to rest while soldering.

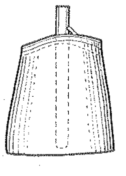


Fig. 560.— Cap and Dowel Invested for Soldering. This Plan Is Preferable to the Two Preceding Methods

When set, the investment is reduced to small size to facilitate soldering, the wax and moisture removed, a little flux applied over the surface of the cap and around the dowel where it is desired the solder should flow, a piece of solder is applied, one end resting on the cap, the other against the dowel, and with the blowpipe flame is fused.

The investment is now removed, the cap pickled in acid to cleanse, and thoroughly washed in water to remove the acid, when it is ready to return to the mouth for final impression.

TAKING THE BITE AND IMPRESSION

Although there are many ways by which an accurate relation may be secured between the backed facing and cap in assembling the crown for final soldering, without taking an impression and bite and constructing casts the safest plan for the beginner at least is to carry out the steps as now outlined.

USE OF THE FACE BOW IN CROWN WORK

To secure esthetic results, it is essential that at least two teeth on either side of the space in which the crown is to be

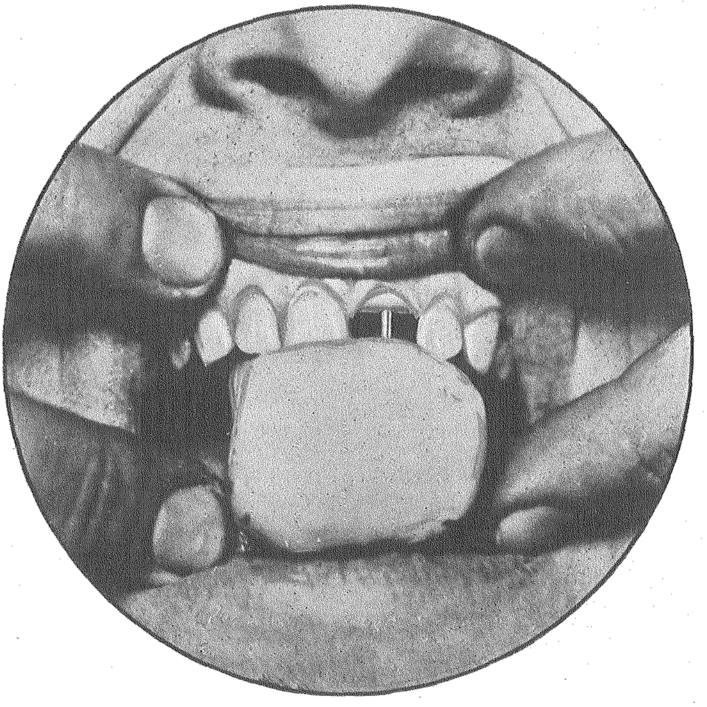


Fig. 561.— Adjustment of Wax for Taking the Bite

placed should be reproduced on the cast, in order that correct alignment and length of crown may be determined accurately, therefore the bite should include from five to six teeth. It is also essential that the crown be so constructed as not to interfere with the teeth in the opposite arch in lateral as well as incisive movements. The use of the face bow will enable the prosthetist to so construct the crown that subsequent changes by grinding will not be required.

In crown work the bite should be secured before the impression is taken, for the reason that when the impression is taken in plaster, as in most cases it should be, the projecting end of the dowel, being imbedded in the plaster, will bring the cap away from the root with the impression. In case the impression is taken first and the cap comes away with it, the cap must be removed and replaced on the root before taking the bite or the latter will be useless or at least unreliable.

Some prosthetists take a combined bite and impression in modeling compound, which in simple cases, where there are

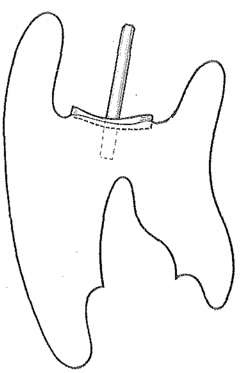


Fig. 562.— Sectional View of Combined Impression and Bite. Root Cap and Dowel in Position

no undercuts present, will answer for the separate bite in wax, and impression in plaster.

DETAILS OF TAKING THE BITE

The cap is set in position on the root, care being taken to see that it is firmly seated.

A piece of wax is formed into a compact mass, about ½x1x2 inches introduced between the teeth, and the patient instructed to close. The wax should extend sufficiently far labially of the teeth to receive and firmly hold the bite fork of the face bow, which is now applied and the face bow adjusted in the usual manner.

While the wax is still soft the patient is instructed to press it against both *upper and lower teeth* with the tongue so as to secure as accurate an impression of their lingual surfaces as possible. Stress should be laid on forcing the wax against the *lower* as well as the *upper teeth,* otherwise the tongue will raise it against the upper teeth only.

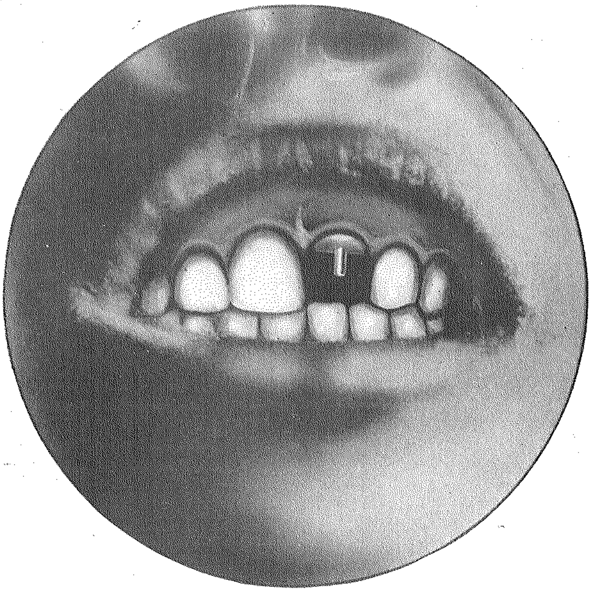


Fig. 563.— Appearance in Mouth of Root Cap with Projecting Dowel. Extreme Labial Margin of Band Is Obscured by Gum Margin

The wax is now chilled, the condyle rods of the face bow released, the patient instructed to open the mouth, and the bite attached to the face bow is removed and laid aside until the cast is secured.

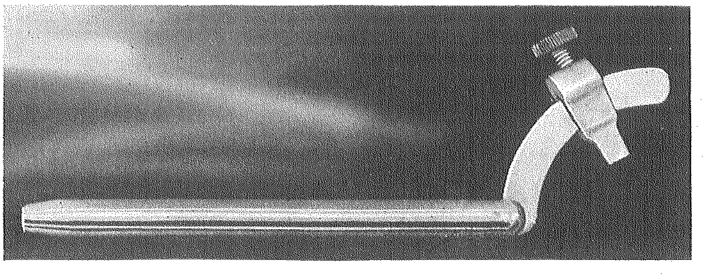


Fig. 564.— Modified Bite Fork with Adjustable Sleeve. Projection for Anchorage in Wax Shown on Concave Side of Fork

A bite fork, modified by having the inner edge of each end reduced by grinding to increase its inner arc, will serve the purpose better than one of regular form.

Still another modification which will be found very useful for taking side bites, as for cuspids, bicuspids and the first molar, can be made as follows: Saw off one of the fork prongs next the stem; to the other, fit a sleeve which will slide freely along the fork, but which can be firmly fixed with a set screw at any point desired. The inner margin of the sleeve is supplied with a projection for extending into the space of a missing tooth. A firm hold is secured in the bite by having sufficient bulk of wax outside the arch to enclose the inner margin of the fork. The projection of the sleeve should be set so as to enter the space of the missing crown.

When the root cap comes away with the bite, as is frequently the case, it must be removed and returned to the root before taking the impression.

DETAILS OF SECURING AN IMPRESSION WITH PLASTER

In crown work it is just as important to secure an accurate impression of that part of the mouth involved as in full denture construction. When much irregularity of surfaces exists, as in teeth with constricted cervices, or when the embrasure spaces are open as a result of tissue absorption, the impression should always be in plaster.

In order to preserve the essential parts of such an impression, so that the teeth involved may be reproduced as perfectly as possible, it will be necessary to fracture it, carefully remove the pieces, and replace them in proper order for the production of the cast.

Any one of three methods may be adopted, as follows:

First, a tray of suitable size is selected and oiled to prevent the plaster from adhering to it. Plaster sufficient to secure an impression of the teeth involved is placed in the tray, introduced in the mouth and given sufficient time to thoroughly harden. The tray is then carefully removed so as not to disturb the impression. With the point of a knife an incisal groove is cut in the plaster to weaken it. The groove should extend well into the space of the missing crown. Pressure on the ends or the extreme border surface outward will fracture the labial portion, which will usually come away intact. With careful manipulation the lingual portion may be released and removed without further fracture. The tray and fractured surfaces of the impression are now cleared of all particles of debris, the pieces replaced in the tray, luted firmly with wax and the cast secured in the usual way.

Second method: A piece of cardboard is cut in the form of a square about $1\frac{1}{2}x1\frac{1}{2}$ inches, and the four corners rounded slightly.

Two opposite sides, each a little less than one-half inch wide, are turned up at right angles to form an improvised impression tray, the bottom of which is a little more than one-

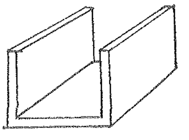


Fig. 565.—Manner of Bending Cardboard for Impression Tray

half inch wide. The sides and floor of the tray may be varied in width to conform to any special requirements, as a greater or less curvature of the arch or a deep or shallow alveolar border.

The plaster is mixed to medium thick consistency, placed in the tray carried against the teeth so as to divide it about equally labially and lingually, and pressed borderward until the incisal edges of the teeth touch the tray floor.

Since the sides of the tray are not rigid, they should be supported with the thumb and fingers while introducing the plaster and until it has begun to set.

When the plaster has set, it is unnecessary to remove the tray from the impression, since the cardboard will be easily bent along the line where fracture will occur. Neither is it

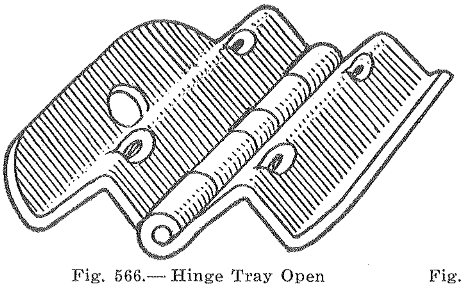


Fig. 566.—Hinge Tray Open

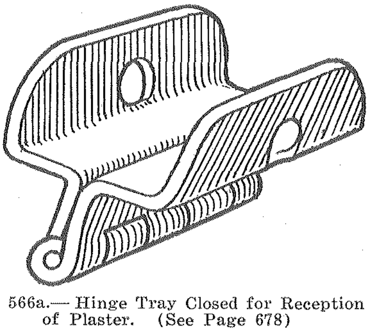


Fig. 566a.—Hinge Tray Closed for Reception of Plaster. (See Page 678)

necessary to groove the impression, for when the tray is carried borderward until its floor comes in contact with the teeth, the plaster is already practically divided into two sections and will readily break along the incisal line with the application of slight force. Furthermore, the cardboard serves the same purpose as a hinged tray, for by removing the particles of debris from the fractured surfaces, the two halves of the impression can be brought together in exactly the right relation to each other, and on luting with wax or wrapping a strand of fine binding wire around the outside, is ready for the production of the cast.

Third method: A very serviceable and permanent tray may be constructed of an ordinary brass hinge, so bent as to present a floor and sides of about the same dimensions as those of the cardboard tray. The joint of the tray is in the center of the floor, while the hinge projects a little below and serves as a handle, or *finger hold* in introducing the tray.

PRODUCTION OF CAST FROM THE IMPRESSION

The impression having been secured, and the fractured pieces correctly adjusted, it is coated with separating medium and allowed to dry.

Usually when an impression is fractured in removal, the cap will remain in position on the root. It may, however, come away, but its position in the impression will usually be disturbed.

Before replacing it, the several parts of the impression are first placed together and firmly attached with sticky wax. The cap is then cleaned and a thin film of wax flowed over the dowel and inside the cap to obliterate any undercuts that may be present. The object of this is to subsequently permit the ready removal of the cap from the cast, without breaking the later. Before the backed facing is finally attached to the cap, the latter is heated slightly to soften the wax, after which it is carefully removed from the cast, the wax cleared away and the cap returned to position, the outer periphery and dowel opening guiding it accurately to place on the cast. Then when the facing is attached with sticky wax, in the exact and final relation it should sustain to the cap, the assembled crown can be removed for investment without danger of disturbing the relation so established.

The cap is now returned to its exact position in the impression where it is luted firmly with a little wax applied to the outside of the lingual band surface.

Plaster is then mixed and the impression filled as for any partial case, special care being taken that no air is confined in the deeper parts of the impression.

ATTACHING THE CASTS TO THE OCCLUDING FRAME

When the face bow has been applied in taking the bite as described, the most convenient as well as accurate method of mounting the casts on the occluding frame is to mount the bite and produce the occlusion cast first.

The face bow with bite fixed to the fork is attached to the frame and the latter inverted. The lower bow is thrown backward out of the way, the interior of the bite coated with a thin film of oil and filled with plaster, building it well above the bite margins. The bow of the frame is brought down in position and plaster applied around it to unite it with that in the bite.

When the plaster has hardened, the face bow and bite fork are removed, and both labial and lingual portions of the bite in which the upper cast is to be fitted are pared down so as to permit the teeth to enter freely. The labial side of the bite should be cut away so as to expose the imprint made by the incisal edges of the natural teeth in the wax, so that in placing the cast in position it can readily be seen when the plaster teeth are in contact with the deepest portion of the bite. Sufficient wax, however, should be left to guide the cast into correct vertical position.

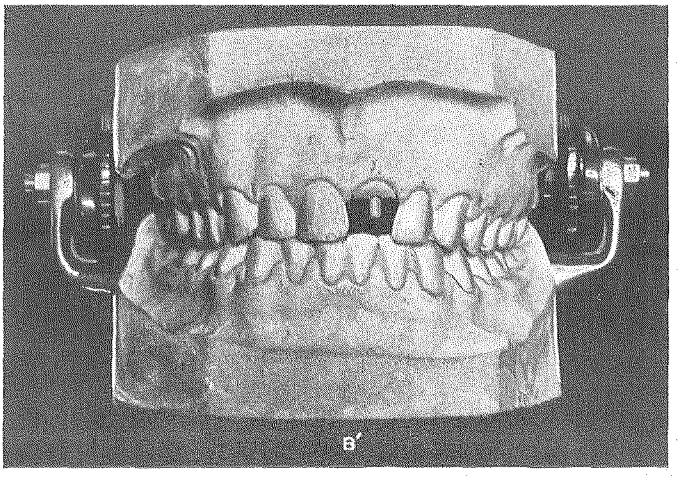


Fig. 567.— Full Casts Mounted on Occluding Frame. Cap in Position. Usually Only Partial Casts Are Developed

The upper cast is now set in the bite, the upper bow of the frame dropped down upon its base, and plaster applied to attach the two firmly. When the plaster has set the wax is thoroughly warmed to prevent breaking the teeth and is then removed. The case is now ready for the selection and grinding of the facing.

SELECTION OF THE FACING

By means of the shade guide, the tints displayed in the natural teeth of the patient can be determined, the number of the shade required noted, and a facing of corresponding color and of suitable form selected.

The form of the facing selected should correspond to the type of proximating natural teeth. In case such a tooth is not procurable, one of the correct shade but slightly larger than required can be selected and by grinding be modified to meet the requirements. The ground surfaces, when the proper contour is developed, can be finished with fine discs, and afterward given a fine glaze with putty powder on a hard felt lathe wheel.

The facing should be wide enough to fill the space and restore strong proximate contact with the adjoining teeth, unless for some special reason this is not advisable.

Usually the facing selected should be slightly longer than required, since both incisal edge and ridge lap must be reduced to required form by grinding.

Since the pins afford the only anchorage of the porcelain to the metal structure of the crown, a facing should be selected having the pins located as close to the incisal edge as possible, so as to bring the anchorage near the point of stress.

GRINDING THE FACING TO THE ROOT CAP

To facilitate the soldering of the backed facing to the root cap, the ridge lap of the facing is beveled from its cervico-

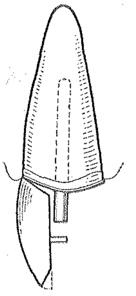


Fig. 568.— Ridge Lap and Incisal Edge of Porcelain Facing Ground and Adjusted to Root Cap

labial margin to the lingual surface. This leaves a V-shaped space of greater or less width between the base of porcelain and the root cap.

In grinding the cervical end of a facing to the required form, care should be taken to develop a distinct line angle

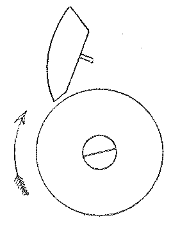


Fig. 569.— Cut Showing Direction Stone Should Rotate in Grinding to Obviate Chipping Margins of Porcelain

between the ridge lap surface and the labial surface to avoid a defective joint between the porcelain and backing.

The stone should revolve from the labial surface lingually to prevent fracture of the margins.

BEVELING THE INCISAL EDGE OF THE FACING

The incisal edge of the facing should be ground to harmonious alignment with the proximating teeth, the facing, however, being shortened slightly to allow for the thickness of the gold tip to be added, and also for the backing, which must cover the ridge lap.

The inciso-lingual line angle should be reduced to about 30 degrees with the lingual surface taken as a base. This is somewhat less than is usually recommended, but when so formed will result in a metal tip of equal or greater strength with less labial exposure of gold than where the porcelain is beveled at an angle of 45 degrees. Special care should also be observed in developing the bevel to avoid fracturing the labial margins of porcelain with the stone.

CHANGE OF COLOR IN PORCELAIN DUE TO METAL BACKING

Different metals are used and various methods are in vogue in backing facings in crown and bridge work. The technic of applying the various metals is similar, but the color effect on the porcelain of the metal employed as a backing should be known in order to avoid undesirable change of tint in the facing of a finished crown.

Pure gold imparts a slightly yellowish tint to very light porcelain, and increases or darkens the tint of yellow porcelain, particularly when the facing is thin.

Allowance, therefore, should be made in the selection of a facing when pure gold is to be used as a backing by choosing one having the correct basic color, but slightly lighter than the shade desired, the variation depending on the thickness of the facing selected.

When 22 k. gold is used, a similar effect is produced, but to a lesser degree, because of its less pronounced yellow color.

Coin gold perceptibly darkens thin, translucent facings of any shade.

Platinum imparts a bluish tint to light porcelain, in some cases darkening it perceptibly.

A greenish yellow tint can be imparted to light yellow porcelain by using an 18 k. alloy known as "green gold," composed of 18 parts of pure gold and 6 parts of pure silver. This gold is almost as soft and easily worked as pure gold.

BACKING THE FACING WITH GOLD

Pure gold is most generally used as a backing because of the ease with which it can be adapted to irregular surfaces. When conformed to a surface it shows but little tendency to warp or spring away as does gold of the lower carats.

Two general methods are in vogue for applying the backings to teeth, first, by burnishing, and second, by swaging, both of which will be outlined.

PERFORATING THE BACKING FOR THE PINS

Spread a thin film of wax over the surface and near the corner of the piece of plate. Place the facing, pins resting on the wax, so that a slight margin of gold shows at the end and

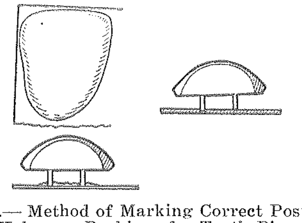


Fig. 570.— Method of Marking Correct Position of Holes, on Backing, for Tooth Pins

along the side. Press the pins into the wax to indicate the location of the holes for the pins. Punch the holes as marked in the wax. Apply the facing and with a sharp instrument mark the outline of the tooth on the backing, allowing a little surplus all around, particularly at the cervical and incisal ends. The gold is then cut to the outline marked.

Another method is to punch one hole near the edge of the plate for the outer pin. Apply the facing, entering the pin in the hole already punched, and rotate the tooth. Remove the facing and punch the other hole, its inner margin or that next the first hole being on the rotation line.

Whatever method is employed, care should be taken to punch the holes the proper distance apart to avoid straining the porcelain as the gold is forced over the pins and against the facing. When the space between the pin holes is either too wide or narrow, such an accident is liable to occur.

The holes should be of the exact diameter of the pins or slightly smaller, but never larger, to obviate the danger of fracture in final soldering, from the flux and solder being drawn into and through the holes next the pins, thereby coming directly in contact with the porcelain.

THE MASON SPACING CALIPER

The Mason spacing calipers and auxiliaries, consisting of a pointed punch and an engine burnishing tool, was designed to and does effectually obviate the liability of both too large

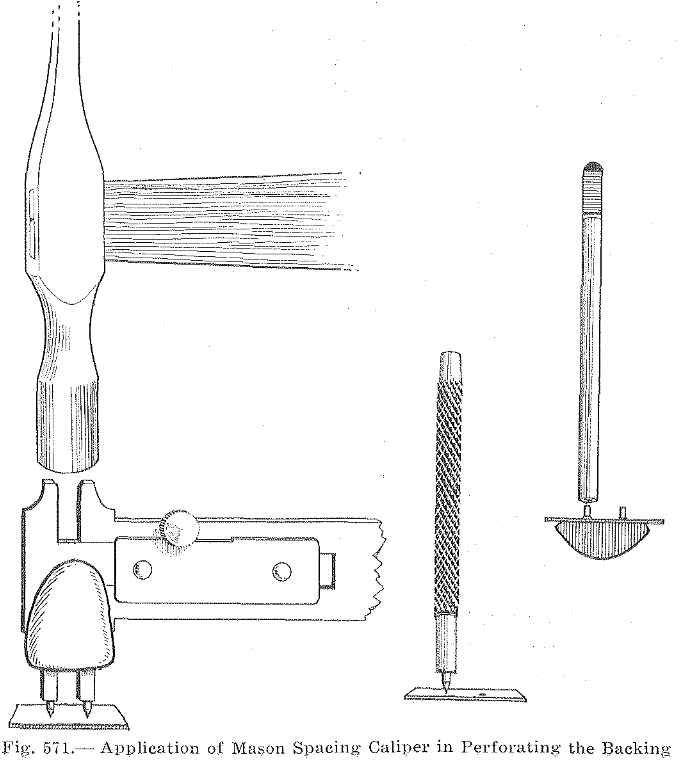


Fig. 571.— Application of Mason Spacing Caliper in Perforating the Backing

or incorrectly located holes. The directions for using the appliances are as follows:

"The pins of the facing are placed in the holes on the side of the caliper which have guide slots to guide the pins into the holes; this accurately spaces the holes, which register with pins of the tooth, held in that position by the thumb nut; the backing is then marked or pierced by the hardened points, which gives the exact spacing for the pins; now place the backing thus marked on a piece of lead; then with the pointed punch the metal or gold is pierced, throwing up a lip, giving an aperture the same size as the pins; the backing thus pierced is placed on the tooth, the lips extending on the pins; finally, to burnish this lip of gold to the pin, the lathe tool is used; this has an aperture in the end which fits over

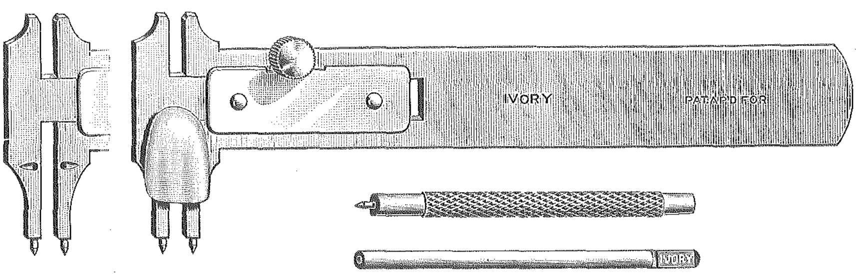


Fig. 572.— The Mason Spacing Caliper and Accessories

the pin; with a high speed engine or lathe the gold is tightly burnished around and slightly raised against the sides of the pins . . . ."

The writer's experience with this appliance has proven it to be a most valuable addition to the laboratory equipment.

THE YOUNG PLATE PERFORATOR

This is another convenient appliance by means of which the tooth serves as a gauge for setting the double end punch

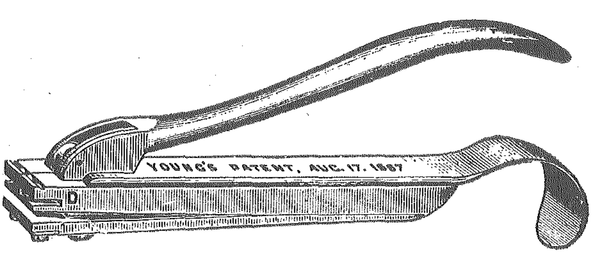


Fig. 573.— The Young Plate Perforator

so that both holes are punched at the same time and at exactly the proper distance apart.

ADAPTING THE BACKING TO THE FACING BY BURNISHING

The backing, cut slightly larger than the surfaces it is to cover, and with holes punched, is applied to the facing and adapted as closely as possible to the porcelain with finger pressure. By means of the contra-angle burnisher or one of the Wilson type, general surface adaptation is secured, after which the borders are gradually worked into close contact with the margins of the facing. The gold should be removed and annealed occasionally to reduce the hardness developed by burnishing. Finally, when as close adaptation as possible has been secured by burnishing, the backing is removed, annealed, returned to place and the facing pressed, pins down, with backing interposed, into a broad cork that has previously been grooved to the general lingual contour of the facing. A piece of wood about the size of a lead pencil, concaved on the

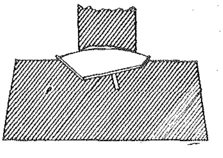


Fig. 574.— Adapting the Backing to Facing Against Cork with Light Hammer Blows

end, is set on the facing and with both pressure and light hammer blows final and close adaptation of the gold to the porcelain is secured.

Previous to this final adaptation, the surplus gold extending over the margins of porcelain should be reduced with a file, applied so as to force the backing toward rather than away from the facing. As before mentioned, a slight surplus of the backing should be allowed to remain on both incisal and gingival margins, until the final finishing of the crown, so that the solder may be drawn outward to the full extent desired. Under no circumstances should the backing on these two ends be reflected over and onto the labial surface, as fracture of the porcelain will occur, due to contraction of the applied lingual solder.

It is absolutely essential that the backing be brought into close and positive contact with the porcelain, not only at the margins, but on the lingual surfaces as well, to avoid the formation of a space between the two, into which organic matter will gradually find its way. When food accumulates in such spaces it gives rise to disagreeable odors, and as it decomposes and darkens will modify the shade of the porcelain.

SWAGING THE BACKING

When the backing has been cut to proper size, the holes punched for the pins, and general adaptation secured with a burnisher, the facing is invested, labial face down, in modeling compound, in the swaging ring.

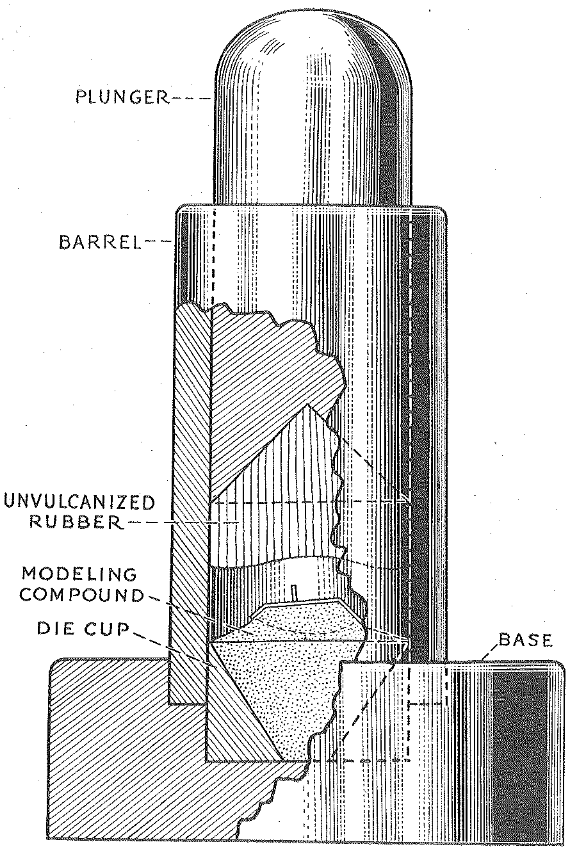


Fig. 575.— Adapting the Backing to Facing in S. S. W. Swager

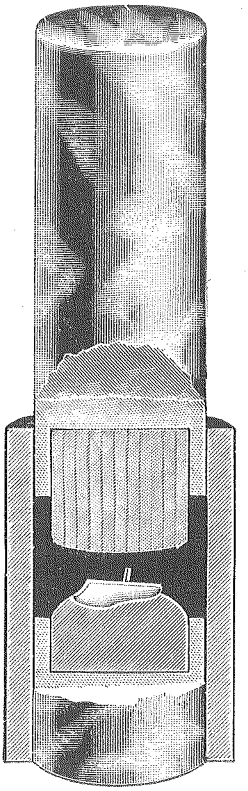


Fig. 576.— Similar Method of Adapting Facing to Backing in Ajax Swager

It should set well above the ring margins so as to freely expose the beveled incisal tip on one end and the ridge lap on the other. The compound should be trimmed so that the margins of the facing are freely exposed to permit the gold being forced in close contact by the unvulcanized rubber.

When the thinner gauges of gold or platinum are used, as 34 or 36 g., two or three light blows on the plunger will set the backing in close contact with the facing. Heavier gauges of metal will require more force. When swaged, the backing is removed and trimmed to desired correct outline, and the backing returned to the facing and reswaged to correct any distortion that may have occurred.

FIXING THE BACKING TO THE FACING

When final adaptation has been developed between facing and backing, the latter should be firmly fixed to the porcelain so that the close and essential relation between the two may not be disturbed while assembling and soldering the crown.

A common practice is to bend the pins over in contact with the backing. As a result, however, the porcelain is subjected to undue strain, and if not fractured immediately, as is frequently the case, is very liable to be in the subsequent soldering process.

A much safer and quite as effectual method is to apply a sharp blade or chisel to the side of pin and turn a light shaving of the platinum down upon the backing. This puts no strain upon the porcelain and holds the gold firmly in place. The Reese Pin Shaver, a small, cylindrical, hollow mandrel, the opening in which is slightly larger than the diameter of a tooth pin, can also be used for shaving the pin and burnishing the shaving down in close contact with the backing. The instrument is passed over the pin in a slightly diagonal direction, and as it is forced along the pin toward the backing, the sharp inner margin of the tool cuts and carries a shaving of platinum down in contact with the gold.

FITTING THE BACKED FACING TO THE ROOT CAP

The facing now having its backing conformed and attached as described is ready for adjustment to the root cap. A small piece of soft wax is placed over the projecting dowel and on the lingual half of the cap, and the facing pressed against it so as to secure proper alignment with the proximating teeth.

If in adjusting the facing the labial surface of the dowel interferes with its labial alignment, the dowel may be partially ground away. Sometimes it is necessary, when the facing is thick or the labio-lingual diameter of the root is short, to remove the greater portion of the projecting dowel. When the root is countersunk and the cap has been burnished into it as previously described, the removal of the dowel projection will not appreciably weaken the attachment of the dowel to the finished crown.

It is sometimes advisable to ream out the lingual side of the root canal, so that in adjusting the dowel it may be bent slightly to the lingual, and thus give more space for the facing.

Special care should be observed to set the cervical margin of the facing in line with the labial surface of the band. It may even project slightly if the alignment of the facing requires, but should never be set to the lingual or the labial band surface, or a projecting shoulder of gold, which cannot be obliterated, will result.

The long axis of the facing must be set at a similar angle of divergence from the perpendicular line of the face or, inciso-apically, as the corresponding tooth on the opposite side of the arch, the line of direction, however, being reversed.

In most cases the backing which covers the ridge lap of the facing can be slightly reduced in thickness by filing, and that portion of gold on the root cap against which the facing rests may also be thinned by grinding. The object of this is to bring the porcelain in as close contact as possible with

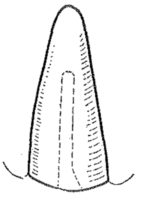


Fig. 577.— Lingual Side of Root Canal Reamed to Receive Bent Dowel

the root face, and thereby reduce the width of the labio-gingival margin of gold in the finished crown. By this step, instead of two thicknesses of gold being interposed between the face end of the root and facing there is the equivalent of only one. When the facing is adjusted in the exact desired relation to the cap, the point of a heated instrument is passed into the wax supporting it and the two are firmly united.

INVESTMENT OF THE ASSEMBLED CROWN FOR SOLDERING

The crown is now carefully removed and its full lingual contour developed in wax. Special care should be taken to flow wax into the space between the backing and root cap around the labial surface to exclude the investment in which the crown is later on inclosed for soldering.

The crown is now assembled, but all of the several parts are not yet permanently united. It must therefore be enclosed in some material capable of resisting heat without perceptible change, that will hold the cap and facing in correct relation to each other after removal of the wax and during the soldering process.

Any of the standard investment materials prepared and sold for this purpose may be employed, or one can be compounded in the laboratory. One of the best "home made" investments for soldering purposes consists of a mixture of two-thirds coarse ground asbestos (short cut fibre), and one-third plaster.

The two ingredients should be measured out in proper proportions and "dry mixed," then placed in the bowl, a sufficient quantity of water added to make a rather stiff mass, and spatulated thoroughly.

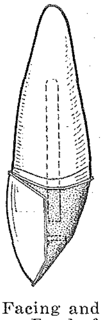


Fig. 578.— Backed Facing and Cap Assembled and Held with Wax, Ready for Investment

An oiled slab should be prepared or a piece of paper placed on the bench. On this the investment is placed, building it up to an inch or more in thickness. The crown cap is completely filled with investment before enclosing in the mass to subsequently exclude the solder.

The crown is now pressed into the plastic mass, being careful to keep its labial face at least one-half inch above the base of the investment, so that the latter may not be fractured when subjected to heat, as is frequently the case when the bulk of investments is too limited. The investment is now built around the sides of the facing and even with, but not above, the incisal end.

The crown should be settled into the plastic mass in a diagonal position rather than horizontally. This is to bring the linguo-gingival edge of the root cap and the incisal end of the facing on a level, so that in flowing the solder gravity will assist in giving the lingual surface its proper contour.

TRIMMING THE INVESTMENT PREPARATORY TO SOLDERING

It is necessary, in order that the flame may be readily applied to all essential parts of the crown and the solder readily fused where needed, that the surplus investment be removed and the investment proper reduced to the smallest possible dimensions consistent with strength and the protection of the porcelain.

First, the sides of the investment are trimmed close to the mesial and distal surfaces of the facing, leaving a sufficient thickness, however, to protect the porcelain.

Second, the ends are reduced close to but not so as to expose the incisal edge of porcelain or the dowel at the opposite end.

Third, an opening should be carefully made from one side to the other so as to expose the labial surface of band and

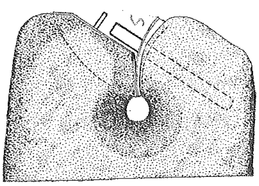


Fig. 579.— Crown Invested for Soldering. Notice the Joint Is Entirely Exposed, While Porcelain Is Protected

margin of backing which projects beyond the ridge lap of the porcelain, but not the facing.

The investment along the sides of the facing and extending down to the labio-cervical opening is now beveled so as to freely expose the entire backing and joint area. The investment next the incisal tip should be removed so that the solder may be freely drawn to the outermost limits of the backing and thus stiffen the gold which forms the incisal tip of the crown.

By so forming the investment the entire joint between the backing and root cap is exposed to view, so that in flowing the solder it can readily be seen when perfect union and required contour has been effected.

REMOVAL OF THE WAX

The investment, trimmed as described, is cleared of debris, the wax warmed and removed with a small instrument.

That in the more constricted space can be entirely cleared away with a fine stream of boiling water.

APPLYING THE FLUX

A thin film of thick borax paste, made by grinding crystal borax with water on a ground glass slab, is now applied to the backing and root cap on those surfaces to be covered by the solder. With a thin wooden spatula or toothpick it should be carried into the constricted V-shaped opening between the ridgelap and the root cap, and along the cervical joint.

The flux should not be spread on the investment along the margins of the backing, where it can come in contact with the porcelain during the soldering, nor be applied so plentifully that it will overflow on these margins when heated.

Should this occur, fracture of the porcelain is liable to result, due to difference in contractility of porcelain and borax, which, under heat, unite. When an oily soldering paste is used instead of one composed of borax and water, the same care should be observed in keeping it away from the porcelain.

DRYING OUT AND HEATING THE CASE FOR SOLDERING

The investment is now set on a sheet of gauze, near the edge or slightly above the Bunsen flame, to gradually drive off the moisture and thoroughly heat it preparatory to soldering.

When dry and thoroughly hot it is transferred to the soldering block, where the blowpipe flame is applied around the base and sides until the investment is red hot, when the solder can be applied and fused.

DEVELOPING THE LINGUAL CONTOUR OF THE CROWN WITH SOLDER

It is common practice to cut the solder into small pieces, apply a number of them at a time to the backing, and when fused to discontinue the flame until more is added, then reapply the flame, continuing this process until the desired lingual contour is developed.

While this method is effective so far as developing the required contour of the crown is concerned, it frequently results in fracture of the facing, due to repeated change of temperature and consequent repeated expansion and contraction of the porcelain.

By far the quickest, most convenient and safest method of applying the solder is to cut it in thin strips about one-eighth inch wide and from three to six inches in length. All surfaces should be covered with a thin film of flux before use. One of these strips is clamped in the beaks of the soldering pliers, and when the investment is thoroughly heated and red, the point of the strip is directed into the deepest part of the V-shaped opening.

The flame of the blowpipe is now applied to that area, when the solder will be instantly fused. As it settles into the

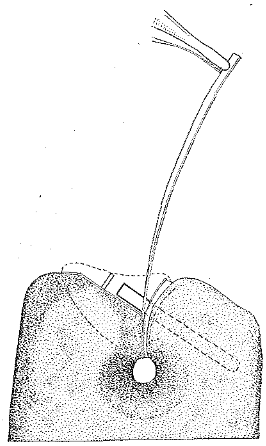


Fig. 580.— Method of Applying the Solder in Strip Form

joint more of the strip is fed into the molten mass, until the proper contour is developed.

Special care should be observed in thickening the backing over the incisal tip and also allowing the solder to over-

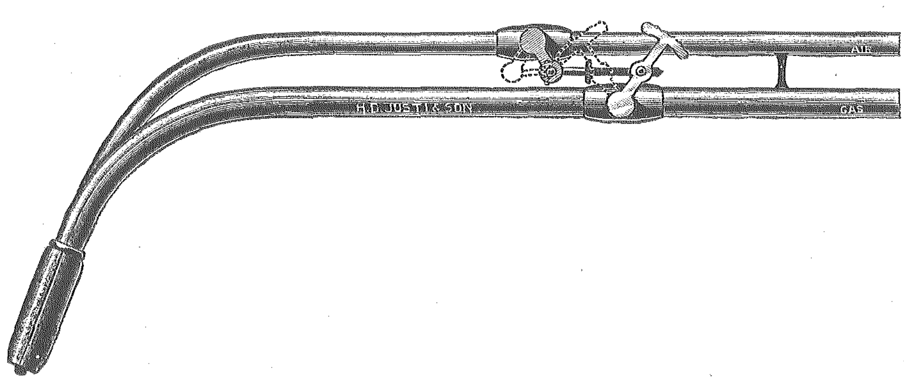


Fig. 581.— The Stiver Blowpipe

flow the lingual surface of the root cap. When the lingual surface of the crown is developed to resemble the natural cingulum of the tooth, much better protection will be afforded the gum margin than where this surface presents an inclined plane inciso-gingivally.

The blowpipe flame should never be directed against the platinum pins of a facing until the porcelain itself is thoroughly heated and well expanded. The reason for this is obvious: porcelain is friable and easily broken; the platinum pins expand quickly when heated, and when highly heated exert great force, within certain limits; this limit of expansive force is greater than the porcelain can stand without fracturing unless itself first expanded.

The three principal causes of fracture of porcelain facings have now been mentioned, viz., contact with and fusing of borax to the porcelain, expansion of the platinum pins, sudden changes of temperature or the intermittent application of the flame.

FINISHING THE CROWN

After the soldering has been completed, the investment should be allowed to cool down gradually, or again fracture of the facing is liable to occur. The investment should be protected against strong, cold drafts of air by placing over it an inverted cup or plaster bowl until the temperature is reduced to such point that it may be comfortably handled with the fingers.

The investment is then broken away, the crown examined to see that no accident has happened, and that the desired contour has been developed. Should contour be deficient at any point the crown must be reinvested and corrections made as needed.

The crown is now pickled in acid to loosen any adherent investment and flux. A convenient method is to boil it in acid in a test tube, after which it should be thoroughly washed to remove the acid.

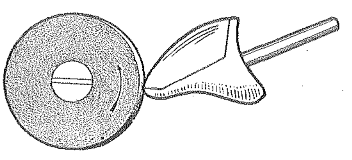


Fig. 582.— Reducing the Surplus Margins of Gold with Stone

The surplus gold can be economically removed with a file, the filings being caught in the gold drawer or on a sheet of paper. The finer finish is accomplished with engine stones and discs, followed by the use of fine pumice stone first and afterward rouge, applied with felt wheels on the lathe. Every file mark and all scratches produced by the coarser polishing powders must be removed and the metal parts polished as well as the finest piece of jewelry. The cervical margin of the band must be beveled and slightly rounded so that it may not prove an irritant to the gingival tissues or form a shoulder for the lodgment of food.

Too much care cannot be bestowed on the finish of the cervical band margin, for on this, together with restoring close proximate contact with the adjoining teeth, will depend the future service and comfort of the substitute.

SETTING THE CROWN

One of the most essential requirements in the setting of a crown is to thoroughly dry the root and adjacent parts and keep them so until the operation is completed and the cement well set.

Since the rubber dam cannot be applied, the lip should be raised with a cotton roll to prevent the oral fluids from interfering with the immediate and subsequent steps.

The general moisture is removed from the mucous tissues and root face with pellets of cotton, from the canal with cotton on a brooch and small cotton or bibulous paper points.

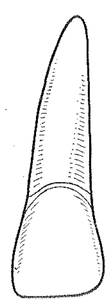


Fig. 583.—Labial View of Finished Crown

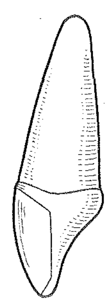


Fig. 584.—Proximal View of Finished Crown.

Finally, with blasts of air from the chip blower or the compressed air point, the parts are thoroughly dried and made ready for the reception of the crown. The crown itself should be dry, clean and free from polishing powder, grease or wax.

A previously tested crown cement should be mixed to thin-medium consistency and thoroughly spatulated.

With a root canal plugger, a small portion of the cement is carried into the canal and worked against the sides and to the apex, continuing this until the entire opening is filled. A thin layer should be worked over the face end of the root. The crown cap is now partially filled with the cement, a little smeared on the dowel and the crown is quickly pressed into position on the root.

Heavy but intermittent pressure should be exerted at first and afterward steady pressure to force out the excess cement confined within the cap and root canal, and which, if not expelled, would elongate the crown to a greater or less extent. Mallet blows are much less effective in seating a crown than heavy maintained pressure, because the cement being more or less plastic and sluggish and closely confined within the cap, is scarcely affected by heavy, sudden blows, while maintained pressure causes it to flow as long as there is any opening through which it can escape.

REMOVAL OF THE EXCESS CEMENT

When the cement has set reasonably hard, which usually requires from fifteen to twenty-five minutes, the excess cement which can be removed without danger of disturbing the crown should be cleared away, first with pellets of cotton, followed by the use of the blunt explorer. When time is limited it is advisable, as soon as the excessive surplus is removed, to dismiss the patient until the cement is thoroughly hardened, or after the lapse of two or three hours, when the removal of the remainder can be effected without danger of loosening the crown.

When satisfied that every trace of the cement has been removed from beneath the gingival tissues, the parts should be syringed with warm normal salt solution, and the gums massaged to restore normal circulation and tone.

Finally, before dismissing the patient a close examination should be made to see that the opposite teeth do not strike the crown in either occlusion or lateral movements. Should such be the case, correction must be made by grinding away the points of contact on either the crown or natural teeth or both, as good judgment dictates.

SETTING A CROWN TEMPORARILY

Sometimes it may be deemed advisable to set a crown temporarily in order to test its efficiency, or for other reasons. This may be done as follows:

A piece of gutta percha baseplate material is cut and formed into a roll or cylinder which will approximately fill the root canal. The canal, root, and adjoining tissues are thoroughly dried, the canal moistened with oil of cajaput, or eucalyptus, the cylinder of gutta-percha is warmed and inserted in the canal. The crown itself is gradually heated, particularly the dowel, and a blast of hot air from the syringe directed against the gutta-percha. The crown is then forced to place on the root, or when it cannot be perfectly seated is quickly removed and the cause determined.

The cause may be due to too much material or to the gutta-percha not being sufficiently plastic. Removal of some of the material and the application of more heat, with quick action and heavy pressure, will usually result in success on second trial.

REMOVAL OF A TEMPORARY CROWN OR A BRIDGE SET WITH GUTTA-PERCHA

Since the easiest way of removing a crown set with gutta-percha is by the application of heat, and since the heat must be sufficient to soften the gutta-percha, the appliance now to be described will be found most efficient.

Remove the bulb from a chip-blower. Pass a common twine string, large enough to fit closely, through the nozzle of the pipe, to form a wick. Pour a few drops of alcohol into the pipe and cork the large end. This forms an alcohol lamp, the wick projecting from the small end. Trim the wick short so that it projects but slightly from the nozzle. A flame varying from one-half inch in length to one no larger than a pin-head may be produced, depending on the projection of the wick.

With this lamp a small flame is applied to the crown. The heat thus applied is transmitted through the dowel to the gutta-percha in the canal, which, when sufficiently softened, will release the crown.

Different Methods of Applying Porcelain Facings and Replaceable Teeth in Single Crowns, and Dummies for Bridges

Porcelain is utilized in various ways, other than that described, as a veneer or partial crown in single crown work, and bridge construction as well.

Since a bridge is nothing more or less than an assemblage of full crowns, combined with partial crowns called dummies, some of the various methods of construction of the different factors of bridges will now be considered.

INTERCHANGEABLE TOOTH FACINGS

To obviate fracture in soldering and facilitate repairs of facings in crowns or bridges, various forms of interchangeable or replaceable porcelain facings are used instead of regular long pin plate teeth.

Replaceable teeth and facings of different forms are now procurable and in many cases are useful, not only in repair cases, but are coming into general use in crown and bridge construction.

The three most common forms of flat back teeth, or facings of this type, are the Steele, the Evslin and the Dimelow. In addition to these, a number of types of partial crowns of the replaceable class, for both anterior and posterior teeth as well, are now available.

Among these partial crowns may be mentioned the Goslee, Gardiner, Merker and posteriors of Steele and Evslin.

STEELE'S INTERCHANGEABLE TOOTH

This consists of a facing of porcelain and a backing of metal. In the back of the facing, beginning at the ridge lap, a hole extends into the porcelain, toward but not to, the incisal edge. This hole is slotted lingually to receive a projection from the backing. The backing consists of a piece of flat metal plate, to which is affixed a tubular post which enters the hole in the facing, and forms the attachment between facing and crown or bridge.

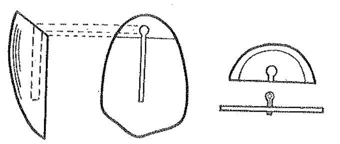


Fig. 585.— Sectional Views of Steele Facing and Backing

APPLICATION OF THE STEELE FACING

The application of a Steele facing to a central incisor crown, as just described, is as follows:

The cap having been constructed and in position on the cast, a facing is selected and ground to fit the root cap. The backing is then adjusted and the surplus trimmed to the margins of porcelain, leaving the incisal edge longer than the porcelain.

Should the tubular post of the backing extend beyond the porcelain at the ridge lap, it is ground flush with the latter.

The facing and backing are now adjusted to the cap. Sticky wax is applied to the backing and melted against the root cap, being careful to keep it from flowing on the porcelain. The assembled crown is now removed from the cast and the facing slipped from the backing.

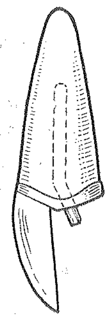


Fig. 586.— Steele Facing Ground to Root Cap

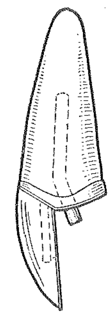


Fig. 587.— Steele Facing with Backing Trimmed and in Position Adjusted to Root Cap

A thin film of Anti-Flux is applied to backing on that surface against which the porcelain rests. This is necessary to prevent the solder or borax flowing over the backing, as the slightest amount of either, if adherent to this surface, will prevent the facing passing to place.

The metal parts of the crown are now invested and soldered as usual.

To clean the metal structure and remove the borax after soldering, the crown should be heated and dropped in a pickle of 30 per cent HCl. If boiled, as is usually the case, the metal of which the tube is composed will be corroded or *honey-combed.*

The facing is slipped in position on the backing, and the surplus gold reduced with stones and discs. The incisal edge of gold should be continuous with the labial contour of porcelain for a short distance to afford protection to the latter against incisal stress. When the metal parts are polished, the facing is set in position with cement and the crown is ready for setting on the root.

STEELE'S INTERCHANGEABLE TOOTH — TECHNIC FOR POSTERIOR CROWNS

Bicuspid and molar teeth of the Steele type can be employed in crown construction, although they are more often used as dummies in bridge work. The method of procedure is as follows:

The root is prepared, a root cap constructed and dowels extending into the root canals are fitted and attached to the cap by soldering. At the same time the cap should be stiffened by flowing solder over it. Casts should be constructed and mounted on the occluding frame.

A porcelain tooth of suitable size is selected and ground to proper length, allowing for the interposed backing of gold over the ridge lap.

The backing is then fitted to the porcelain in the usual manner. To its cervical end is attached an extension of 22 or 24k. gold plate, to cover the ridge lap and extend slightly beyond the buccal margin of the tooth.

The backed tooth is now set in position on the root cap and waxed in proper relation to the latter, after which the assembled crown is removed from the cast, the porcelain removed from position, Anti-Flux applied to the buccal surface of the backing, the metal structure invested and developed to proper contour with solder. By using inlay wax in assembling the crown, the cap and backing may be united and the lingual contour developed by the casting method.

STEELE INTERCHANGEABLE TOOTH, TECHNIC FOR CAST DUMMIES

A facing is selected and ground to the cast. The backing is then applied and trimmed to correct peripheral outline.

Inlay wax is now applied to the lingual surface of the backing and the desired contour of the tooth is developed by carving.

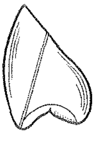


Fig. 588.— Bicuspid Dummy Consisting of Steele Facing, Backing, Occlusal Surface. Partial Lingual Contour Developed in Inlay Wax

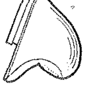


Fig. 589.— Backing and Wax with Steele Facing Removed

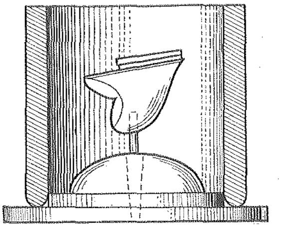


Fig. 590.—The Dummy, Minus Porcelain, Invested for Casting

The facing is now removed, a sprue former attached to the wax in such manner that when invested the gold will enter the matrix at the highest point.

The case is invested and cast by usual methods of procedure.

CONSTRUCTION OF DUMMIES WITH SWAGED CUSPS

When it is deemed advisable to construct the dummy with swaged occlusal surface the procedure is as follows:

A tooth of suitable size is selected, ground and backed as previously described. A cusp is carved in plaster or some medium by means of which a counterdie may be secured and a cusp swaged.

This is trimmed and fitted to the backing, the facing is adjusted and the assembled dummy tested as to its occlusal relations with the opposite teeth. When satisfactory, the facing is removed, and the metal structure is invested and soldered.

REFLECTING THE BACKING OVER THE CERVICAL MARGIN OF PORCELAIN

In some cases it may be considered advisable to reflect the extension which is added to the principal backing of a Steele tooth or facing over the gingival margin of porcelain. The object in doing this is to form a socked or gingival cup for

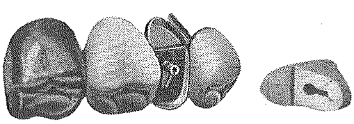


Fig. 591.— Bridge Showing Socket-Like Form, of Support for Steele Bicuspid

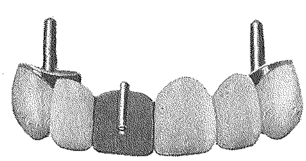


Fig. 592.— Anterior Bridge Composed of Steele Facings. Central Incisor Removed

the better protection of the porcelain against stress. When this plan is followed the cervical margin of the porcelain should be beveled slightly at the expense of the labial or buccal surface. This permits the reflected gold being finished flush with the porcelain without eliminating the shoulder.

Utilizing Long Pin Plate Teeth for Removable Facings

One of the main considerations in the use of replaceable facings of any type, in addition to ease of repair when fractured with use, is to avoid danger of fracture of porcelain during soldering operations.

A long pin facing, or ordinary *plate tooth,* is often utilized as a removable facing for the same reason that specialized forms of interchangeable teeth are employed.

One of the common methods of procedure is as follows: The facing is ground to correct form and backed with gold in the usual manner. The pins must be parallel with each

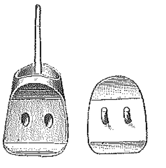


Fig. 593.— Long Pin Tooth Ground, Backing Adapted and Waxed in Position on Root Cap. Facing Removed

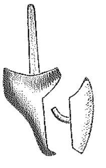


Fig. 594.— Proximal View of Removed Facing, Showing Pins Bent Gingivally

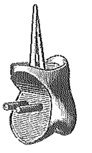


Fig. 595.— Assembled Bicuspid Dummy, Facing Removed, Carbon Points Inserted

other but not necessarily at right angles to the inciso-gingival plane of the lingual surface of the facing. Usually the pins are bent slightly toward the ridge lap to give them a hook-like contact with the backing.

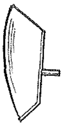


Fig. 596.— Long Pin Facing Ground and Backed for Bicuspid Dummy

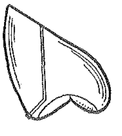


Fig. 597.— Facing Backed, Lingual Contour Developed in Wax

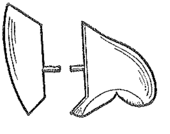


Fig. 598.— Facing Removed from Dummy, Carbon Points Inserted Through Backing in Wax

The backed facing is waxed in correct relation to its root cap, or if for a dummy its lingual contour is developed in wax to the desired form.

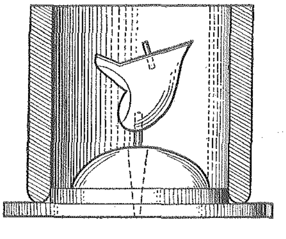


Fig. 599.— Dummy in Position for Investing within Casting Ring

The facing is carefully removed and in the openings in the wax formed by withdrawal of the pins, small pieces of carbon are inserted, the ends of which should project from the backing. This is necessary in order that they may be caught in and held by the investment.

The assembled metal parts are now united by casting or soldering. The carbon points are broken off and that enclosed within the gold is drilled out to receive the pins.

The facing is then fitted to the metal and when correctly adjusted, the pins are slightly roughened and the facing set with cement.

The Evslin Interchangeable Tooth

This tooth is made of porcelain in the form of facings for anterior replacements and with fully contoured bucco-occlusal surfaces for posterior replacements.

A posterior tooth of this type, in its general contour, is deficient on the lingual surface. In this surface a dovetailed space exists for receiving a lug of clasp metal of corresponding shape, which forms a part of the metal structure of the crown or dummy, box or socket.

In this, as in practically all other types of replaceable facings, the porcelain serves as a veneer for obscuring the essential metallic structural parts of a crown or bridge.

The dovetailed lug which is attached to the socket, and the opening in the porcelain are so related that, in adjusting the two parts together, the facing is not brought into close contact with the backing until the two are in nearly correct rela-

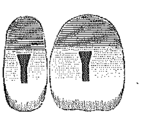


Fig. 600.— Lingual View of Evslin Bicuspid and Molar

tion to each other. Stated differently, the facing approaches its normal position or seat against the backing and base of the crown in an inclined direction and does not jam or become tightly wedged until practically seated. For this reason the incisal edge of an anterior facing may be beveled at an angle and the backing adapted accordingly, which, when reinforced with solder, forms a tip or metal protection for the porcelain against stress.

Backings of 24 k., 34-gauge gold with lugs attached may be procured or the prosthetist may attach the individual lug to any gauge and carat of gold he desires to use for the backing.

EVSLIN FACINGS — TECHNIC FOR ANTERIOR CROWNS

Construct the root cap by either direct or indirect method, adapt and solder dowel. Place on natural root, take bite and impression and mount casts on occluding frame. Select facing of suitable form and color and grind to position. Bevel incisal edge of porcelain at an angle of about 35 degs. to lingual surface. The facing should be slightly shorter than the required length of crown to allow for extension of backing over ridge lap and for the thickness of the metallic incisal tip.

Anneal backing with lug attached and adjust to facing, passing the square end of the lug into the slot incisally. Burnish and swage backing directly against the tooth, annealing

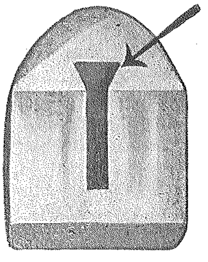


Fig. 601.— Tooth Ground, Incisal Edge Beveled

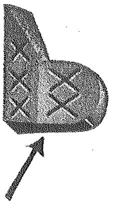


Fig. 602.— Pin or Lug to Be Attached to Backing

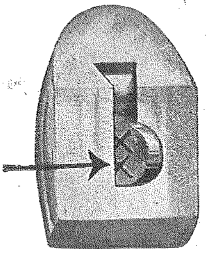


Fig. 603.— Lug Fitted in Recess in Facing

and reswaging until perfect adaptation is secured. Trim backing flush with mesial and distal surfaces of facing, but allow it to project slightly beyond both cervical margin and incisal edge.

Apply film of sticky wax over lingual surface of backing while the latter is still on the facing and chill it. This is to prevent distortion of the backing while removing the facing. Heat a piece of sticky wax and apply to the labial surface of the facing. This serves as a handle in separating it from the backing. The separation of the facing and backing at this time is necessary, to see that the two have not become wedged or jammed by the rough edges of the backing left by the file.

When this test has been carried out, the sticky wax is removed from the facing, the latter is returned to the backing, the two are set in correct relation to the proximating teeth on the root cap and the backing firmly luted in position with sticky wax.

The assembled crown is now removed from the model, the facing again removed from its position, and the backing and lug coated with Anti-Flux to prevent the solder from flowing on those surfaces against which the porcelain comes in contact.

When the dummy is constructed with an individual saddle, the backing should extend over the ridge lap of the facing

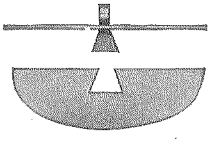


Fig. 604.— Sectional View of Facing, Lug, and Backing

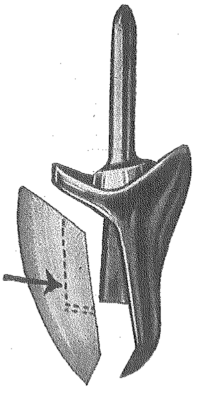


Fig. 605.— Facing Removed from Metal Structure

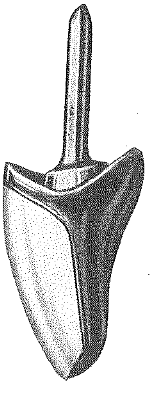


Fig. 606.— Appearance of Finished Crown

to the labial or buccal surface. The disc of gold which forms the saddle is adapted to the alveolar border and extended labially or buccally to meet the backing on these surfaces. When assembled, the lingual contour of the dummy is completed with wax. Usually the surface of the plaster cast covered by the saddle is scraped slightly before assembling and waxing the two parts together, to insure firm bearing of the completed dummy upon the ridge when the bridge is permanently set.

EVSLIN TEETH — TECHNIC FOR POSTERIOR CROWNS

The root cap having been constructed, impression and bite taken, casts secured and mounted on the occluding frame, the construction steps are as follows:

A posterior tooth of suitable form and color is selected and ground to suitable length. The mesial and distal surfaces

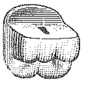


Fig. 607.— Evslin Molar

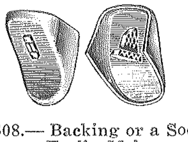


Fig. 608.— Backing or a Socket for Evslin Molar

should be beveled by grinding from the ridge lap occlusally. This is essential so that the sides of the gold socket may pass along these surfaces without producing unnecessary bulk in the interproximate space. Furthermore, the socket in which the porcelain rests can thus be made in boxlike form and will afford better retention for the tooth.

A backing with lug attached is adjusted and burnished to the porcelain. The surplus is then cut away, the tooth imbedded, occlusal and buccal surfaces down in moldine in the swaging ring and the backing swaged into close contact with the porcelain.

Remove the tooth and backing from the swager, flow sticky wax over the backing and separate. Correct any overhang of the gold margins, return tooth to place and wax backing to root cap, building the lingual contour out as desired.

The assembled crown is now removed from the model, the porcelain removed, Anti-Flux applied to the buccal surface of the backing, the case invested, as usual, for soldering.

The wax is now removed from between the root cap and the socket which receives the base of the tooth, the case heated

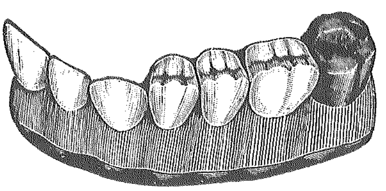


Fig. 609.— Buccal View of Posterior Bridge, Evslin Facings in Position

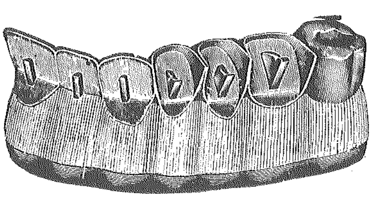


Fig. 610.— Same Case as the Preceding, Facings Removed

and solder flowed in to complete the lingual contour of the crown.

Pickle in acid wash and return the facing to position, being careful not to use much force. If obstructions, as nodules or excess solder, are present, remove them with a file or engine burs.

The surplus gold at the margins is removed with files, engine stones and discs.

The direction of movement in filing, grinding and polishing should always be from the gold toward the porcelain.

When the metal part of the crown is roughly contoured and moderately well smoothed up, the facing is cemented in place.

The final polishing on the lathe should be deferred until the facing is cemented in position, or the square margins of the metal next the porcelain will be rounded and thus leave a visible groove between the two.

EVSLIN TEETH — TECHNIC FOR ANTERIOR DUMMIES IN BRIDGE WORK

The abutment crowns of the bridge having been constructed, they are set in position on the roots in the mouth and a bite and an impression secured. The casts are then formed and mounted on the occluding frame.

Evslin facings of suitable color and form to meet the requirements of the case are selected and ground, as when long

Fig. 611.— These Cuts Show Protection Afforded Incisal Edge of Porcelain, also Form of Backing Sometimes Employed for Anterior Facings

pin, flat back facings are used, the ridge lap of the facing being ground to fit the irregularities of the border.

The facing is then backed as for a crown except that usually the backing does not extend onto the ridge lap.

The extent to which the backing covers the porcelain, however, depends upon the type of dummy being constructed, as it is sometimes extended over the ridge lap to form a socket.

INTERCHANGEABLE TEETH

Removable, replaceable and *interchangeable* teeth of various forms have been designed for use in crown and bridge work, the object of which is to obviate subjecting the porcelain to soldering operations and thereby avoid danger of fracture from this cause.

In the use of teeth of this type, the metal structure is built around and adapted to the porcelain, and after completion the teeth are cemented in position.

A distinction should be made between *removable flat back facings* and certain types of *removable* or *replaceable teeth.* A replaceable facing usually has within the body of porcelain a slotted opening which receives a correspondingly shaped lug of metal projecting from the crown or bridge structure. A *replaceable* tooth usually has, in addition to this or some similar means of anchorage, a *standardized base* composed of planes, so disposed as to aid in resisting displacement under masticatory stress.

A tooth formed with a standardized base of the character described can thus be readily replaced in case of fracture.

Replaceable teeth represent more nearly the anatomic types of natural teeth than facings of any class. Not only are the labial surfaces of the anterior teeth represented, but a portion of the lingual surfaces are reproduced, while in the posterior teeth, the buccal, occlusal and a portion of the lingual surfaces are developed in porcelain.

Among the well-known teeth of this type, as well as new forms which have recently appeared, are the Goslee, the Steele and Evslin posteriors, the Gardiner and the Merker. A brief description of the Steele and the Evslin teeth has already been outlined.

The Goslee Tooth

This consists of a partially contoured porcelain crown, deficient in its lingual areas. Within the lingual side, and at

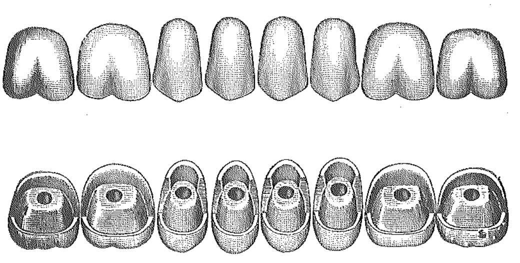


Fig. 612.— Buccal and Lingual View of Goslee Interchangeable Posterior Teeth

right angle to the long axis of the tooth, is developed a flat seat. In this seat is a cylindrical opening, extending incisally

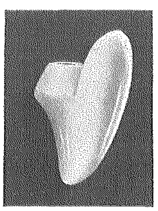


Fig. 613.— Proximal View of Goslee Incisor Facing

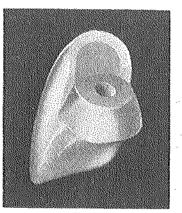


Fig. 614.— A Goslee Incisor Facing, Showing Basal Seat Opening for Dowel and Flaring Lingual Surfaces

or occlusally into the body of the tooth, for the reception of a dowel which forms a part of the metal structure. The sides flare outwardly, and occlusally or incisally, from the seat. In the bicuspids and molars, the flaring sides terminate within

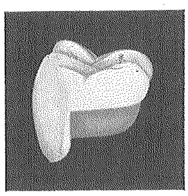


Fig. 615.— Proximal View of Goslee Interchangeable Tooth

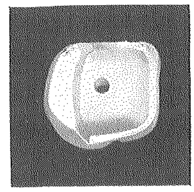


Fig. 616.— Cervical View of Goslee Tooth

and form a depressed shoulder just beneath the mesial, distal and lingual surfaces of the crown.

TECHNIC OF APPLICATION OF THE GOSLEE TOOTH IN CROWN WORK

Prepare a root cap, preferably by the indirect method, using 36 gauge platinum or pure gold plate. By forming a depressed area in the central portion of the root, the walls of which are but slightly divergent, the root periphery may be decidedly beveled so that in the completed crown no peripheral shoulder will be present. In forming the cap, it is swaged into the depressed area and thus forms a shoulder for guiding the cap to and holding it in correct position on the root.

Through openings in the cap, dowels are introduced into the root canals. The relation between the dowels and cap is secured and their subsequent attachment by soldering is accomplished by methods previously described. At the time of attaching the dowels, high grade solder or 22k. plate should be flowed over the root cap to stiffen it and fill the depressed central area.

The cap, with dowels soldered in place, is now returned to the root and the peripheral margin of the band corrected by burnishing.

An impression and bite or a bite-impression is secured, removing it from the mouth with the face bow.

A film of wax is flowed over the dowels and inside the root cap to facilitate removal of the cap from the cast later on.

The cap is placed in position in the impression and casts developed and attached to the occluding frame.

A Goslee tooth of suitable size is selected and ground, if necessary, to meet requirements.

It is then imbedded, occlusal end down, in modeling compound, in the swaging ring. The surfaces to which the gold is to be applied should be above the ring margins, so that the rubber in the swager may force the gold against all required areas.

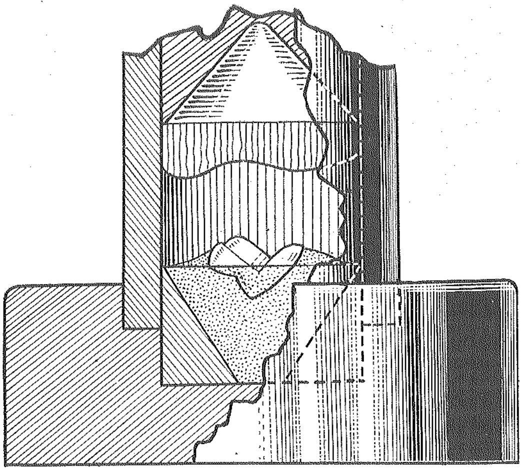


Fig. 617.— Goslee Tooth Invested in Swaging Ring, Preparatory to Adapting Socket. Tooth Set in a Diagonal Position for Swaging

A disc of 36 g. pure gold, or platinum, somewhat larger than the areas to be covered, is applied to the crown base, and with finger pressure and burnisher adapted to the porcelain.

When reasonably close adaptation has thus been secured and the excessive surplus removed, final adaptation is developed by swaging.

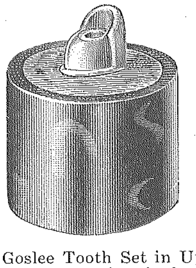


Fig. 618.— Goslee Tooth Set in Upright Position for Swaging Socket

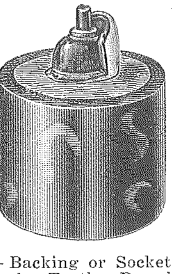


Fig. 619.— Backing or Socket Adapted to Goslee Tooth. Dowel in Position

An opening in the gold socket is now made for the reception of the short dowel, which may be of regular form and headed on one end, or a piece of 14 g. clasp metal wire, sufficiently long to project slightly beyond the socket, may be used. With dowel in position, the cap is reswaged.

Wax is applied to the dowel and against the gold, the two removed and united with high grade solder. The gold should also be stiffened by flowing a film of solder over its general surfaces, but not along the margins.

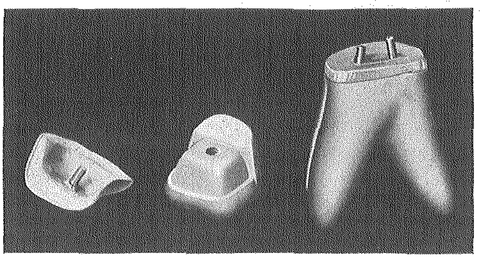


Fig. 620.— Metal Socket, Swaged, with Dowel Attached, Goslee Tooth. Form of Root Cap Usually Employed for Molar Teeth

The socket is now returned to the porcelain for final swaging, after which the tooth is removed from the moldine.

The tooth in its socket is now adjusted to the root cap and waxed in position.

Previously, however, the root cap is heated slightly to soften the wax around the dowel, removed, freed from wax, and returned to position on the cast.

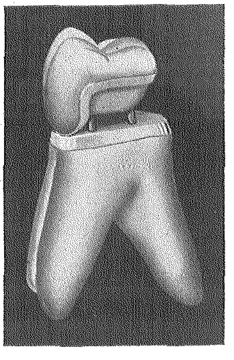


Fig. 621.— Crown with Socket, Adjusted to Root Cap, Ready for Waxing Together

The assembled crown is waxed to the desired contour, removed from the cast, the porcelain removed from its socket and the metal structure invested for completing the required contour, either by soldering or casting.

The Goslee tooth is capable of a wide range of application in bridge work, when sufficient space is present in which,

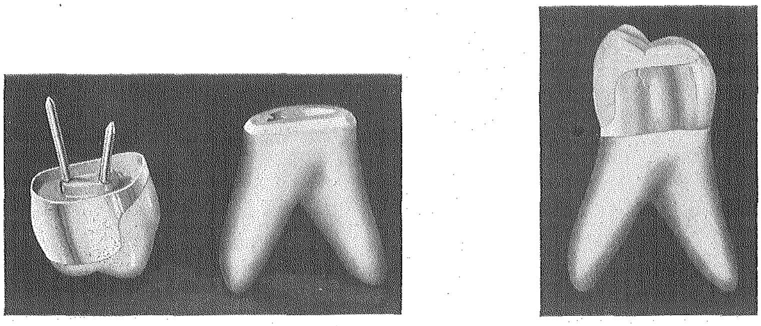


Fig. 622.— Two Views of Finished Crown

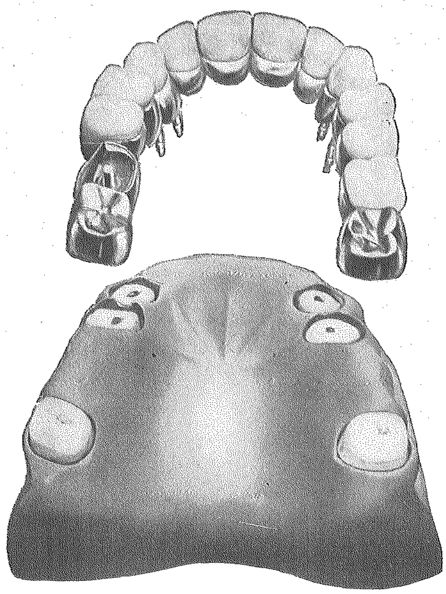


Fig. 623.— A Bridge Composed of Goslee Teeth Combined with Gold Shell Crowns

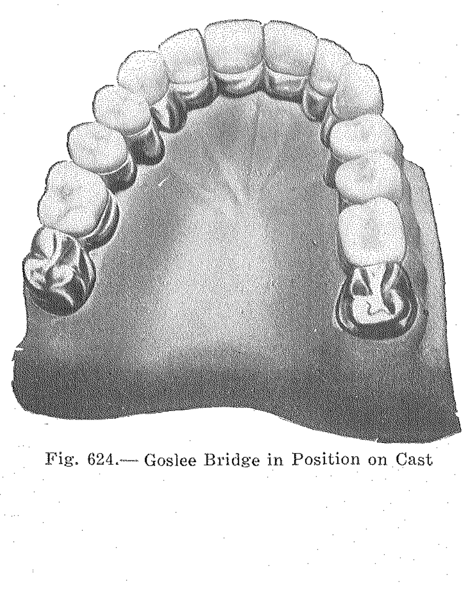


Fig. 624.— Goslee Bridge in Position on Cast

in addition to the porcelain replacements, a rigid metal structure may be introduced.

The individual saddle is often applied in connection with teeth of this type to very great hygienic advantage.

The Gardiner Replaceable Tooth

This tooth is supplied for both anterior and posterior replacements. In form, it is somewhat novel, having a broader base than occlusal area.

Instead of having an opening within the body of the crown for the reception of a lug, the base of porcelain presents a square or rectangular projection, which is received by and enclosed within a correspondingly shaped depression in the socket.

To give the crown additional stability and resistance to stress, the base is composed of flat planes, placed at varying

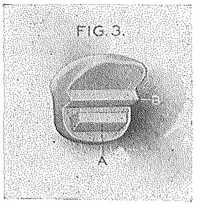


Fig. 625.— Cervical View, Showing Dispositions of the Various Basal Planes

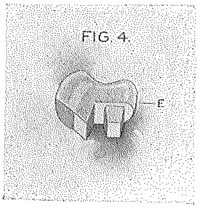


Fig. 626.— Proximo-Cervical View of Gardiner Tooth, Showing Anchorage Lug of Porcelain

angles. These planes are so disposed as to tend to *seat* the crown firmly in its socket under masticatory stress.

Because of the extremely constricted bulk of porcelain entering into the construction of the tooth, it can be applied in many cases in limited spaces without requiring appreciable modification of form.

The planes are so disposed as to give uniformity of thickness to the occlusal body of porcelain. The projecting lug is placed directly under the lingual cusps, thus giving support to an otherwise weak area of porcelain.

TECHNIC OF APPLICATION OF THE GARDINER TOOTH

The root cap is formed by any of the previously described methods, an impression secured, casts developed, and mounted on the occluding frame.

A tooth of suitable form and color is selected and fitted to the root cap, due allowance being made in its length for the interposition of the socket.

The tooth is then imbedded, occlusal end down, in moldine, in the swaging ring, and a 36 gauge pure gold or platinum socket developed by burnishing and swaging.

When adapted, the margins of the socket are trimmed so as to form a collar around the entire peripheral margins of

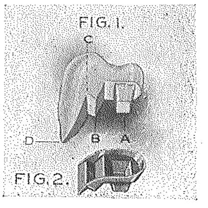


Fig. 627.— View of Gardiner Tooth with Swaged Socket

the tooth, as should be the case in practically all types of replaceable teeth.

To prevent distortion in handling and soldering, a film of high grade solder should be flowed on the under, or cervical, areas of the socket, but not over the peripheral margins.

When this plan is adopted, the margins should be reburnished to the porcelain before investment.

The socket, with crown in position, is now adjusted to the root cap, the two united with wax, the assembled crown removed from cast, the porcelain removed from socket and the metal parts invested for soldering or casting.

APPLICATION OF THE GARDINER TOOTH IN BRIDGE WORK

Teeth of suitable form and width are selected to fill the space between the abutment supports. Sockets are formed

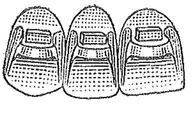


Fig. 628.— Lingual View of Teeth Removed from Bridge

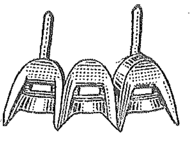


Fig. 629.— Labial View of Metal Structure of Bridge

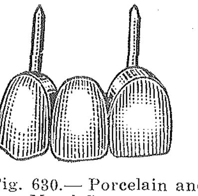


Fig. 630.— Porcelain and Metal Structure Assembled

in the manner described. These should be stiffened with a solder or plate that will not fuse in the final assembling and soldering of the bridge.

Before permanently attaching the porcelain teeth to their sockets with cement, the surfaces to be covered by the latter

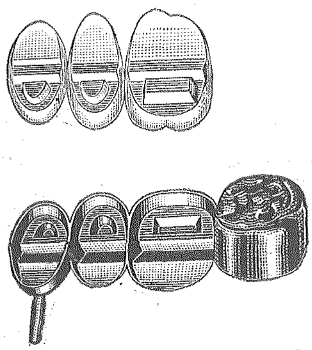


Fig. 631.— Four-Tooth Bridge, Porcelain Removed from Metal Sockets

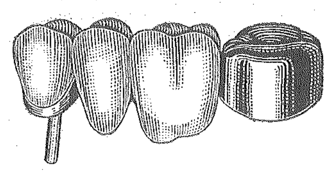


Fig. 632.— Porcelain and Metal Structure Assembled

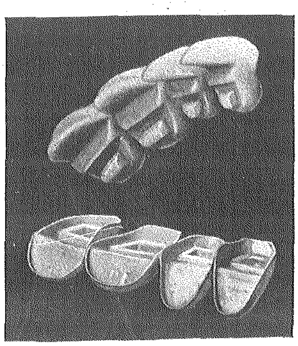


Fig. 633.— Cut Showing Manner of Flanging the Metal Sockets to Increase Porcelain Anchorage

should be etched with hydro-fluoric acid, or the glaze removed with discs.

The Merker Replaceable Tooth

This tooth, comparatively new, possesses two points of interest. The base is composed of two flat planes disposed at

Fig. 634.— Proximal Views of Merker Anterior and Posterior Teeth, Seated on Metal Bases

right angles to the long axis of the tooth. A small, rather deep opening in each plane extends occlusally for the reception of two iridio-platinum anchor dowels, which, during constructive stages, are adjusted to the metal socket.

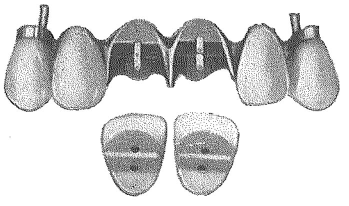


Fig. 635.— Anterior Bridge Composed of Merker Replaceable Teeth, Two Central Incisors of Which Are Removed from Position

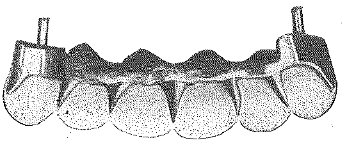


Fig. 636.— Lingual View of the Anterior Bridge

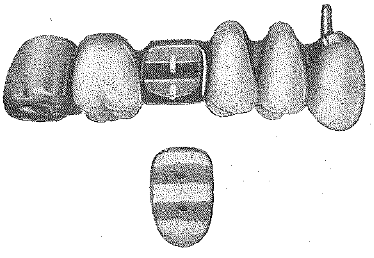


Fig. 637.— Posterior Bridge, First Molar Removed from Metal Structure

The application of this crown in crown and bridge work is practically identical to the steps outlined for the Goslee crown.

THE DIATORIC USED AS A REPLACEABLE TOOTH

Diatoric posterior teeth are often used as replaceable teeth in bridge structures. When utilized for such purpose the basal periphery is usually reduced so as to permit the

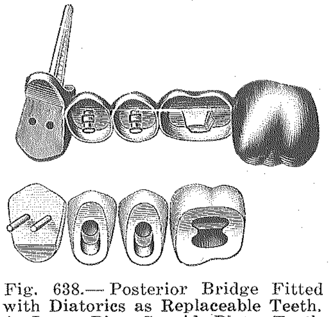


Fig. 638.— Posterior Bridge Fitted with Diatorics as Replaceable Teeth. A Long Pin, Cuspid Plate Tooth Applied as a Replaceable Filling

formation of a collar around the socket. In addition to the anchorage afforded by the peripheral collar, during the swaging of the socket, the gold is carried into the central opening of the crown base. This forms a projection on the metal structure and fulfills the purpose of a dowel. In some cases short, grooved dowels are adapted to the socket, as in the Goslee crown.

Full Contoured Porcelain Crowns

Crowns composed of porcelain and metal, although admirably adapted to and indispensable in some cases, are frequently deficient in esthetic effects, the tinge of porcelain being adversely affected by the presence of the metal.

To overcome this very decided objection, full contoured porcelain crowns are very often used when conditions as to mesio-distal and occluso-gingival space will permit.

Crowns of this type are supplied by the manufacturers, in great variety of forms and shades, and when well selected and skillfully applied to natural roots, are not distinguishable from natural teeth.

Full contoured porcelain crowns may be divided into two general classes, viz., *fixed dowel crowns* and *detached dowel crowns.* The principal advantage of a detached dowel crown over one having a fixed dowel is that the porcelain base of the former can be readily adapted to the root face, the absence of the dowel permitting unrestricted grinding on areas that interfere with close peripheral adaptation.

FIXED DOWEL CROWNS

The Logan, Twentieth Century and Johnson & Lund are types of the attached dowel crown, the dowel being enclosed

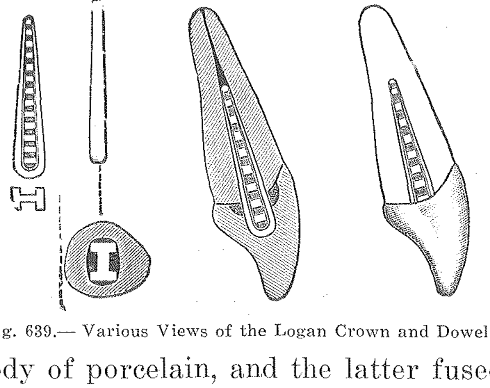


Fig. 639.— Various Views of the Logan Crown and Dowel

within the body of porcelain, and the latter fused around it. Since the technic of application of crowns of this type is similar, a description of one will answer for all, whether plain or combined with a root cap or cast base.

TECHNIC OF ADAPTING A PLAIN LOGAN CROWN TO A NATURAL ROOT

It will be assumed that the apex of the root to be crowned has been sealed with a permanent filling.

The remaining portion of the natural crown is reduced by means of stones and Ottolengui root facers, slightly beneath the gum margin, being careful while doing so to avoid unnecessary injury of the soft tissues.

The root canal is first enlarged with graded sizes of round burs as previously described, omitting the use of No. 10 and

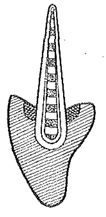


Fig. 640.— Sectional View of a Logan Crown

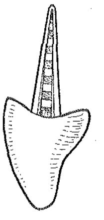


Fig. 641.— Proximal View of a Logan Crown

substituting therefor a fissure bur, the diameter of which is slightly larger than the mesio-distal thickness of the dowel next the crown base.

By means of the fissure bur the canal is enlarged labially and lingually sufficiently to receive the dowel at its greatest diameter, while the mesial and distal dentin walls of the root are not materially reduced and consequently weakened as is the case when a taper reamer is employed.

From a stock of crowns one of suitable form and color is selected. In size it should be slightly longer than required, since both base and incisal edge must be modified by grinding, the first to secure necessary adaptation, the second for esthetic reasons. The width of the crown should be sufficient to afford strong knuckling contact with proximating teeth. The periphery of the crown base should slightly exceed that of the root face, since a subsequent step reduces the excess of porcelain until it coincides with the root periphery. If too small, a shoulder is formed which cannot be obliterated, the root projecting beyond the crown base.

ADAPTING THE CROWN TO THE ROOT

The crown is now applied to the root and the points requiring gross reduction are removed with suitable stones. Close adaptation is developed by interposing a disc of carbon paper between the crown base and root face to mark the high points. These are ground away and the steps repeated until close peripheral adaptation between crown and root is secured.

Care should be observed while making these tests to see that the crown is in correct alignment labio-lingually, which may be done, when necessary, by bending the dowel.

When close adaptation of crown base to root face has been developed, the incisal edge or other areas of the crown are modified with stones and discs, to coincide with the type of

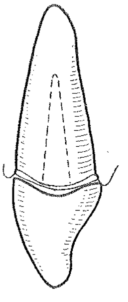


Fig. 642.— Logan Crown Applied to Root Before Adapting to Root Face Has Been Accomplished

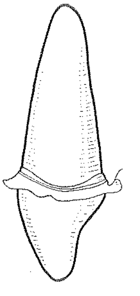


Fig. 643.— Carbon Paper Interposed Between Crown Base and Root Face, to Disclose Points of Interference

proximating teeth. When these show wear or ridged surface markings, similar surfaces and markings should be developed on the crown.

Sometimes the proximating natural teeth show unusual colors in or beneath the enamel, and which cannot be removed by any means employed. The setting of a porcelan crown or replacement of any type between teeth so marked, unless it is of closely corresponding color, is unsightly.

STAINING OF PORCELAIN TEETH

Porcelain stains, both oil and water colors, are procurable, by means of which a tooth or crown can be made to match the most unusual shades found in natural teeth. The technic of application of such colors is simple. The tooth to be stained is thoroughly cleansed and washed in alcohol, a pigment of the desired shade is mixed with water or one of the essential oils as cloves or glycerin, and applied with a small brush by painting it over the surfaces or stippling, the degree of color being dependent upon the layer of pigment applied.

When applied, the colors should be slowly dried, moderate heat accelerating the evaporation of the liquid. It is then introduced in the furnace and vitrified, the tooth resting on a bed of pulverized silex, on the slab, and face upward. The colors glaze at a temperature varying from 1100 degs. F. to 1500 degs. F. A little experience with these stains will enable the prosthetist to produce most beautiful esthetic results.

In case a suitable shade of Logan or any of the types of crowns mentioned cannot be procured, they should be stained to coincide with the colors observed in the natural teeth.

SECURING PERIPHERAL ADAPTATION OF CROWN BASE TO ROOT

The final step in adaptation consists in removing the excess or *overhang* of porcelain over the root, and lining the two peripheries up until they form continuous surfaces. The steps are as follows:

A disc of white baseplate gutta percha, slightly larger than the crown base, is punctured in its center and passed over the dowel and against the porcelain. Moistening the

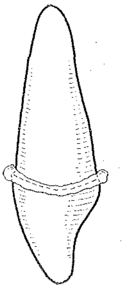


Fig. 644.—Gutta Percha Interposed Between Crown Base and Root Face to Disclose Extent of Projecting Porcelain Over Root Margins

surface of the disc next the crown base with oil of cajaput will cause the gutta percha to adhere firmly to the porcelain.

The crown and disc are warmed and the crown forced to place on its root. Under pressure, the gutta percha being forced against the root, an impression of not only the face but of the periphery as well is secured. A blast of cold air directed on the disc will chill it so that removal can be effected without distortion. If the steps have been properly carried out a distinct impression of the root periphery will be seen in the gutta percha.

A coarse, large size engine stone, running at a high speed, is lightly applied to the surplus gutta percha, and the latter removed until the stone comes in contact with the projecting shoulder of porcelain. The grinding is continued until the porcelain is reduced to the peripheral margin of the root as indicated in the gutta percha impression. During the grinding process the crown and disc should be immersed in cold water from time to time to obviate distortion of the gutta percha from frictional heat of the stone.

During first grinding the prosthetist should not attempt to develop correct axial contour to the crown, but merely to

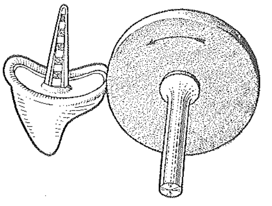


Fig. 645.— Application of Stone to Remove Excess Peripheral Porcelain

remove the projecting shoulder, after which the gutta percha may be removed and axial contour developed with suitable stones. The final polish on surfaces which have been ground and disced, is accomplished with putty powder, applied with a soft wood or hard felt wheel, running at high speed.

The crown, having been ground to correct outline form, its base shaped to coincide with the root periphery, its sur-

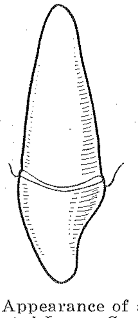


Fig. 646.— Appearance of a Properly Adapted Logan Crown

faces polished, and, if necessary, stained, it is ready for mounting on the root.

SETTING THE CROWN

Cotton rolls should be placed under the lip or in such location as to guard against moisture during the setting of the crown. The root canal and root face should be thoroughly dried with cotton points and warm air. Cement of medium consistency is thoroughly mixed and worked into the root canal and applied over the root face. The dowel and crown base is also covered with a thin film, and if a depression is present in the base of the crown it should also be filled. The crown is now set in position, considerable force being required to seat it and expel the excess cement.

Pressure should be maintained upon the crown until the cement has set, which usually requires from eight to ten minutes. Further time should be given the cement to thoroughly harden before removing the peripheral surplus. A small, angular blade instrument like a gold knife, used in finishing the margins of gold fillings, can be used in removing the surplus cement which should be cut or shaved rather than broken from along the joint.

When loosened and the particles of cement are removed as well as can be with cotton and pliers, the gum tissues should be syringed with warm water and the crown tested as to its incisal or occlusal relation with opposite teeth. If satisfactory the patient is dismissed with instructions to avoid subjecting the crown to any stress for several hours, in order that the cement may not be disturbed until thoroughly crystallized.

The Banded Logan Crown

The technic of construction of a banded Logan crown is as follows: A root cap is constructed by methods previously outlined under the heading, "Construction of a Porcelain Faced Crown" (page 641). The enlargement of the root canal for the reception of the rectangular dowel of the Logan crown is essentially the same as detailed for a plain Logan crown.

ADAPTING THE LOGAN CROWN TO THE ROOT CAP

Before perforating the root cap for the reception of the dowel the root canal should be enlarged and the crown adapted to the root face by grinding. The lingual side of the crown base should be reduced to form a V-shaped space, which later on is filled with solder.

The general adaptation of the crown to root face having been developed, the root cap is set in position on the root and with a burnisher indented to indicate the location and extent of the opening for dowel. A series of small holes can be drilled through the cap while in position on the root, or it can be removed and the holes punched with plate punch. In either case the several holes are connected by passing a fine fissure bur through the intervening divisions.

The dowel is now forced through the more or less irregular slot, the excess gold being forced into the entrance of the root canal, the margins of gold thus fitting tightly against the dowel.

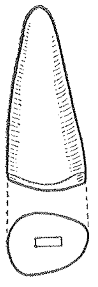


Fig. 647.— Prepared Root with Cap. Notice Form of Opening in Cap Required for Dowel

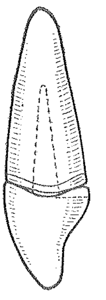


Fig. 648.— Crown Resting on Root Cap. Dotted Line Shows Lingual Reduction of Porcelain Required

A disc of gold, slightly larger than the crown base, is perforated with a corresponding rectangular slot, placed on a large cork and the dowel forced through it until the crown base rests upon the disc. By repeated burnishing and annealing the disc is closely adapted to the porcelain.

The peripheral excess of the disc is removed, close to, but not exactly even with the crown periphery, a slight surplus

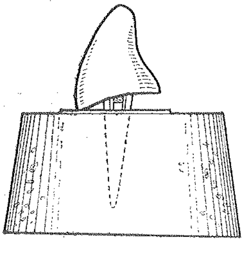


Fig. 649.— Adapting Gold Disc to Crown Base, Against Cork

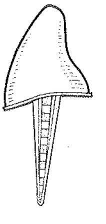


Fig. 650.— Disc Adapted and Peripheral Excess Removed

being necessary to insure the solder being drawn out to full contour.

The cap, disc and crown are now assembled on the root and their relation noted. Particular attention should be given the labial alignment of the crown and band. When the crown sets to the lingual of the labial band surface, it may be brought forward by bending the dowel to the lingual and extending the slot in the cap to the labial, it being necessary in some cases to ream the root canal also for the accommodation of the dowel. When the crown extends to the labial of the band surface and its labial alignment is approximately correct, the solder may be drawn through so as to fill the space between the disc and labial band surface, and the gold and porcelain

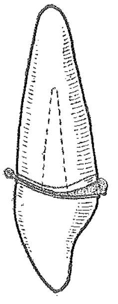


Fig. 651.— Securing Relation Between Crown, Disc and Root Cap, with Wax

dressed smoothly to form a continuous surface in the final finishing of the crown.

Two thicknesses of gold plate. the disc and cap top, are interposed between the root face and crown base. Both of these may be reduced somewhat to bring the crown closer to the root, and lessen the display of gold on the labial surface of the finished crown.

ASSEMBLING THE SEVERAL PARTS OF THE CROWN

The cap, disc and crown having been fitted in correct relation to each other on the natural root, they are assembled as follows:

The crown and disc are removed, all of the parts dried, sticky wax is applied around the dowel and against the disc and softened with a hot spatula. The crown is then forced

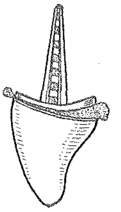


Fig. 652.— The Assembled Parts Removed, Ready for Investment

against the cap, the interposed wax pressing the cap against the root, and the disc against the crown base. When the wax is chilled, the three parts, now firmly united, are removed from the root (see Fig. 652), the surplux wax trimmed away and any openings between cap and disc filled in with wax, when the crown is ready for investment.

INVESTING THE BANDED LOGAN FOR SOLDERING

The investment of a banded Logan crown for soldering is essentially the same as the investment of a porcelain-faced crown. The joint surfaces between disc and root cap must be entirely exposed to prevent the confinement of air in con-

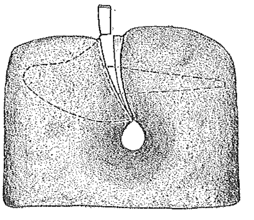


Fig. 653.— Crown Invested for Soldering. Notice Small Wedge of Metal to Be Inserted Between Root Cap and Disc to Prevent Displacement of the Latter in Soldering

stricted spaces and, further, so that in soldering it may readily be seen when the joint is filled.

When the investment has hardened, the surplus trimmed away, and the joint surfaces freely exposed, the wax is removed by pouring a fine stream of boiling water into the space. Care should be taken to remove every particle of wax, for if any is left and flux is applied, it will act as a carrier for the latter, and when heat is applied the wax will melt and pass beyond the gold surfaces onto the porcelain, thus inviting fracture of the crown.

SOLDERING THE CROWN

The joint areas to be soldered are covered with a thin film of thick borax paste, a thin piece of wood, as a delicate, wedge-shaped toothpick, being most useful in introducing it in constricted spaces.

When fluxed, the invested case is set on a piece of gauze, over a Bunsen burner, and thoroughly heated, until the base of the investment is red, when it may be removed to the soldering block and the blow-pipe flame applied to bring it to suitable temperature for soldering.

The solder, in the form of a long strip, is applied in the deepest part of the joint area, and as it melts is fed into the fused mass until proper contour is attained.

To obviate the tendency of the disc being drawn away from the crown base by the contraction of the solder in cooling, a wedge of plate metal should be inserted between the cap and disc, before placing the case on the Bunsen burner.

FINISHING THE CROWN

When cooled, the investment is broken away, the crown placed in a test tube and boiled in a pickle of 25 per cent H Cl,

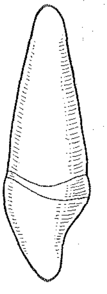


Fig. 654.— Appearance of the Finished Crown

after which it is finished in the usual manner with stones and discs, the final polishing being accomplished with fine powders on the lathe wheel.

THE DAVIS CROWN

The *Davis* is a fully-contoured porcelain crown, having a central cavity within its base for the reception of an anchorage dowel.

The dowel, which accompanies the crown, and of which there are varying sizes, consists of a pin having a shoulder

Fig. 655.— Sectional View of Davis Crown Before and After the Base Has Been Modified. Special Care Must Be Observed to Preserve the Shoulder Depression in Crown Base for Reception of Dowel Collar

near the crown end. From the shoulder, one portion tapers apically for insertion in the root, while the shorter is parallel sided for insertion in the crown base. The dowel is grooved in several places throughout its length to afford better anchorage within the cement. From 13 to 16 gauge iridio-platinum or clasp metal wire may be used as dowels if desired.

There are three general methods of applying crowns of this type to the roots of natural teeth, the crowns so applied being designated as *plain, cast base,* and *banded.*

APPLICATION OF THE PLAIN DAVIS CROWN

A Davis crown without cap or metal base may be applied to the root of a tooth in several ways, the following of which, if carefully carried out, will yield good results. After the root has been properly treated and filled, the remaining portion of natural crown is reduced slightly beneath the gum margin.

The root face should usually be given a distinct labio-lingual convexity sufficiently marked to guide the crown base to position without any tendency to rotate.

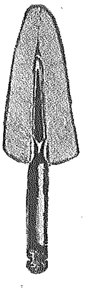


Fig. 656.— Root Reamer in Canal

Fig. 657.— Dowel in Canal

The root canal is opened up first with small burs and afterward enlarged with a reamer corresponding in taper with the

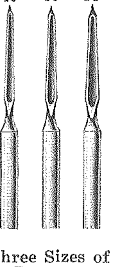


Fig. 658.— Three Sizes of Root Reamers

dowel. To avoid excessive enlargement of the root canal, the dowel should be inserted from time to time and tested as to closeness of adaptation to the canal walls. The shoulder should rest squarely upon the root face, while the sides of the dowel fit closely within the canal. This latter requirement, however desirable, cannot always be realized, it being necessary at times to incline the dowel in some direction to bring the crown in alignment with proximating teeth.

A crown should be selected slightly longer than required and with a base a little larger than the root face.

The dowel is now removed from the canal and the crown base adapted to the root, first removing the grosser points of contact with moderately coarse stones.

Close adaptation is developed by returning the dowel to the root canal, placing a disc of carbon paper over it and applying the crown to the root face, the interposed carbon indicating the points of interference.

In all of these tests, care should be taken to hold the crown in correct alignment with the proximating teeth before applying pressure against the carbon paper.

The points indicated on the base of the crown by the carbon are ground away and the tests repeated until close adaptation, particularly peripherally, is obtained.

In some cases it may be found necessary to bend the dowel slightly to bring the crown into correct alignment with the proximating teeth. In other cases an *offset* dowel may be re-

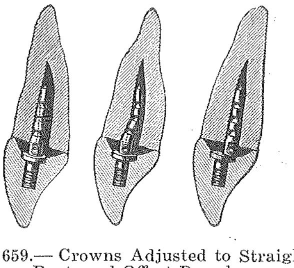


Fig. 659.— Crowns Adjusted to Straight, Bent, and Offset Dowels

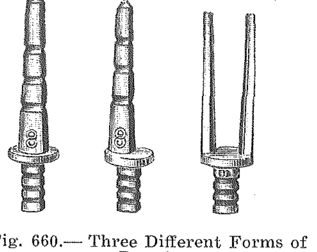


Fig. 660.— Three Different Forms of Dowels

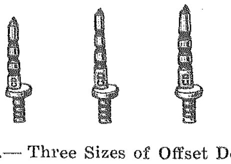


Fig. 661.— Three Sizes of Offset Dowels

quired, and again it may be necessary to ream the canal wall away, thus permitting the dowel to move bodily, in the direction indicated.

Special care should be observed to see that the shoulder of the dowel rests in the depression in the crown base. When it fails to rest within the depression in the porcelain designed for it, the attachment of crown to dowel will be weakened because of the shortening of the latter.

REDUCING THE PERIPHERAL SHOULDER

Apply a disc of white baseplate gutta percha to the crown base, having first moistened the disc with oil of cajaput and warmed the porcelain slightly to develop adhesion. Perforate the disc in its central area to allow the dowel to pass through.

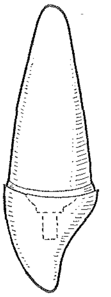


Fig. 662.— Plain Davis, Adapted to Root Face, Excess Peripheral Shoulder Not Yet Removed

Moisten the face end of root with water. Direct a blast of hot air on the gutta percha and force the crown to place. A few drops of cold water will chill the gutta percha, and on removal of the crown it will adhere to and come away with the latter.

The excess porcelain is now ground away to the line of root periphery as indicated in the gutta percha impression. The steps are similar to those of correcting the base of a plain Logan crown. (See page 719.)

GENERAL MODIFICATION OF THE CROWN BY GRINDING

The incisal or occlusal relation of the crown is tested and any modification as to length or general contour corrected. All surfaces so modified should be polished with fine discs, followed with putty powder on the lathe wheel.

SETTING THE CROWN

The crown, dowel, root face and canal are thoroughly dried. A mix of cement of medium consistency is made and introduced in the canal and in the opening in crown, after which more is added to the crown base. The crown is now forced

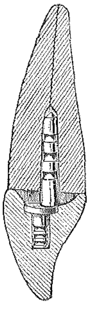


Fig. 663.— Sectional View of Crown, Offset Dowel, and Root

to place and held firmly until the cement has hardened, when the surplus is carefully removed.

THE DAVIS CROWN IN BRIDGE WORK

The Davis crown can often be applied to advantage in bridge work. When so utilized, the base of the crown selected for the dummy must be reduced sufficiently to give space for

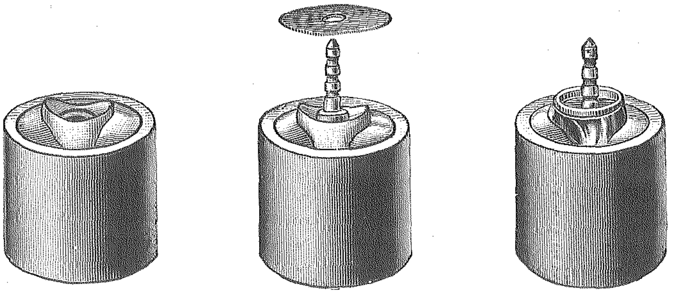


Fig. 664.— Swaging Disc Against Crown Base and Dowel Collar

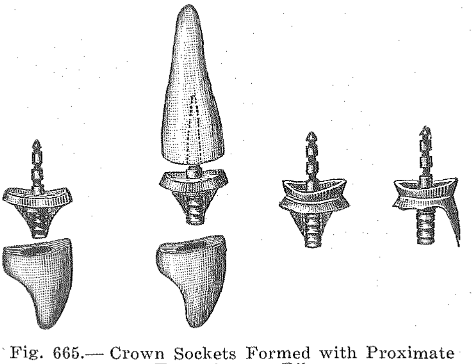


Fig. 665.— Crown Sockets Formed with Proximate Extensions or Ribs

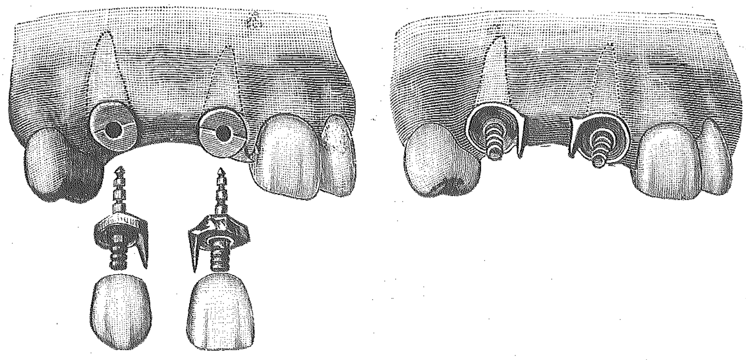


Fig. 666.— Root Caps with Perpendicular Ribs, Designed to Unite with Corresponding Ribs of Dummy Socket. First View Removed, Second View in Position

the metal structure. It is also advisable to groove the proximating surfaces of crowns and swage base caps or sockets, the sides of which are conformed to and fit within the proximal grooves. These perpendicular ribs add greatly to the

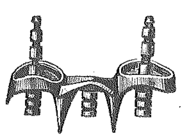


Fig. 667.— Interproximal Extensions, Incisally, of Gold in Small Bridge Structure Formed by Grooving Davis Crowns on Their Mesial and Distal Surfaces. Object, to Resist Tendency of Crowns to Tip Buccally or Lingually Under Stress

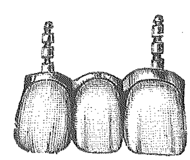


Fig. 668.—The Completed Bridge Ready for Permanent Setting

stability of the porcelain, tending, as they do, to resist torsional strain. The principal anchorage is secured by means of short dowels set within the sockets, to which they are attached during the constructive stages of the individual dummies.

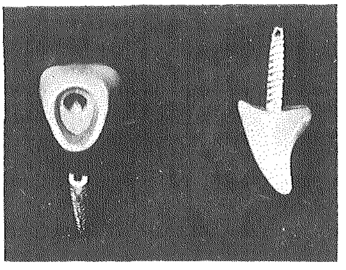


Fig. 669.— Justi Crown, Showing Crescent Opening for Dowel. Also Crown with Dowel in Position

The Cast Base Davis Crown

The prosthetist who can grind a perfect joint between crown base and root face will find only occasional need for interposing a cast base between crown and root.

A cast base as ordinarily constructed neither obviates splitting of the root nor displacement of the crown under stress.

The insertion of short dowels, or iridio-platinum, in lingual areas of the root face, to the mesial or distal of the root canal, or beveling the lingual periphery of the root so that the projecting lip of the cast base may engage with it, will largely reduce the tendency of a root to split under stress.

These and other similar means of obviating root splitting, although simple and efficient, are often ignored in the class of work under consideration.

Cast bases are most strongly indicated in those cases where considerable loss of root structure has occurred, and when the fitting of a peripheral band would be difficult, if not impossible.

Construction of a Cast Base Davis Crown

After the apex of the root is filled the remaining portion of the natural crown is removed. In case the crown has been

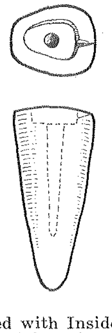


Fig. 670.— Root Prepared with Inside Shoulder Depression, Showing Labial V-Shaped Notch

lost through extensive caries, all leathery decay should be removed and the root margins rendered smooth and firm.

A crown is now selected and ground to meet requirements.

When the root has not suffered loss of structure from caries, space for the cast base is gained at the expense of grinding both root and lingual areas of the crown base.

When space to be occupied by the cast base is limited it is advisable, in order to impart rigidity to the wax pattern, to extend a V-shaped groove from the canal to the labial surface of the root. Notching of the crown base will also prove beneficial, but the notch should terminate within the labial periphery.

Such notches form strengthening ribs in the wax pattern and prevent distortion while handling and investing.

The crown having been ground to requirements, the root face prepared, the canal reamed and dowel fitted, the next step is to form the wax pattern.

The crown base is coated with a thin film of oil, the dowel inserted in the crown, a piece of softened inlay wax passed over the dowel and against the crown base. The crown is now

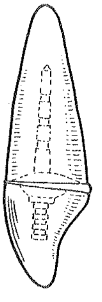


Fig. 671.— Davis Crown in Position on Root Wax Model for Cast Base Interposed

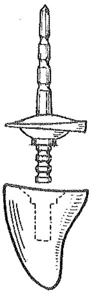


Fig. 672.— Crown and United Wax Base and Dowel Removed from Root

forced firmly against the root face, being careful to keep it in proper alignment with the proximating teeth.

When chilled, the surplus wax is trimmed away, even with root and crown peripheries. This step must be carefully carried out or the peripheral margins of the pattern will be disturbed.

The crown is now removed, which usually is easily accomplished if the base was previously oiled.

The wax pattern is removed by grasping the projecting end of the dowel lightly with the pliers, being careful not to rotate or oscillate it.

If satisfactory, the oil is removed with a camel's-hair brush and soapy water, or its surfaces can be cleansed with a spray of acetone, which will dissolve the oil without affecting the wax.

A sprue former is now attached in the thickest portion of the lingual area, usually at right angles to the dowel, and it is ready for investment in the casting ring.

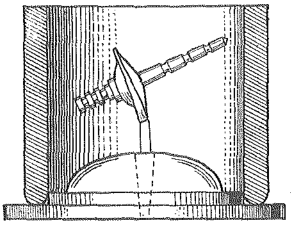


Fig. 673.— Wax Model Mounted for Investing

The Banded Davis Crown

The following method of applying a Davis crown to a banded or capped root is comparatively simple and satisfactory:

After treatment and filling of the canal, the remaining portion of natural crown is removed, the peripheral ring of enamel cleaved away, and the root faced, practically at right angles to its long axis. To this the cap is fitted in the usual manner and perforated in line with the root canal, previously reamed, for the reception of the dowel.

The crown is now selected and ground away on its lingual side to form a V-shaped opening with the cap.

In the base of the crown a shallow, yet distinct, V-groove should be cut, extending from the lingual surface to the central area. The gold, when forced into this groove, forms a rib which guides the crown into proper position on the base.

The crown, base upward, is now imbedded in moldine, in the swaging ring. A short dowel is inserted in the crown and a disc of 36 gauge pure gold, perforated in the center, is passed over the dowel and against the base of the crown.

The disc is now adapted to the crown base with burnishers and the adaptation completed by swaging. Care should be taken to force the gold into the V-shaped groove in the crown base.

The peripheral surplus is now removed and the disc, if distorted, is reswaged.

The short dowel is formed by excising the apical four-fifths of a dowel of regular size. It is used so that a place may be made in the disc for the regular dowel, which is now substituted.

The several parts are assembled in the following order: The cap is set in position on the root, the dowel inserted in crown base, and the disc passed over the dowel until it rests against the porcelain. A pellet of softened wax is placed on

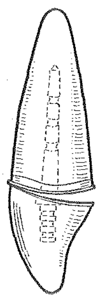


Fig. 674.—Davis Crown, Modified, in Position on Root, Disc and Cap Interposed

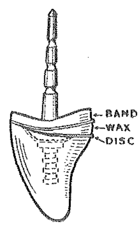


Fig. 675.—Crown, Disc, Interposed Wax, Dowel and Root Cap, Removed from Root

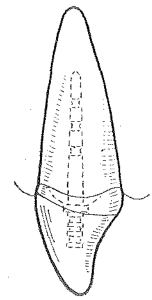


Fig. 676.—Finished Banded Davis as It Appears on Root

the root cap, the dowel inserted in the wax and the crown and disc forced to position on the root.

If the parts are free from moisture and the wax sufficiently plastic and adhesive, the assembled crown can be removed without difficulty.

To obviate disturbance of relation, a hot spatula should be applied to the wax at several points between disc and cap.

All spaces should be filled in with additional wax where needed, and the structure contoured to desired form.

The crown is now removed and the assembled metal parts united either by casting or soldering.

CHAPTER XXVIII

THE GOLD SHELL CROWN

(MORRISON CROWN)

The two-piece, gold shell crown, as ordinarily constructed, consists of an axial band and a swaged occlusal surface, both developed from plate gold, so contoured and united as to represent the anatomic form of the lost natural crown it is designed to replace.

ADVANTAGES

A crown of this type is strong, economical and efficient. The constructive details, although requiring care in their execution, are comparatively simple. Because of the ease with which sheet gold can be wrought in this method of crown construction, most beautiful esthetic forms can be produced by "the man who knows" anatomic tooth forms, and technic as well.

DISADVANTAGES

The color of gold as compared with porcelain for tooth replacement, is objectionable, therefore gold crowns should not be placed in conspicuous locations.

WHERE INDICATED

Gold shell crowns are most commonly indicated in the restoration of badly decayed molars in either arch, occasionally in second bicuspids, and sometimes, but rarely, in first bicuspids, when filling operations are likely to prove unsatisfactory. In bridge work, when occluso-gingival space is too limited for the combined use of metal and porcelain, a shell crown of the type under consideration, or some modification of it for an abutment is practically indispensable.

MODIFICATIONS OF THE METAL SHELL CROWN

There are many modifications in constructive details of the metallic shell crown, consisting principally of the manner of obtaining axial contour of the band and of forming and attaching the cusp surfaces to the axial section.

A sufficient knowledge for practical purposes of these various types of crowns can be gained from a full description of the two-piece Morrison crown, as now constructed, together with a brief description of the cast crown.

Technical Details of Gold Shell Crown Construction

PRELIMINARY PREPARATION OF THE TOOTH OR ROOT

The preliminary work of most importance in this as in all classes of crown construction is the proper treatment and successful filling of the root canals. This should, in practically all cases, be completed before attempting the peripheral reduction of the tooth or root.

RESTORING A BADLY DECAYED NATURAL TOOTH FOR ANCHORAGE PURPOSES

When most of the natural crown has been lost from any cause, it is imperative that a considerable portion of it be restored by operative procedures, to afford firm anchorage for the substitute crown. This may be accomplished in two ways: first, with amalgam, and second, by means of a suitably shaped casting, usually of Weston's metal or silver.

THE AMALGAM METHOD OF RESTORATION

When the roots have been properly filled, the canals are reamed out to receive one or more anchorage posts, depending on the requirements for such means of anchorage. The wire posts should extend deeply in the canals to avoid danger of loosening when the crown is set and later subjected to stress. The How anchor screw post is most useful for such purpose. Also a special form of screw made by the Blue Island Specialty Co. By this method both root canal and post are threaded, and when, in setting the post, a little cement is applied around it, firm anchorage of the post within the canal of the root is insured. When a taper screw is employed care should be taken to avoid splitting the root in its introduction.

After posts are set, a soldered copper band constructed to fit the root is adapted to its periphery and trimmed sufficiently short to clear the occlusal surfaces of the opposite teeth. Into this matrix amalgam is packed and the patient dismissed for twenty-four hours or longer, so that the amalgam may harden, and will not be disturbed in removal of the matrix or in subsequent root preparation.

On removal of the matrix, usually accomplished by cutting with a sharp chisel, the amalgam stump is treated as if it were tooth structure, and reduced with stones, discs and files in conjunction with the peripheral ring of enamel.

RESTORATION BY MEANS OF A CASTING

To restore a defective crown with a casting, the root canals should be enlarged as previously mentioned. When two posts are to supply the anchorage, the canals which receive them should be reamed parallel with each other, so that the posts may come away with the wax model without distorting their relation. If this is not possible, one good-sized post, deeply

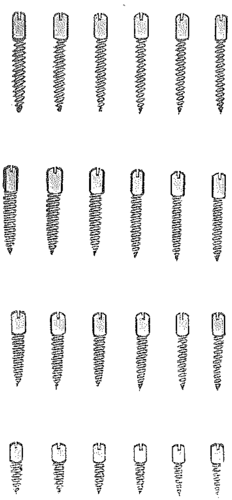


Fig. 677.— Various Sizes of Anchor Screws

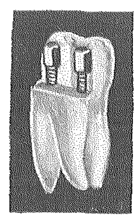


Fig. 678.— Molar Tooth with Anchor Screws Set in Root Canals

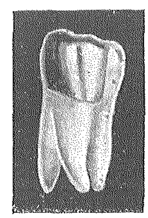


Fig. 679.— Tooth Restored with Amalgam

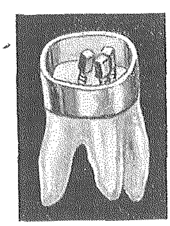


Fig. 680.— Molar Root Banded, Anchor Screws Set in Root Canals, Matrix in Position

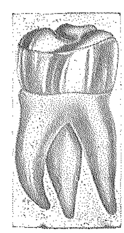


Fig. 681.— Molar Restored with Amalgam. Band Still in Position. For Crown Restoration the Band Should Not Be Contoured Nor the Occlusal Surfaces Developed

seated, in conjunction with such additional anchorage as may be developed by squaring out the pulp chamber will usually fulfill requirements.

The posts are set in position in the canals, after which inlay wax is applied and built to required form. The wax model is then removed — the post, or posts, coming away with it — invested, cast, and set in position with cement.

The object in making such restoration is to increase the hold of the crown to the natural root, as well as afford a solid foundation for the crown when subjected to masticatory stress. Without such means the attachment of the substitute to the natural crown, when the latter is badly decayed, is liable to prove unstable.

CASES IN WHICH EXCESSIVE ROOT RESTORATION IS REQUIRED

Cases frequently present in which the axial walls of a tooth may be partially or wholly decayed or broken away beneath the gum margin. In such case peripheral root preparation cannot be undertaken without forcing back the soft tissues and freely exposing the root face and margins.

When the pulp chamber is open and of such form as to afford anchorage, baseplate gutta percha can be packed into it and over the face end of the root, of sufficient thickness when compressed, to "overflow" and force the soft tissues beyond the root periphery. The packing should be left in position for twenty-four or forty-eight hours. If, on removal, the root face is not sufficiently exposed, the packing should be renewed so as to still further force the tissues outward beyond the root periphery.

Should the pulp chamber anchorage prove insufficient to hold the gutta percha in position, a small, flat-headed screw, about one-fourth to three-eighths of an inch long, or longer if necessary, may be screwed into the root canal, and the packing material built around the projecting head. In case the root canals have not yet been treated and filled, extreme care should be exercised not to force any putrescent matter through the apex. It is also usually best to puncture the gutta percha with a small instrument to permit any gas that might accumulate in the pulp chamber to escape during the compression process.

When sufficient clearance space has been gained in the manner described a matrix should be applied and adapted to the root periphery. The entire band is then filled with cement, which is allowed to set, when an opening may be drilled through the center, into the pulp chamber, through which the canals may be treated and filled.

The matrix must remain in position during the entire treatment of the root to prevent return of soft tissues. After treatment is completed the cement is removed from the matrix, anchor screws or posts inserted in the canals, and amalgam substituted, as previously outlined.

WEDGING

When the teeth adjoining the space the crown is to occupy have moved toward each other, thus reducing it, they should be forced apart by wedging, so that interproximal space next the crown, both mesially and distally, may be restored.

A wedge, shaped from palm wood (the handle of a palm leaf fan) should be inserted tightly between the inclined teeth, its base resting on the stump of root to be crowned. The fibers of wood should run bucco-lingually. When inserted dry the wood fibers will swell and gradually force the teeth apart, usually without much inconvenience. While the process is slow, requiring a week or more of time and insertion of progressively larger wedges as space is gained, it is an essential step and should in all cases, when possible, be accomplished by this or other effective means.

PREPARATION OF THE TOOTH OR ROOT FOR THE BAND

The same general principles of root preparation previously outlined in the porcelain-faced anterior crown, of converting the remaining portion of natural tooth into a slightly tapering cone, the base beneath free margin of gum at point of termination of crown band, apex pointing occlusally or incisally, apply with equal force in preparing posterior teeth for the reception of shell crowns.

REDUCTION OF THE OCCLUSAL SURFACE OF THE CROWN

The preparation of a root or tooth for the reception of a shell crown does not involve the shortening of the natural crown when present to the same extent as is required for anterior porcelain-faced restorations. In fact, the natural crown is left as long as possible to furnish anchorage and obviate displacement of the substitute crown under lateral stress. Sufficient reduction, however, must be made to afford space for a thick, well-reinforced occlusal cap to the shell. About one-sixteenth of an inch space, seen from the buccal, when the teeth are in occlusion will usually be ample. Should this not prove sufficient, the face of the root may be readily reduced later on when fitting the band. The occlusal surface is cut away to the required extent with a five-eighths to three-fourths inch, coarse carborundum stone. Care should be taken not to mar the proximating teeth.

REDUCTION OF THE AXIAL WALLS OF THE TOOTH

A thin edge carborundum stone is used to reduce the mesial and distal surfaces. The wheel is allowed to touch the tooth lightly, yet must be held firmly and under perfect control of the operator to avoid injury to the lips, cheeks, tongue and gums. The first cut is begun slightly inside of or at the dento-enamel junction, and the stone so held that its edge will come through to the proximate surface of enamel at the gingival line. A second cut is usually required on both mesial and

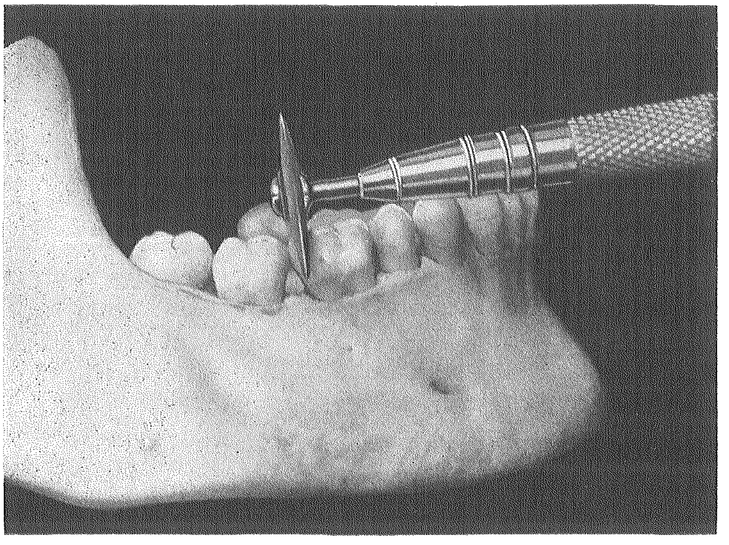


Fig. 682.— Thin-Edge Carborundum Stone in Position for Removing Distal Contour of Lower First Molar

distal surfaces, to complete the rough blocking off of these surfaces.

The buccal and lingual surfaces are reduced with rather small square-faced stones so applied as to avoid injury to the

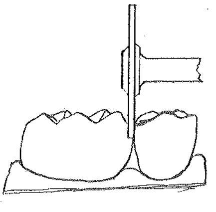


Fig. 683.— Diagrammatic View of Position of Stone. Cutting at Expense of Molar Tooth

cheeks and tongue. The removal of enamel with these stones cannot usually be carried below the gingival line.

With small knife-edge stones and discs the peripheral ring of enamel just under the gum margin can be partially, and in some areas entirely, removed. It is frequently a difficult task to remove the enamel from those locations where the surfaces turn from buccal and lingual into the mesial and distal embrasures. Small rubber and carborundum wheels carried in the port polisher, applied so that their outer surfaces or ends can reach the constricted areas will be found very useful in reducing the root to symmetrical form.

The enamel cleavers of ordinary form are of but little service in removing enamel from molar teeth, since it is not pos-

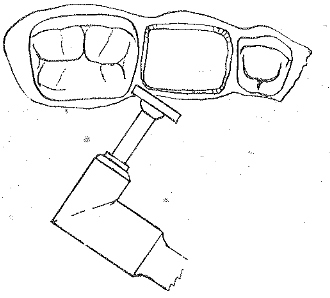


Fig. 684.— Application of Small Stone in Right Angle Hand Piece to Disto-Lingual Angle of Crown

sible to apply the necessary force effectively back of the bicuspids.

Dr. W. E. Harper has designed a contra-angle handle which holds a variety of short shank, regular and other forms of cleavers and files. These can be used to advantage in the

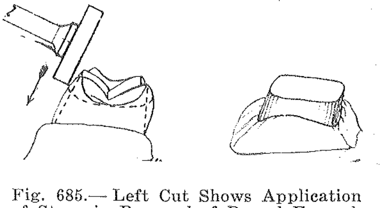


Fig. 685.— Left Cut Shows Application of Stone in Removal of Buccal Enamel. Dotted Line, the Usual Amount of Tooth Structure Removed. Right Cut, Outline of Prepared Tooth

removal of enamel in difficult locations, where the ordinary forms of cleavers are inapplicable.

By carefully introducing carborundum paper discs and warping them around the angles, much of the final preparation can be accomplished without serious injury to the soft parts.

The root files can be used to advantage, particularly in the embrasures. When the instrument is held in the right hand, the thumb of the left is placed against the buccal border surface, the index finger to the lingual. The thumb is used as a fulcrum with the result that greater and more direct force can be applied against the enamel in the interproximate spaces than is possible with any other position.

GENERAL FORM OF THE PREPARED ROOT OR TOOTH

The flare of axial surfaces should be plainly noticeable, but not too marked; that is, the convergence of peripheral

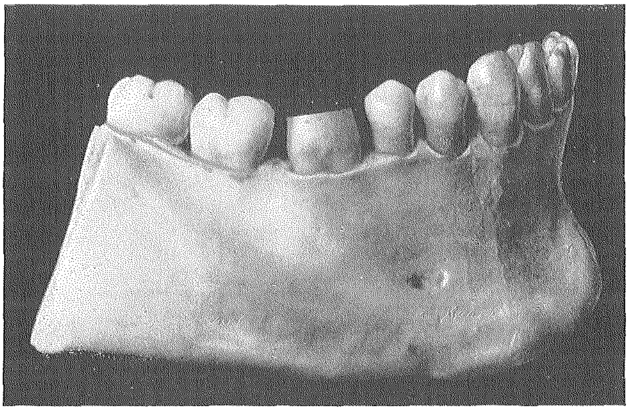


Fig. 686.— General Form of Reversed Cone After Removal of Enamel

surfaces from the base of the cone under free margin of the gum outward or occlusally should range from two to five degrees.

Certain facts must be kept continually in mind during root preparation, viz., the gingival cone of the natural tooth must

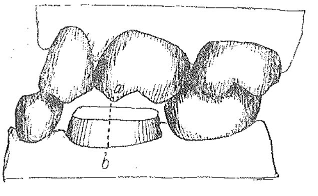


Fig. 687.— Cut Showing Relation of Prepared Tooth to Occluding Teeth

in all cases be reversed; the base of the new cone must be extended apically as far or even slightly beyond the point where the cervical end of the band, when permanently set, will rest; the formation of shoulders or grooves, or any irregular surfaces that will interfere with the correct fitting of the band, must be avoided.

TESTING THE CORRECTNESS OF ROOT PREPARATION

The two tests previously mentioned under root preparation for a porcelain-faced crown are applicable for proving the correctness of root preparation for shell, as well as other classes of crowns. The first of these — passing a delicate instrument apically — is dependent quite as much on tactile sense as on the eye, for revealing irregular surfaces, grooves, shoulders or any remaining portions of enamel, and for determining whether the sides have the proper flare.

The final test is in the root measurement itself, which, if easily removed, indicates that the remaining portion of the tooth between the position of measurement and its occlusal end converges or becomes smaller.

TAKING THE PERIPHERAL MEASUREMENT OF ROOT FOR BAND

The wire loop is formed, placed in a holder, applied to the root and tightened. The loop should seldom ever be pressed under the free margin of the gum, unless the root is exces-

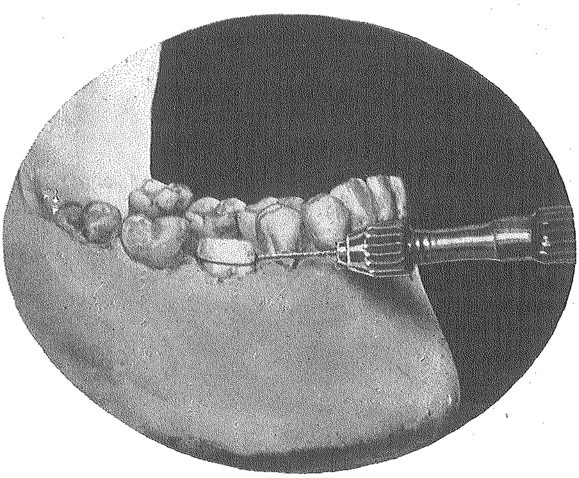


Fig. 688.— Securing the Wire Measurement. The Wire Loop Should Not Be Carried to the Extreme Gingival Position of Cone

sively cone-shaped, the idea being to form the band slightly smaller than actually required and drive it to place in fitting, thus insuring a close and accurate adaptation to the root periphery. On removal of the measurement, the loop is cut opposite the twist, and laid aside until the measurement for the band width is obtained.

DETERMINING WIDTH OF BAND

As a matter of economy, the band should be cut of approximately correct width. The width may be determined by measuring the distance between the deepest curve of the gingiva of the root to be crowned, to the tips of the cusps of the opposing teeth. Should the dip of the gingival gum curvature approach the root apex more closely on one side than the other, the greater width must be used for the band measurement. For example, when marked tissue absorption extends apically, exposing more or less of the surface of the lingual root of an

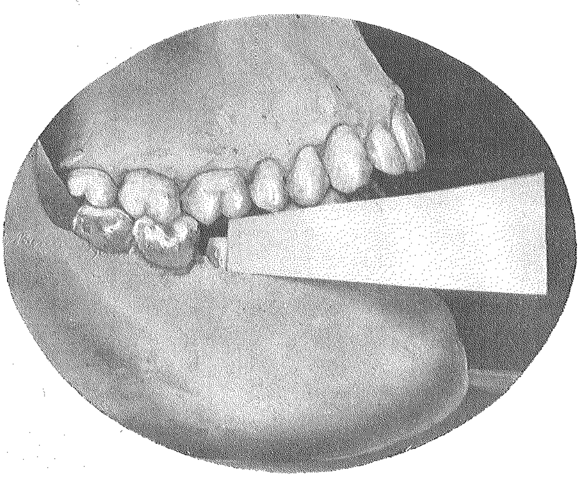


Fig. 689.— Tapering Cardboard, Used to Determine Width of Band

upper first molar, the band should be wide enough to cover the entire exposed area. There are better methods, however, of adapting crowns to teeth around which gingival absorption has occurred to a considerable extent than by the application of a band. In such cases the shoulder crown in which no overlapping of gold on the root occurs, is far more hygienic and serviceable than any type of banded crown.

A piece of ordinary cardboard, cut on a taper with the narrow end squared, serves as a convenient gauge. If too wide, the sides of the card are reduced, while if too narrow the end is cut away until the width coincides with the distance designated. A pair of dividers may also be used for securing the measurement. The length and width of band having been determined, the next step is to lay it out, and cut it from the piece of gold plate.

CUTTING THE BAND ACCORDING TO MEASUREMENT

As has been previously pointed out, the outer envelop of the average posterior natural tooth represents two cones, an occlusal and a gingival, reversed, and with their bases meeting in a common plane in the mid-crown region.

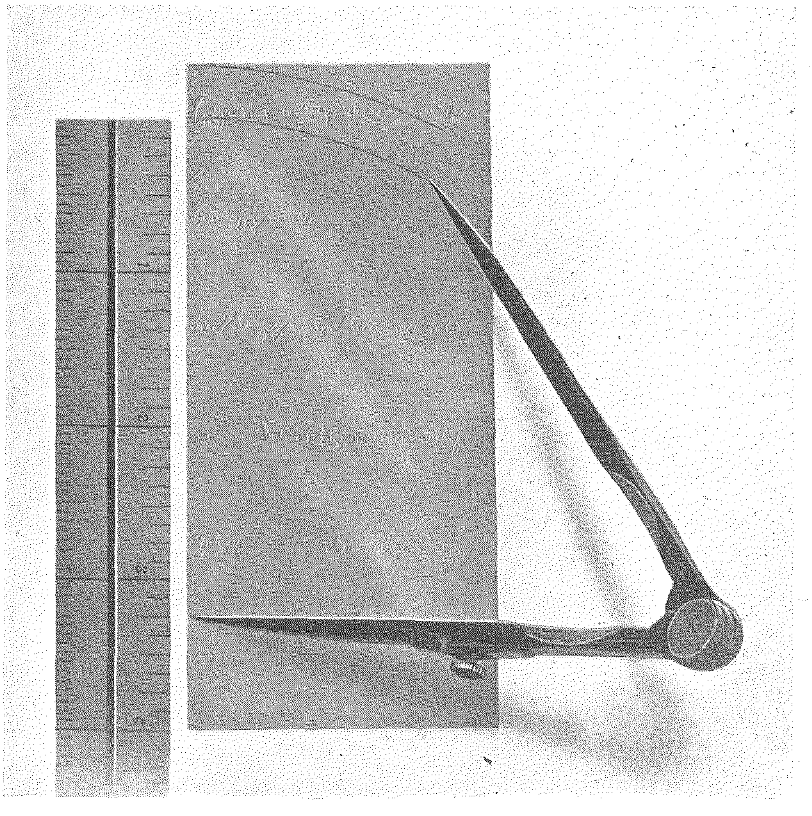


Fig. 690.—Scribing the Cervical End of Axial Cone Band. The Outer Arc Represents the Occlusal End of the Band. The Distance Between the Two Arcs Is Determined by the Cardboard Measurement

To reproduce such an envelop in gold, one of two plans is followed: first, form the band as a cylinder and by swelling and stretching, gain contact with proximating teeth, increase the mesio-distal diameter of the band at the occlusal surface, and the bucco-lingual diameter in its mid-crown area to represent the axial contour of the natural tooth. Second, form the band as a section of a cone, representing the flare of the average, natural gingival cone, and reduce the occlusal end by compression, contouring to the required dimensions. Of the two methods, the latter is much the simpler and better in every way.

By referring to anatomic forms of teeth on page 634 it will be seen that the average flare of the gingival cone of molars is 25 degrees. Unless the space which the crown will occupy is constricted, a cone having this flare should be used.

CUTTING A CONE BAND

To cut a band by this method, the dividers are placed at the edge of the card or piece of gold plate, the points set at

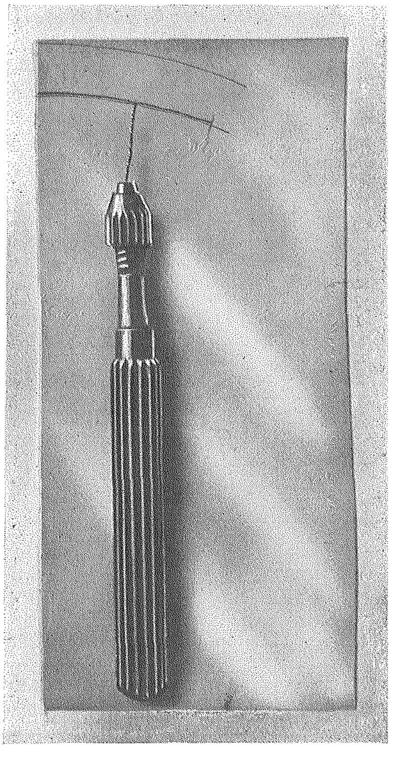


Fig. 691.— Marking the Length of Band with Wire Root Measurement

$3\frac{1}{4}$ inches apart and an arc is struck, somewhat longer than the root measurement. The radius is then increased the width of the band, as determined by the cardboard measurement, and from the same center a second arc is struck, representing the occlusal end of the band.

When curvature of the gingival gum margin, around the root being crowned, is very marked, as is frequently the case, the cervical end of the cone band must be reduced by scribing and trimming, to conform to such curvature. This naturally reduces the height of the cone, entirely at the expense of its

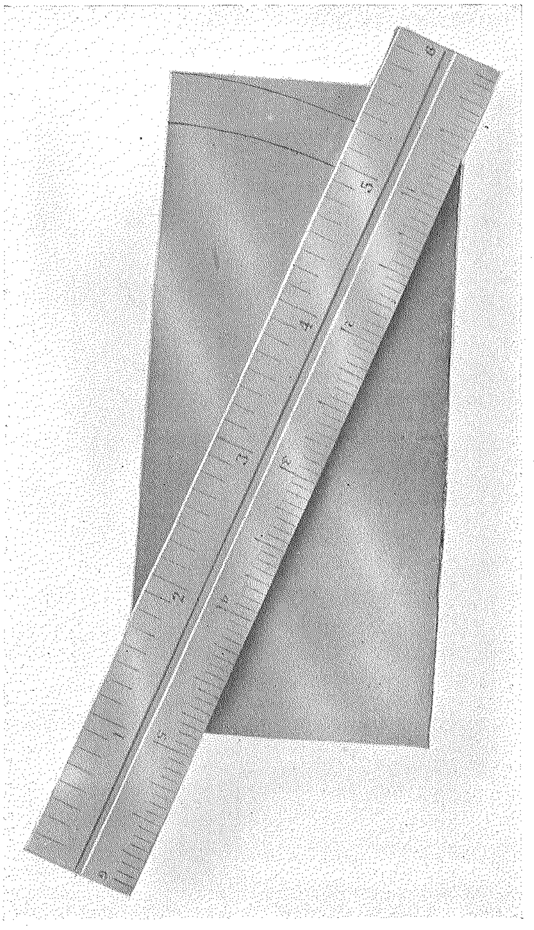


Fig. 692.— Rule Placed on Measurement Length of Band and on Center from which Arcs Were Developed

smaller end, and enlarges its cervical diameter or peripheral length proportionately.

On returning the band to the root it will usually be found entirely too large. And while reduction of its cervical diameter may be effected with contouring pliers, anatomic outlines of the axial surfaces will be disturbed.

When it is evident that much reduction of the cervical end of the cone must be made, the band should be marked and cut from one to three thirty-seconds of an inch shorter than the root measurement.

The measurement is laid off on the gold plate and the band cut as follows:

The wire measurement is curved to correspond with the gingival arc on which it is now laid, one end of the wire being brought even with the outer margin of the gold plate. The other end of the band is marked even with the wire measure-

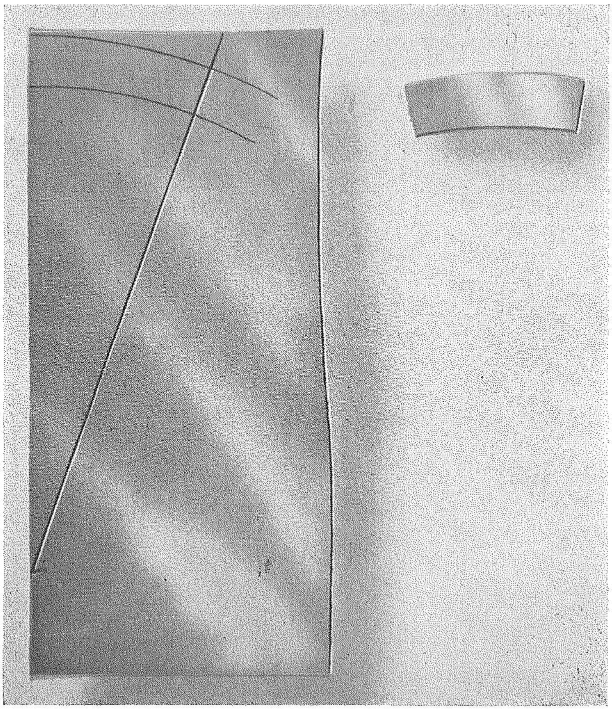


Fig. 693.— Line Drawn with Rule to Indicate Divergence of Inner End of Band. The Outer End of the Band at the Edge of Plate Is Correct. Upper Left Corner Shows Form of Band

ment, or in case of decided gingival curvature, proportionately shorter, in accordance with the slight or pronounced curvature of the gingival tissues.

Lay a rule against this point and the center from which the arc was developed and mark the end of the band. When the gold plate is placed parallel with the outer edge of the card the opposite or outer end of the band will have the proper flare. The gold is cut and bent in the form of a cone, the two ends abutting squarely against each other.

WIRING THE BAND

The band ends should be held in contact with binding wire, for, although they may be soldered without the use of the binder, they will usually spring apart, at one or the other edge of the band, and the union be imperfect.

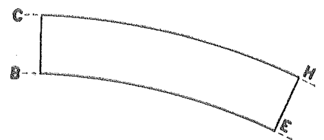


Fig. 694.— Diagrammatic View of Band Before Bending

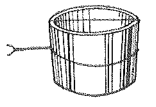


Fig. 695.— Band Ends, Butted and Held with Crossed Binding Wire

Since the wire will not keep its position on the cone as ordinarily applied it should be crossed and carried around the band occluso-gingivally and twisted tightly, the surplus being placed on the opposite side of the cone, from the joint.

SOLDERING THE BAND

Borax is applied to the joint, a small piece of solder laid across, and the band ends united in the usual manner.

FITTING THE BAND TO THE ROOT

The band is conformed to the general outline of the root and pressed down until in contact with the gingiva. The scribing tool is applied and the gingival line marked on the buccal surface. Usually, because of difficulty in applying the scribing instrument to the lingual surface, an explorer can be substituted and the lingual curvature approximately marked in this manner. It is advisable to mark too close rather than too far from the gingiva and cut accordingly to avoid shortening of the band width. After trimming off the gross surplus a second application of band to root will disclose the points needing further reduction.

Naturally, as previously stated, when much curvature is present the band, when trimmed, will become enlarged. This may be compensated for in two ways: first, by cutting the band slightly shorter than the measurement at the start, and second, by reducing the gingival periphery with suitable contouring pliers of the Peso or Benson type.

CONTOURING THE BAND

In forcing the band to place its bucco-lingual diameter will be somewhat increased beyond true anatomic dimension. This distortion, however, can be readily corrected by applying the round beak of the Benson plier inside the band about the middle, occluso-gingivally, and with careful pressure on the outer side with the flatbeak the occlusal cone can be reduced to proper form. No appreciable pressure should be exerted

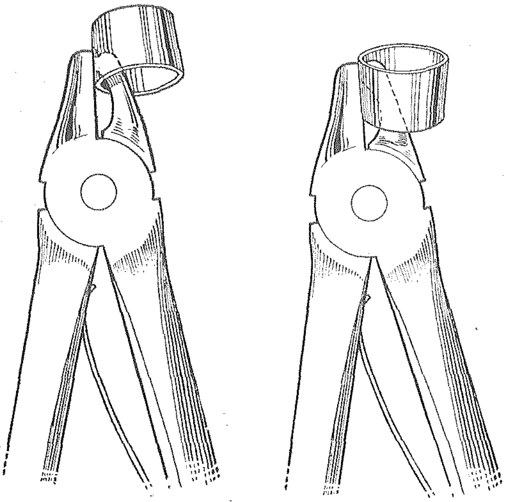


Fig. 696.— Reducing the Occlusal End of Band with Benson Pliers

on the handles to force the beaks together, as this, by thinning the gold, would increase the diameter and contour of the band in the mid-crown area.

The Benson pliers are designed primarily for effective contouring of bands in any location where convex surfaces are required, the heavy handles and short beaks being specially adapted for developing great force. One beak is flat, the other round, the latter acting on gold plate as a ball pene hammer does against metal on an anvil.

The accompanying cut shows an extensively contoured crown, formed with these pliers by Dr. Benson, the axial band

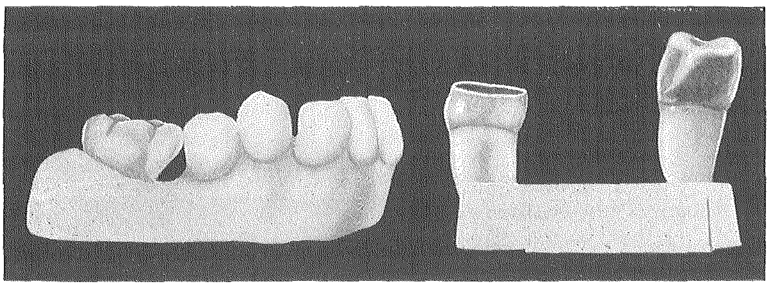


Fig. 697.— Second Molar Inclined Forward from Loss of First Molar. Crown Contoured to Form Proximal Contact with Second Bicuspid (Benson)

Fig. 698.— Bicuspid Bands Contoured. Strip at Bottom Shows Doubler Attached to Main Band. Notice Flaring Ends of Latter (Benson)

being expanded in order to develop contact with a tooth some distance removed. In this case, a piece of gold was sweated against the straight band to give additional material for expanding and thus obviate weakening of the crown walls.

The thickening of the band walls is essential where extensive contouring is carried out. It is not essential when the band is developed to represent the section of a cone except in unusual cases.

FORCING THE BAND TO PLACE ON ROOT

When properly contoured, it should be forced to position under the free margin of the gum, usually about one-twentieth of an inch, in some cases a little more, when the peridental attachment will permit.

By placing a flattened piece of wood on the occlusal surface of the band, the patient can assist in setting it by biting

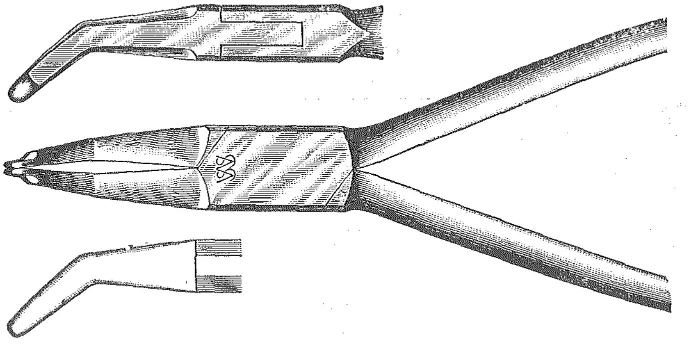


Fig. 699.— Contouring and Band-Expanding Pliers Designed by Writer

on the wood. Test of the length of band is made by closure of the teeth, and any points of interference are reduced by trimming. The occlusal end of the band should be squared with the flat side of a file so that the cusp when developed and similarly treated will form a close joint with the band.

TESTING THE BITE

The band, having been fitted to the root, a wax bite should be taken with the band on its root, together with the proximating teeth. The mass of wax should be large enough to receive and firmly hold the bite fork of the face bow. It should also be of the hard variety, so that when chilled it will retain its shape, and not become distorted in subsequent handling.

The bite fork is inserted in the wax, to the outside, in such manner as not to interfere with occlusion, the wax introduced in the mouth and the patient instructed to close. The face

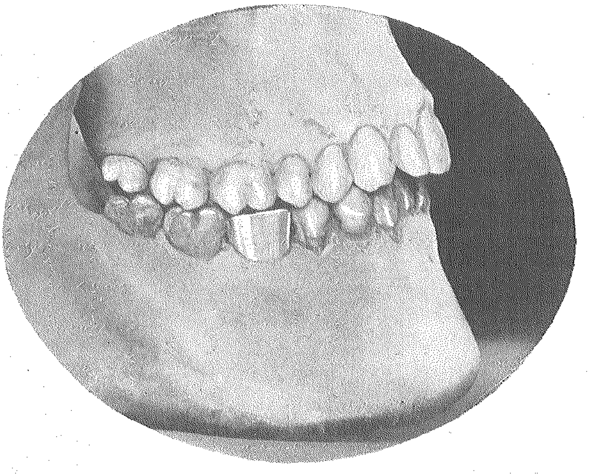


Fig. 700.— Band in Position on Root

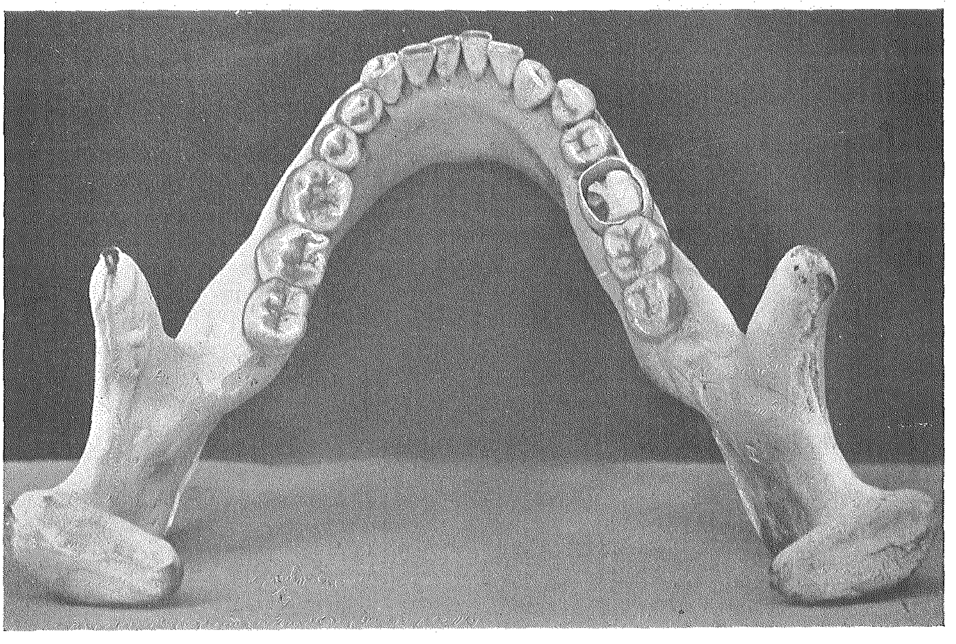


Fig. 701.— Occlusal View of the Contoured Band in Position

bow is adjusted to the bite fork, and over the condyles, the several clamps tightened, and the bite, attached to the bow, removed from the mouth.

An impression of the band on its root is obtained, together with two or three of the adjoining teeth on either side. From this a cast is developed, which, when removed and trimmed,

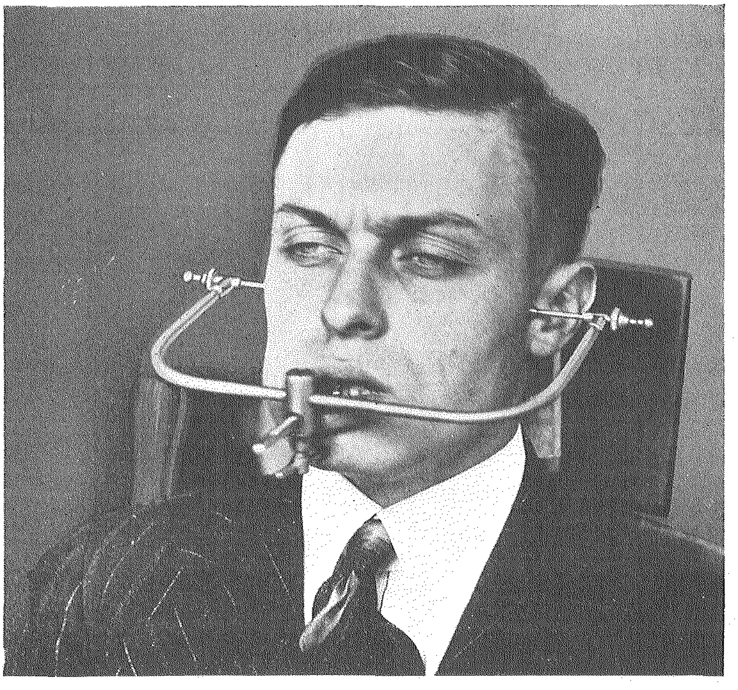


Fig. 702.— Taking the Bite with Molar Band in Position

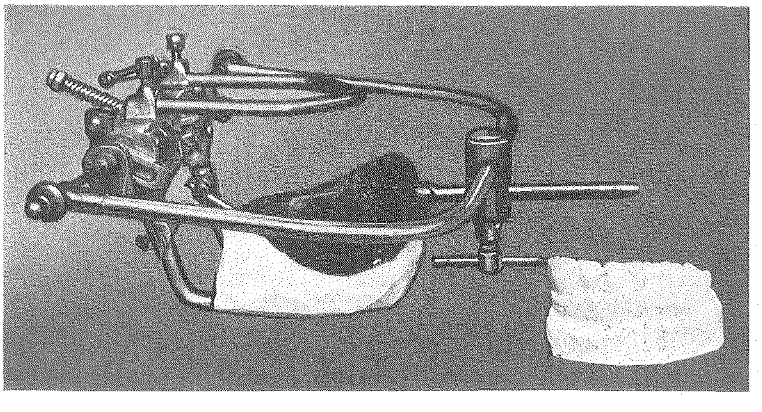


Fig. 703.— Bite Mounted on Occluding Frame, Lower Cast Developed

is fitted to the wax bite and attached to the upper bow of the frame. The sides of the wax bite should be trimmed as previously described to permit the occlusal surfaces of the teeth to become seated against the wax.

MOUNTING THE BITE ON THE OCCLUDING FRAME

The face bow is adjusted to the occluding frame, the wax bite oiled, and that side which is to form the occlusion cast is filled with plaster, and at the same time attached to the bow of the frame. When hardened, the cast carrying the band is

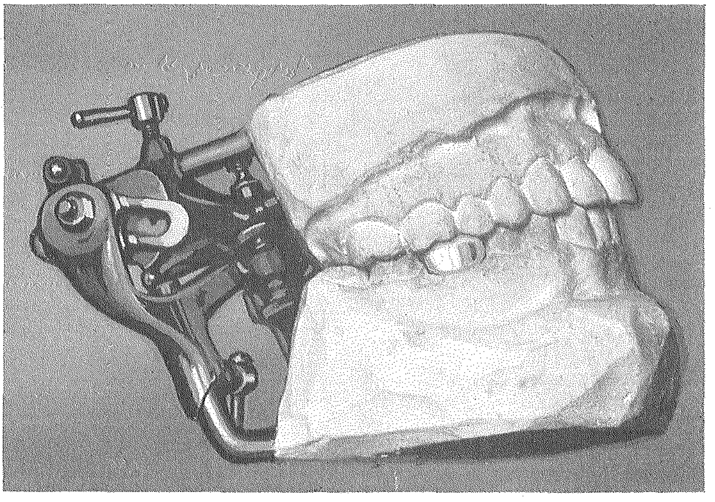


Fig. 704.— Both Casts Mounted, Axial Band Contoured and Occluded Against Upper Teeth

fitted in its bite and attached to the opposite bow. After removal of the bite, the occlusal surfaces of the occluding teeth opposite the band are coated with separating medium.

DEVELOPING THE CUSPS OF THE CROWN IN PLASTER

When the occlusal surface of a crown is to be swaged, it is necessary to develop a pattern of the form desired, in plaster or some medium, by means of which a suitable counterdie can be constructed. One of the most common methods of carrying out this step is as follows:

A mix of plaster is made and applied in the occlusal end of the band, slightly in excess of the amount required for the cusps. While soft, the two casts are occluded, the surplus plaster being forced buccally and lingually. On separating the casts it will be seen that the central groove of the occlusal surface to be carved has been fairly well developed by the buccal marginal ridges of the lower occluding teeth. The groove, however, should be deepened slightly, and some small, unnecessary ridges on the occlusal surface reduced, to bring out the general anatomic form of the tooth. The peripheral surplus is trimmed even, and continuous with the axial walls of the band at this time, but later on must be rounded in to form the marginal ridges.

The frame should be subjected to lateral movements and the points of interference noted and trimmed accordingly. This step might be termed *development of clearance paths*. The trimming of the peripheral margins of the plaster to represent the marginal ridges of the crown should be carefully carried out, since these boundaries of the occlusal surface give character and individuality to the substitute.

Finally, the developmental lines and finer surface markings are carved in the occlusal surface. To do this well, the prosthetist should have a knowledge of typical forms of the teeth.

TYPICAL FORMS OF NATURAL TEETH

A number of sketches of natural teeth have been carefully drawn, showing various surfaces, among them the occlusal surfaces of seven types of teeth that the crown and bridge worker should be thoroughly familiar with, able to draw in

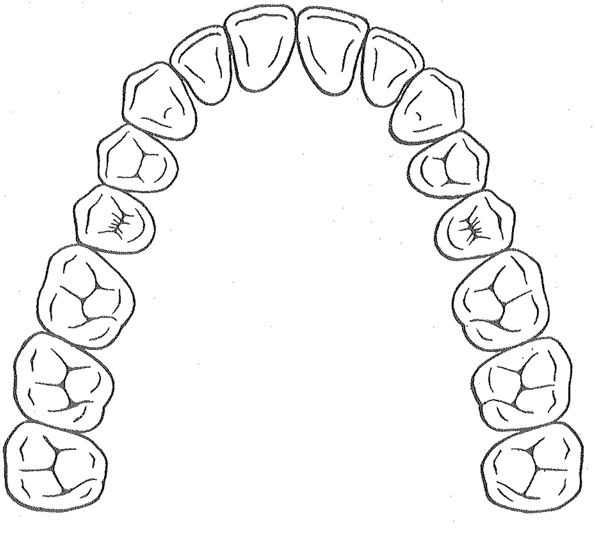


Fig. 705.— Diagrammatic Drawing of Upper Teeth, Showing Principal Lines

pencil, carve in wax or plaster, or model in clay. These are not presented in reverse, it being taken for granted that familiarity with one type of tooth will enable the prosthetist to carve it for either right or left side. (See Figs. 706 to 740, inclusive.)

UPPER RIGHT FIRST MOLAR

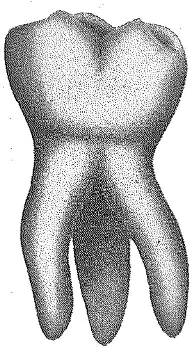


Fig. 706.— Buccal

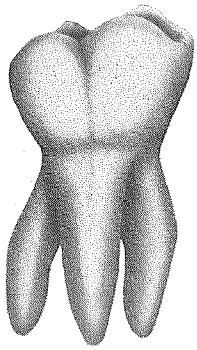


Fig. 707.— Lingual

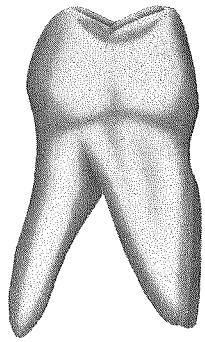


Fig. 708.— Mesial

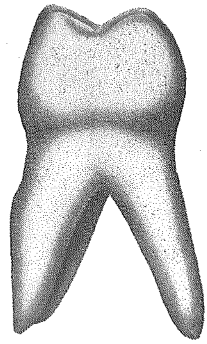


Fig. 709.— Distal

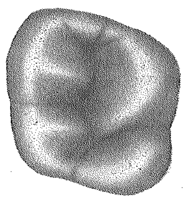


Fig. 710.— Occlusal

LOWER RIGHT FIRST MOLAR

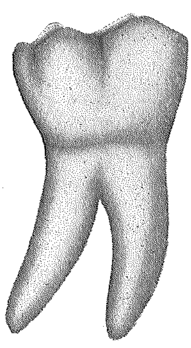


Fig. 711.— Buccal

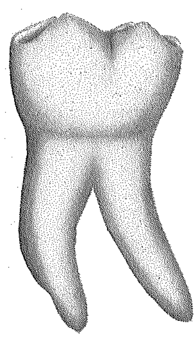


Fig. 712.— Lingual

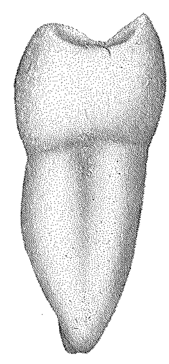


Fig. 713.— Mesial

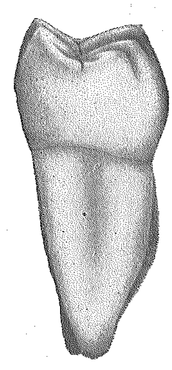


Fig. 714.— Distal

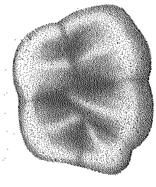


Fig. 715.— Occlusal

LOWER RIGHT SECOND MOLAR

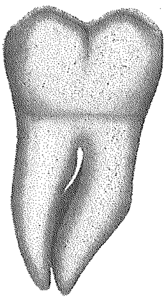


Fig. 716.— Buccal

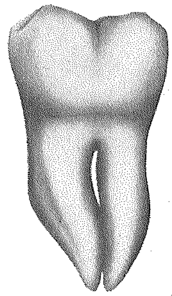


Fig. 717.— Lingual

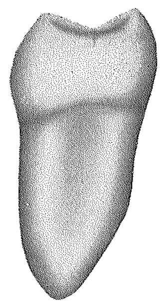


Fig. 718.— Mesial

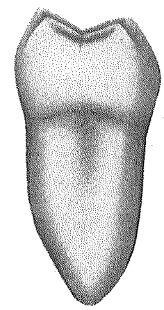


Fig. 719.— Distal

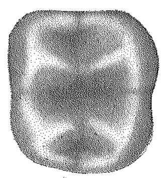


Fig. 720.— Occlusal

UPPER LEFT FIRST BICUSPID

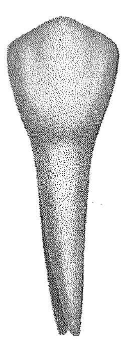


Fig. 721.— Buccal

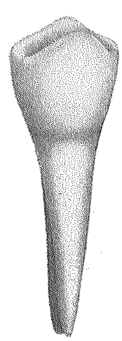


Fig. 722.— Lingual

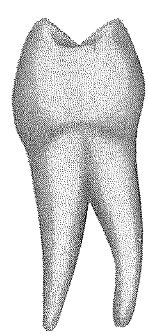


Fig. 723.— Mesial

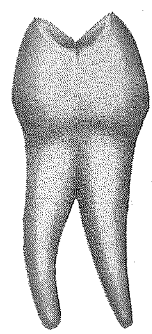


Fig. 724.— Distal

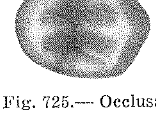


Fig. 725.— Occlusal

UPPER RIGHT SECOND BICUSPID

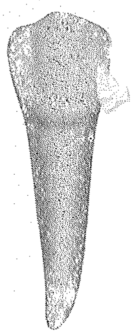


Fig. 726.— Buccal

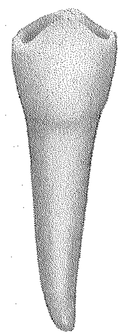


Fig. 727.— Lingual

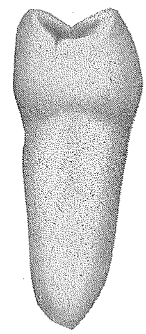


Fig. 728.— Mesial

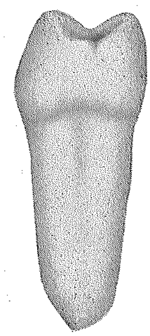


Fig. 729.— Distal

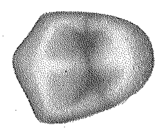


Fig. 730.— Occlusal

LOWER LEFT FIRST BICUSPID

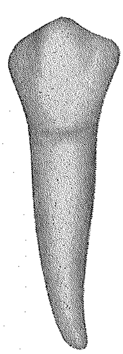


Fig. 731.— Buccal

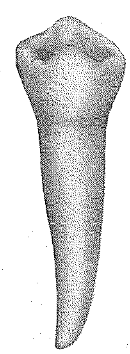


Fig. 732.— Lingual

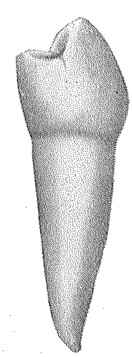


Fig. 733.— Mesial

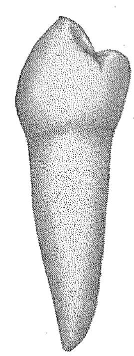


Fig. 734.— Distal

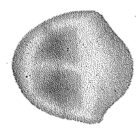


Fig. 735.— Occlusal

LOWER LEFT SECOND BICUSPID

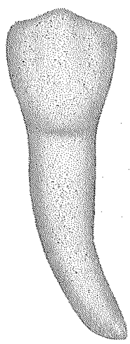


Fig. 736.— Buccal

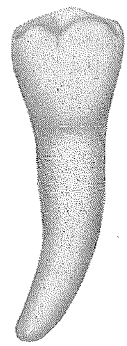


Fig. 737.— Lingual

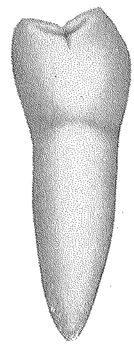


Fig. 738.— Mesial

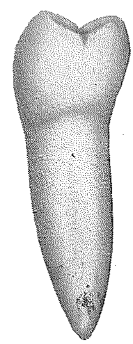


Fig. 739.— Distal

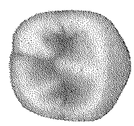


Fig. 740.— Occlusal

REPRODUCING THE CUSP SURFACES IN GOLD

Two general methods are in vogue for forming the occlusal surfaces of a crown. First, by swaging the cusps, and second, by casting them. When swaged, a counterdie is constructed and in this the cusps are formed. When cast, the cusps are carved in wax, in the gold band, the two invested, and the cusps cast directly to the axial band.

CONSTRUCTING THE COUNTERDIE — DIRECT METHOD

A common procedure in forming the counterdie is as follows: The cusps having been developed in plaster, the crown

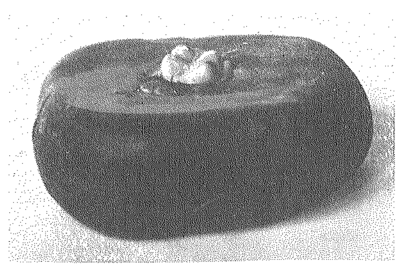


Fig. 741.— Crown Band Imbedded in Moldine. Carved Cusps Exposed Ready for Placing the Swaging Ring and Casting the Counterdie

band with cusps attached is removed from the cast and imbedded, cervical end down, in moldine to the line of junction of the gold with the plaster, thus leaving only the cusps exposed. A small rubber ring, or the metal ring of a swaging device, is centered over the cusps, on the moldine, and fusible metal poured in the ring and over the cusp surfaces in sufficient quantity to form a resistant counterdie. When chilled, the moldine and crown are removed and the counterdie, if satisfactory, is oiled, the gold annealed, and swaged into the cusp depressions.

Very often the cusp surfaces of the counterdie matrix will be defective, as a result of pouring the heated metal over the imperfectly dried plaster carving. This may be largely overcome by eliminating all moisture from the plaster before imbedding the crown in moldine. Two or three very small holes may be drilled through the plaster cusps and after the crown is imbedded in the ring a small wire is introduced through the holes and passed entirely through the moldine base, to form free vents for the downward escape of steam. The disturbance of the molten metal while hardening is thus, in most cases, averted.

CONSTRUCTING THE COUNTERDIE — INDIRECT METHOD

A very excellent method of constructing a counterdie without casting directly to the carved surfaces, and which will yield a dense casting, is as follows:

It is well known that dense castings of fusible metal, free from porosity or surface imperfections, can be successfully cast against moldine, because the latter contains no moisture. Neither does the glycerine, with which moldine is mixed, to render it plastic, volatilize under the fused metal. Therefore, by reproducing the reverse of the desired counterdie surfaces in moldine a dense counterdie will result from casting fusible metal against such surfaces.

The cusps are carved in the same manner as previously described. By this method hard wax or modeling compound will serve quite as well as plaster as a medium in which to carve the cusps.

When carved, remove the crown from the cast, make a mix of plaster and spread on a piece of paper, forming a flat mass about three-eighths inch thick and one and one-half inches in diameter. With the point of a knife or a brush fill in the inequalities of the carved surfaces and quickly press the crown, occlusal end down, in the soft plaster. The cusps should be fully imbedded to the band margin. Remove the surplus plaster from around the crown. When the plaster has set, remove crown and carving. Trim the margins of the matrix to eliminate undercuts. The plaster with cusp depression now represents the essential surfaces of a counterdie. This must be reproduced in metal which can be accomplished as follows: Dust the cusp surfaces and plaster slab with talcum powder and brush off the surplus. Press a small mass of moldine in the cusp depressions and a larger mass over the upper surface of the plaster slab. The two masses of moldine should firmly unite, which will occur if surfaces are fresh and sufficient pressure is applied. The upper surface of the moldine should be flat, to afford a firm base on which to rest when, later on, it is inverted.

The plaster and moldine are carefully separated to avoid distorting the latter. On the surface of moldine, which was pressed against the plaster, will be seen a raised occlusal surface of exactly the same size and form as the plaster pattern. The moldine is set on the bench, a casting ring centered over the cusps and filled with fusible metal.

When the metal has hardened and the ring and moldine are separated, the counterdie surfaces will be found dense, and with finest details reproduced. Since the steps are carried out quickly while the plaster is damp, the surface of the moldine may absorb a little moisture from the latter. This can be removed before casting, by dusting freely with talcum powder and removing the surplus with a soft brush.

DEVELOPING A COUNTERDIE WITH METALLINE COMPOUND

Metalline Compound is a moderately hard substance, heavily loaded with graphite, somewhat resembling modeling compound in that it becomes plastic with heat and hardens quickly. Fusible metal can be cast directly against it without distorting its surfaces, since a higher temperature is required to soften it than modeling compound.

It can be carved readily, and if, in carving, too much is removed, more can be added with a hot spatula and the surface corrected. By its use a most excellent counterdie can be quickly formed as follows: With the casts mounted on the occluding frame and the band in position on its cast, a pellet of Metalline Compound, slightly larger than that required for the cusps, is softened, placed in the occlusal end of the band and the casts occluded. When hard, the cusps are carved as usual. With a small burnisher the cusp surfaces are rendered perfectly smooth.

The Metalline carving is carefully lifted out of the band, to prevent distortion, and that portion which entered the band is pared away with a sharp knife, even with the impression of its occlusal end. This converts the Metalline carving into an occlusal form of exactly the right depth for the cusps. It now resembles in form one of the Hollingsworth metal cusp patterns.

The upper or occlusal surfaces are now coated with a thin film of glycerin, and all surplus removed with absorbent cotton.

A small pellet of soft moldine no larger than a pin-head is thinly spread on a flat surface of polished steel. On this the metalline carving is set and pressed lightly against the moldine, to cause the base of the carving to adhere to the steel. The object in cementing the carving to the steel is to prevent its displacement by the metal in casting. If the cusp carving is not adherent to the steel, the fusible metal, because of its greater specific gravity, will settle under and cause it to rise to the surface. Another method of obviating displacement of the carving is to press it against the steel with a small wire while pouring the metal. The steel should be moderately cool, so as to chill the fusible metal quickly before the cusp forms are softened.

A ring is centered over the cusp and the fusible metal cast into it. When the steps are properly carried out, a sharp, well defined counterdie is obtained.

SWAGING THE CUSPS IN AN OPEN COUNTERDIE

A piece of soft wood about four inches long and one-half inch square is shaped, on one end, to the general outline of the cusp depression and driven into it and the counterdie is oiled.

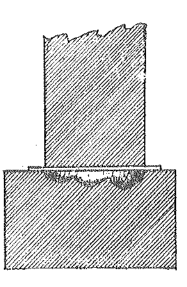


Fig. 742.— Disc of Gold with Softwood in Position Ready for Swaging in Counterdie

A disc of 31 or 32 gauge, 22 carat gold plate is annealed, evenly centered over the cusp depression, the conformed end of the stick set squarely on it and given a sharp blow with the hammer.

Any folds that have begun to form around the margins are corrected with pliers, and the swaging process continued until general adaptation is secured. The finer lines and sharp ridges of the cusps are developed with a blunt-pointed hickory

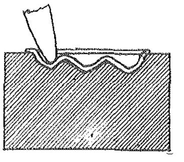


Fig. 743.— Developing the Finer Occlusal Surface Markings with Hardwood Point

stick, or a rather small but round edge chaser, using light, rapid hammer blows. Finally, by applying the piece of soft wood with heavy hammer, the gold is driven against all surfaces of the matrix. The gold is pickled in acid, polished with pumice to remove all traces of base metal, when it is ready for the final step of fitting.

REMOVING PERIPHERAL SURPLUS OF GOLD

With a pair of shears the marginal surplus of gold is removed and the surfaces of the occlusal cap to be united with the band are flattened with a file.

ADAPTING THE OCCLUSAL CAP TO THE BAND

By placing a pellet of soft wax in the band to steady the cusps and returning the latter to position, from time to time, on the band, both length and occlusal relations may be determined and corrected as required.

The cusp margins should rest flat upon the occlusal end of the axial band, while the peripheries of both should coincide.

When trimmed to correct length, so that in lateral movements the cusp planes do not interfere with the opposite occluding teeth, the crown can be removed from its cast and the two permanently united by soldering.

DEVELOPING THE MARGINAL RIDGES OF THE CROWN ON THE AXIAL BAND

A most excellent method of developing the cusp elevations on a crown, and which largely reduces the difficulties of carving the occlusal surface, is as follows:

The axial band is formed as wide or even slightly wider than the occluso-cervical height of the finished crown.

The steps of fitting of band to root and contouring of the axial surfaces are carried out as previously described. Since the length of band will not permit the teeth to occlude, a bite cannot be taken until the occlusal band margins are corrected.

Instead of trimming this end of the band to represent a horizontal plane, as is usually done and as has been previ-

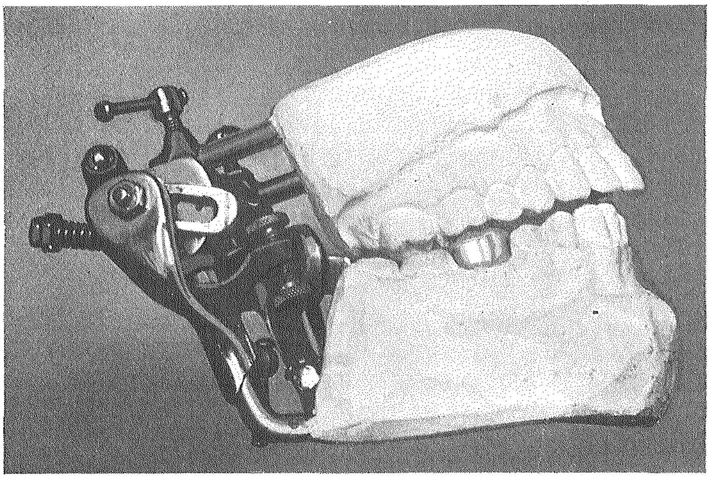


Fig. 744.— The Axial Crown Band Notched to Occlude with Opposite Teeth

ously described, it is notched to represent the various cusp elevations and sloping planes of the marginal ridges.

The mesial and distal occlusal margins must also be notched to receive the opposite occluding cusps which rest in the central groove.

This can easily and quickly be carried out in the mouth, the general alignment of the cusps of proximating teeth and the cusps of the occluding teeth serving as guides while trimming the band margin.

The patient should subject the mandible to lateral movements to test the correctness of clearance paths.

When trimmed so that the occlusal band margins intercuspate properly, not only in occlusion, but in lateral mandibular movements as well, the bite may be taken as usual, casts developed and the crown finished by any of the ordinary methods desired.

If the cusps are to be cast, inlay wax may be applied and carved in the mouth, the band and carving removed and invested directly, without taking an impression or bite or developing casts.

Carving the cusps is a very simple operation, since the cusp elevations and depth of grooves are already established while the central groove is clearly indicated by the cusps of the occluding teeth in the wax bite.

DEVELOPING THE CUSP SURFACES IN A SWAGER

Crown swagers are very commonly used in dental laboratory procedures, and for many purposes are most useful and convenient. A swager, however, is not as effective in the development of cusp surfaces from thick gold plate as is the method previously outlined. Therefore, when the swager alone is employed, the cusps must be developed from light gauges of gold plate, or when a heavy gauge is used, which in all cases is more desirable, the two methods may be combined. The following plan is productive of good results:

Before placing the counterdie in the swager its surfaces are oiled. A disc of 30 or 31 gauge, 22 carat gold plate is annealed and centered over the depression, into which it is

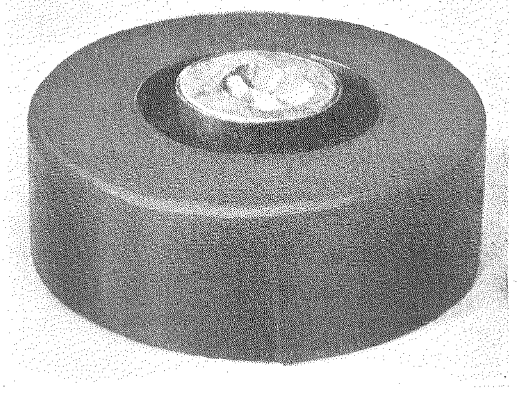


Fig. 745.— Counterdie in Position in Swager Base

swaged by means of the soft and hard wood punches, as previously described on page 762.

Remove the excessive peripheral surplus, pickle and anneal the partially developed cap, return it to the counterdie, place the latter in the swager, and with a heavy rawhide mallet drive the gold into the matrix. Usually it will be necessary to develop the finer surface markings of the cusps with the blunt hardwood point, or fine-pointed steel chaser. Final adaptation and removal of warpage are accomplished in the swager.

Fitting the occlusal cap to the axial band is accomplished as previously outlined. It should be pickled in acid, cleansed and polished to remove all traces of base metal.

ASSEMBLING AND SOLDERING THE BAND AND OCCLUSAL CAP

Remove the band from the cast, pickle in acid and cleanse in water. Apply borax to the inner cusp surfaces and the occlusal end of the band.

Adjust the occlusal cap and band in proper relation to each other as indicated by the coincidence of their peripheries, and bind together with untinned binding wire, bringing the ends over the cervical end of the crown, to form a loop for

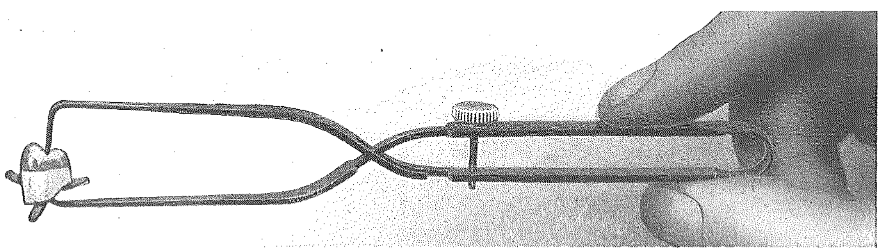


Fig. 746.— The Kerr Soldering Tweezers Holding Occlusal Cap and Crown Band in Position

holding while soldering. The wires may be crossed, if necessary, to hold the occlusal cap in proper relation.

The occlusal cap and band may be held in proper relation to each other without wiring by means of the Kerr soldering tweezers. One beak of this appliance is bent at right angles to the handle. Opposite this point and attached to the other beak is a loose, three-prong table. The crown is held by setting the cervical end of the band on the adjustable table, while the right angle point rests in the central area of the occlusal cap.

Small pieces of fluxed solder are placed within the crown, the latter carried to and held within the Bunsen flame, occlusal end down, where it is carefully and uniformly heated until the solder fuses. Sufficient solder should be applied to form a thick, rigid, occlusal cap, three or four times thicker than the swaged cusps. Care should be taken to see that not only the joint areas are perfectly united, but that the solder has been drawn up slightly along the inner margins of the band as well. The solder, when so disposed, strengthens the occlusal surface and obviates the danger of it wearing through under masticatory stress.

FINISHING THE CROWN

The finishing of the crown is accomplished with engine stones and discs, and the final polish developed with felt and brush wheels on the lathe.

A piece of wood about four inches long and three-eighths inch in diameter, reduced at one end so as to fit loosely within the crown, will serve as a handle for holding it while polishing. The handle is applied by placing a pellet of heated modeling compound on the reduced end, pressing it into the crown

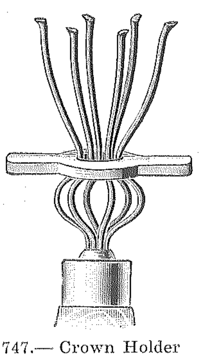


Fig. 747.— Crown Holder

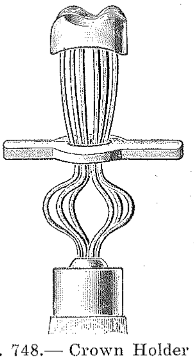


Fig. 748.— Crown Holder Applied

and chilling. When the crown is polished, by warming it slightly to soften the compound, the handle may be removed.

A convenient appliance designed for holding crowns consists of a group of divergent steel springs, set in a handle. When compressed inwardly, and introduced in the crown, the springs press outward and hold it firmly while polishing (see Figures 747 and 748).

SETTING THE CROWN

When finished and the polishing powder is removed, the crown is washed in alcohol and laid aside while the tooth is cleansed and dried and the cement mixed.

Cotton rolls may be used to guard against the encroachment of saliva during the earlier stages of setting the crown and until the cement begins to set.

The cotton may be held in various ways, one of the most convenient being to apply a clamp to a proximating tooth, and place cotton rolls under its lingual buccal bows.

A convenient type of cotton roll holder, specially designed for such purpose, the Ivory, is illustrated in Figure 749.

One objection to the use of any clamp in this operation is that when applied before the setting of the crown, the occlu-

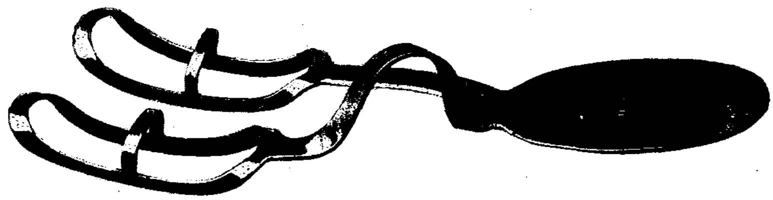


Fig. 749.— The Ivory Cotton Roll Holder

sion cannot be tested, the clamp bows interfering with closure of the opposing teeth.

After forcing the crown to place, a clamp may be applied to advantage.

The usual order of procedure is to apply cement within the crown somewhat in excess of the amount required, and quickly carry it to place.

It should be forced in position with finger pressure, after which the patient is instructed to bite the crown to place. Usually a piece of soft wood is inserted between the occlusal

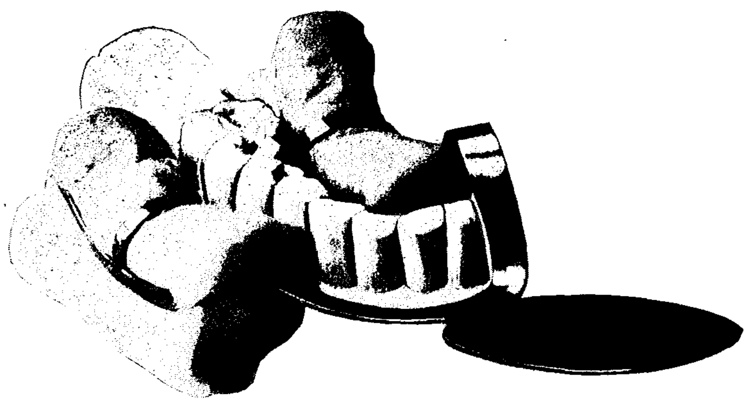


Fig. 750.— The Cotton Roll Holder Applied to Teeth

surface of the crown and the opposing teeth to act as a cushion on which to bite.

This procedure will force out the excess cement if the latter is of suitable consistency to flow. If too stiff to flow under steady pressure, mallet blows will be even less effective, although the latter method is frequently adopted, usually to the injury of the peridental membrane.

When seated and the cement has set, the surplus should be removed, the gums syringed with warm, normal salt solution, and massaged to relieve the general discomfort resulting from the operation.

CASTING THE CUSPS

The occlusal surface of a crown may be cast directly to the axial band. This method, in some cases, obviates the construction of a counterdie, as well as the necessity for forming casts of the mouth. Technical procedures of this method of developing a crown vary considerably, but the general principles are similar. The following is a simple and common method of procedure:

Form, fit and contour the axial band to the tooth as described. Apply a block of softened inlay wax to the occlusal end of the tooth, within the band. Instruct the patient to close in simple occlusion. Trim off peripheral surplus of wax and instruct the patient to bite sideways and in various directions. This step develops clearance paths for the cusps of opposite teeth. With small carving instruments, the fine lines and surface markings are developed in the wax, and the occlusal surface given its desired form and contour.

Remove the band and carving from the tooth. Usually the bulk of wax within the band is greater than necessary to reproduce in gold. It may be removed by chilling the wax and scraping from the interior of the crown with a discoid instrument. The wax may be reduced to a layer of uniform thickness, over the entire occlusal area, by holding the crown against a strong light while scraping away the excess. The transmission of light through the wax clearly indicates the thick and thin areas. This method was suggested by Dr. J. W. Birkland a number of years ago. Another method of removing the wax is as follows:

A small metal tube with a receptacle for holding the melted wax is heated and passed against the interior of the crown. As the wax melts it is withdrawn by suction, a small rubber hose, attached to the metal tube, being held in the mouth. This is a design of Dr. F. E. Roach and is called a *wax sucker*.

A sprue former is attached to the cusp surfaces at some convenient point, the crown invested in a casting ring, so that the wax occupies as nearly a central position as possible in the ring. Casting is accomplished in the usual manner.

Sometimes the cast cusps fail to unite perfectly with the axial band at all points, and in some instances not at all. When this occurs, the casting may be soldered to the band.

To obviate the failure of union mentioned, the occlusal end of the band may be notched with the shears, and the dentated edges bent slightly before applying the wax and carving the cusps. This method develops positive mechanical anchorage between the band and casting.

Cast Crowns

Various other methods are in vogue for casting crowns, either whole or in part, which have proved more or less satisfactory.

One of these methods consists in preparing the root decidedly cone shaped or so that the band, when adapted closely to it, will withdraw.

The band is now formed to fit the root closely, so that when driven on it will cling to the axial walls firmly. It may have a disc soldered to the occlusal end, thus converting it into a deep cap, or the occlusal end may be left open.

Inlay wax is applied to the axial walls and occlusal surface of the cap and the crown developed to the desired contour by carving.

Since it is difficult to adapt the wax to the cap in the mouth, an impression-bite should be taken with the band or root cap in position. From this casts are developed and mounted on the occluding frame. The band is then carefully removed from its cast, being careful not to disturb its cervical matrix. Inlay wax is now applied to and melted against its outer surface and over its occlusal end. It is now returned to position on the cast, the occlusal area softened and the occluding teeth pressed into it, after which the cusps are carved to desired form. The axial outlines of the crown are developed by removing surplus or making additions of wax as required.

The waxed crown can be returned to the mouth if necessary for testing its occlusal adaptation, length, general contour, etc.

When satisfactory, it is invested and cast in the usual manner.

Oftentimes in casting a crown of this type, the contraction of investment within the band walls is sufficient to permit the gold to enter, thus interfering with the fit of closely adapted bands.

Dr. Weinstein suggests the insertion of a closed end copper thimble, slightly smaller than the interior of the crown. The crown is first filled with investment, and the thimble inserted, closed end first, so as not to touch the crown walls.

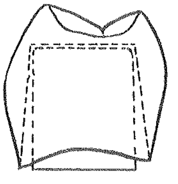


Fig. 751.— Thimble Inserted in Crown to Prevent Excessive Contraction of Inclosed Investment

The interior of the thimble is also filled with investment, after which the crown may be invested in the usual manner.

The contraction of investment between interior crown walls and thimble is so slight that no gold will enter in casting.

The Shoulder Crown

The *Shoulder Crown* is designed to obviate the overlaying of a band against the peripheral surfaces of a tooth. The axial surfaces adjacent to the joint junction between the tooth and a crown of this type being continuous, is similar to that of an inlay with adjacent tooth surfaces. The advantages of such a crown, therefore, when well adapted, are obvious.

PREPARATION OF THE NATURAL TOOTH

The axial surfaces of the tooth are prepared so as to converge more or less uniformly cervico-occlusally. Instead of terminating cervically, in a cone, the base of which is more or less indefinite, the axial surfaces should terminate in a distinct cervical shoulder. This shoulder should be formed at right angles to the long axis of the tooth. Should be about one thirty-second of an inch wide, more or less, and should follow the curve of the gingival gum tissues.

When possible it should be located under the free gum margin, but if inconvenient to so locate it, the hygienic value of the crown will not be impaired, since, as before stated, the surface of the crown with that of the tooth is continuous.

CONSTRUCTION OF THE CROWN

The usual method of construction consists in taking an impression of the prepared tooth in an open end band, filled with softened modeling compound. This is filled with amalgam, forming the base sufficiently wide and deep to resist stress of swaging.

When separated from the impression the die is imbedded in moldine, in the swaging ring, and a cap fitted to it. A light gauge, 22 carat gold, seamless thimble, slightly longer than the cervico-occlusal length of the prepared tooth, is adapted to the metal die, first with the horn pene mallet and afterward by swaging. The cervical end of the cap should be reflected against the shoulder and its outer margin trimmed to coincide with the root periphery. The cap may be formed of a band, and its occlusal end closed with a disc.

Heavy platinum or gold foil is sometimes used, being conformed to the die, first by burnishing and afterward by swaging. The folds or wrinkles, which naturally result from this method of adapting the foil, in no way seriously interferes with the adaptation of the crown.

When the cap is developed it is returned to the root for an impression-bite, from which casts are developed.

Inlay wax is now applied to the outer surfaces of the cap and the crown carved to meet occlusal and esthetic requirements, after which it is cast in the usual manner.

Seamless Gold Crowns

A seamless crown is formed from a single disc of gold plate, and is therefore devoid of soldered joints.

With mandrels of gradually decreasing size, the disc is forced through a series of holes in a device much like a draw plate, and is thus converted into a thimble. From this thimble the crown is developed by swaging.

Thimbles are comparatively simple to construct, but most prosthetists use the manufactured thimbles which the supply houses carry in stock in various sizes and gauges of gold.

Although there are many variations in detail, there are only two general methods of constructing seamless gold crowns.

First, by swaging the thimble within a matrix, and second, by swaging it over a die. By either method a model or pattern of the desired form of crown must first be formed, in order to construct the matrix or die. The construction of the pattern is practically the same in either case except that in the die method the pattern must be slightly smaller than the proposed crown is to be, since the gold is adapted over or outside of the die, and is therefore larger than the latter, or the pattern from which the die is developed.

THE MATRIX METHOD

First, the tooth is prepared as for an ordinary shell crown. To this is fitted a seamless or soldered copper band of the same gauge as the gold thimble to be used. The band should be scribed and fitted under the gingival margin of the gums exactly the same as a gold band is fitted.

Its axial walls should be contoured to the desired form, its occlusal end notched to represent the cusp elevations.

The occlusal surface is filled in with softened metalline compound and when carved to correct form, the band and carving are removed from the tooth.

Fill the inside of the band with moldine, flush with its gingival margin, and within this insert a small wood or metal peg, allowing it to project about one-fourth inch, to serve as an anchorage for the pattern in casting the counterdie.

Form some moldine into a cake about two inches in diameter and one-half inch thick, giving its upper central surface a slightly convex form.

Set the crown on this convex surface, cervical end down, the projecting peg entering the moldine base. With the point

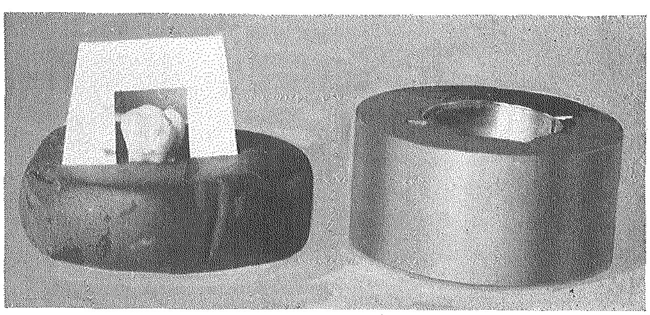


Fig. 752.— Left Cut Shows Pattern Crown Set on Moldine Slab with Cardboard Set in Position to Divide the Metal as It Is Poured. Right Cut Shows Swaging Ring Ready to Apply Over Crown, on Moldine Base

of a knife adapt the moldine neatly to the cervical margin of the band, being careful not to imbed the latter in the clay. The upper surface of moldine on which the cervical end of the crown rests gives form to the cervical margin of the counterdie, and since the gingival curvature as well as length of crown depends upon this margin of the counterdie, care should be taken to carry out this step accurately.

A special ring, of which there are two general forms, is used in which to cast the counterdie matrix. Both forms of rings have tapered openings extending through them so that counterdies, when cast, will part readily from them. In one ring there are two slots formed in the inner wall and opposite each other for holding a U-shaped piece of cardboard, for partially dividing the metal in casting. In the other, there are two metal ribs extending centrally toward the pattern, which fulfill the same purpose as the cardboard. A plain, heavy-walled ring with a taper opening will, however, answer the purpose equally as well.

The U-shaped cardboard is now cut and fitted in the ring slots, the central portion of the card being removed, and the opening made sufficiently large to avoid encroachment of the card margins on the pattern crown.

The ring should be so centered over the pattern that the card edges are opposite its greatest diameter, so that when

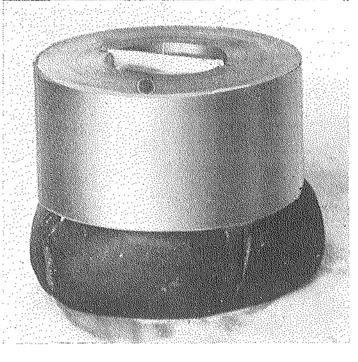


Fig. 753.— Swaging Ring Resting on Moldine Base Ready for the Counterdie Metal

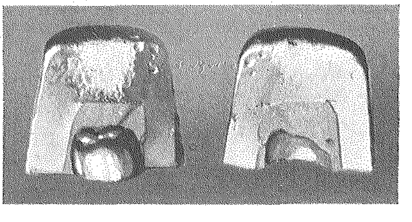


Fig. 754.— Counterdie or Metal Matrix Cast and Split Apart

cast and the counterdie is split, both halves will be readily released from the pattern.

Fusible metal is now cast into the ring, around and over the model crown. When hardened, the casting is removed, the blade of a knife is inserted in the slot made by the cardboard, and with a sharp hammer blow the die is split in two pieces.

The pattern is now removed and the counterdie, if satisfactory, is trimmed, oiled, and returned to the casting ring.

SWAGING THE CROWN

A gold thimble is selected, slightly longer than the depth of matrix and which fits closely into it. The interior of the thimble is filled with baseplate gutta percha, a square end, steel mandrel, which will pass into the thimble and fit it closely, is pressed against the gutta percha and given two or three blows with the hammer.

The thimble is now removed and examined, to note the result of the first swaging. The principal accident liable to occur during swaging is tearing of the gold. By thoroughly cleaning the crown, polishing, annealing and continuing the swaging process slowly, the gold can be forced out against the matrix walls and partially into correct occlusal form.

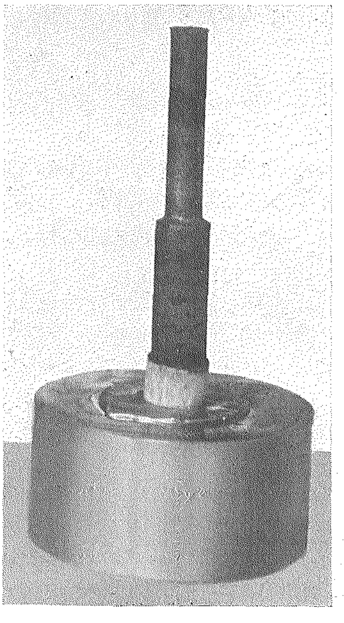


Fig. 755.— Preliminary Stage of Swaging the Thimble in Matrix

Development of the fine occlusal lines usually requires the application of a hardwood point or a small, somewhat round-pointed steel mandrel. At no time during the swaging process can the gold be forced too rapidly, or splitting of the walls will most likely result. When developed to correct form, the cervical surplus of the crown is removed even with the cervical margin of the matrix.

Usually a little correction of this end of the crown with the contouring pliers is required.

The inner cusp surfaces should be thickened by flowing solder inside the crown.

Sometimes, to avoid danger of the gingival end of a seamless crown stretching, when set and subjected to stress, a film of high grade solder is flowed around its entire outer periphery. When polished, such addition will not be noticeable.

The steps of finishing and setting the crown are similar to those of any gold shell crown.

Swaging a Seamless Crown by the Die Method

When the crown is to be swaged over a die, the pattern must, as before stated, be smaller than the required crown by an amount equal to the thickness of the walls of the gold thimble, otherwise when completed the finished crown will be correspondingly larger than the pattern.

A convenient and accurate method of forming the pattern is as follows:

A copper band of the same gauge as the gold to be used is fitted to the root, as previously described. The axial walls should be contoured and the occlusal end notched or occluded with the opposite teeth. The cusps are carved in plaster and when the crown is removed the inner walls of the band are coated with a thin film of oil. The remaining interior space is filled with plaster, which should unite with the cusp carving. The plaster last added should also extend about one-eighth inch beyond the cervical end of the crown to form a pedestal for the pattern.

The band is now carefully divided with a fine fissure bur usually applied on the lingual side, being careful not to mar the plaster while doing so. The ends are then bent outward and the band carefully removed, leaving a pattern of the tooth in plaster.

The plaster cusps overhang the axial surfaces an amount equal to the thickness of the band walls.

This overhang should be carved away so that the surfaces are continuous. No reduction of the occlusal surfaces is necessary, as the slight amount in extra length of the crown (about 1-100 of an inch) can be removed from the cervical end in final fitting. The pedestal or cervical extension should be trimmed so as to show a slight shoulder, to outline the termination of the cervical end of the crown.

The pattern, now wholly composed of plaster, is coated with separating medium.

A small mix of plaster is made and spread on a sheet of paper. It should be about three-eighths inch thick and one and one-fourth inches square, flattened on its upper surface.

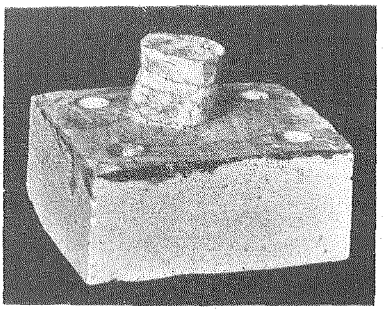


Fig. 756.— Occlusal Surface of Pattern Crown Imbedded in Plaster

Into this the varnished pattern is pressed, so as to imbed the occlusal area and some of the axio-occlusal periphery, usually about one-eighth inch of the occlusal end of the pattern. When hardened, the plaster is trimmed smoothly, small depressions made in the four angles to serve as guides for the subsequent pieces to be constructed, and its surface varnished.

Another mix of plaster is now made and applied to one-half the crown and pedestal. This should embrace approxi-

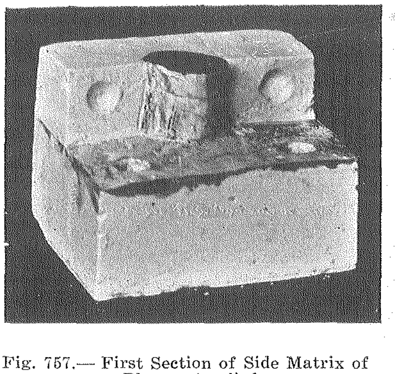


Fig. 757.— First Section of Side Matrix of Plaster Applied

mately one-half the pattern, the line of greatest diameter indicating the amount of surface to cover. Its ends and sides should be squared up, and the surfaces extending from the pattern outward, trimmed perpendicularly. Guide depressions should also be made in these surfaces.

When hardened, the fresh areas of plaster are varnished and another mix made and applied against the opposite side of the pattern, building it up in conjunction with the other two pieces to form a rectangular block, in the top of which the base of the pedestal is seen.

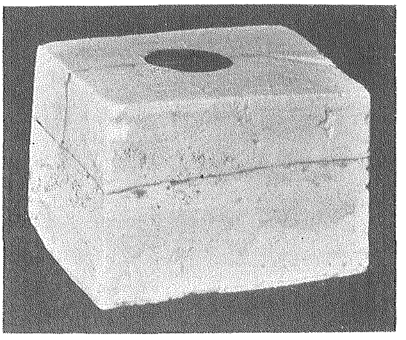


Fig. 758.— Plaster Matrix Complete, But Not Separated

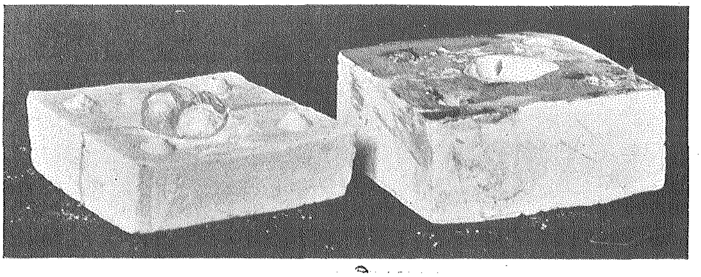


Fig. 759.— Upper Half of Matrix Removed

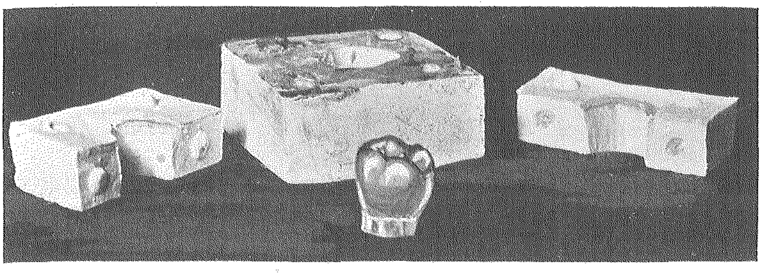


Fig. 760.— Matrix Separated and Pattern Crown Removed

When hardened and squared up, a few light hammer blows will loosen the several pieces and the pattern can be removed.

On placing the three pieces together, a matrix will be formed, representing in reverse the form of the pattern.

The external opening is now beveled slightly, the block bound together with rubber bands or binding wire, the ring of a swaging device is set on top of the block and evenly centered over the opening.

Fusible alloy is now melted and cast into the matrix and ring.

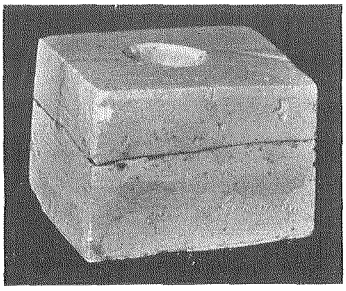


Fig. 761.— Matrix Assembled, Showing Cervical Opening

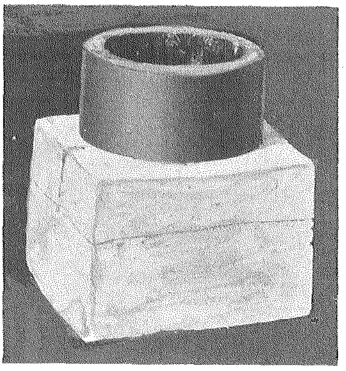


Fig. 762.— Swaging Ring Placed Ready for Casting the Die

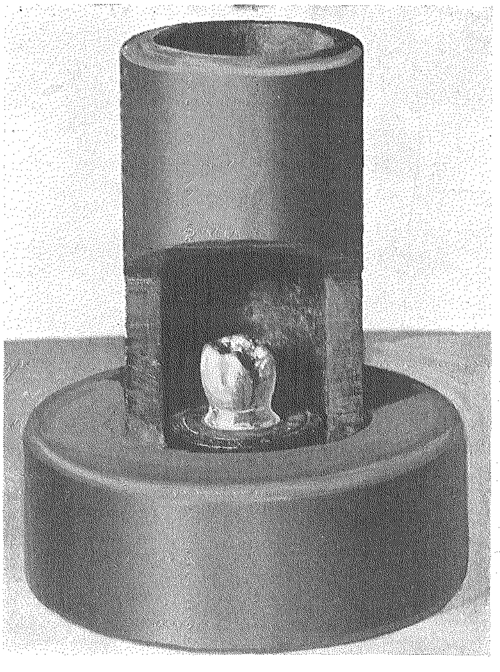


Fig. 763.— Die in Position in Swager

When cold, and the plaster is removed, a die of the tooth with a cervical extension will be seen, attached to and standing above the metal within the swaging ring.

The rough margins of the die are smoothed up, the latter oiled, and a thimble selected that will telescope over the die tooth and extend to its cervical line or slightly below.

SWAGING THE CROWN

The thimble and upper surface of the die are now covered with tissue paper, to prevent the swaging material of whatever kind from finding its way between thimble and die.

The ring is placed in the swager, the outer barrel set over it and with one heavy hammer blow the adaptation of gold to die is begun. An examination of the thimble is now made.

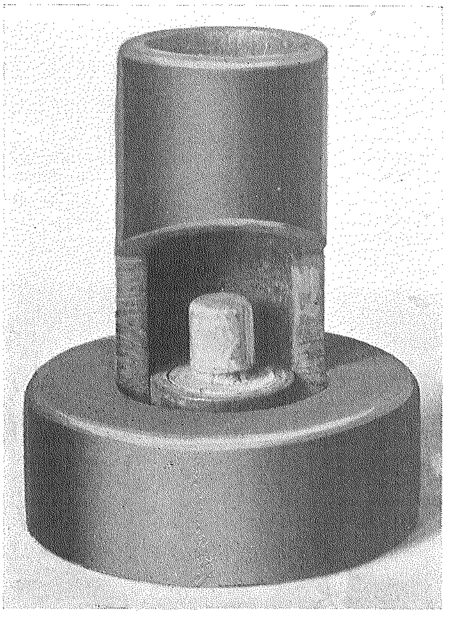


Fig. 764.— Thimble in Position on Die

Invariably, after the first swaging, one or more folds of gold have begun to form around the cervical constriction. These can be obliterated without removing the thimble from the die by means of light blows with the horn pene mallet or the small riveting hammer.

When corrected, the gold is again subjected to another single, heavy hammer blow in the swager, and wrinkles or folds removed as before.

This process is repeated until the gold is constricted gingivally so that folds cannot develop.

The occlusal surface, in the meantime, has become only partially conformed. With the riveting hammer and a small steel mandrel, the occlusal surface lines are developed, after which the crown is once more returned to the swager for final adaptation.

Since in practically every case the crown pattern, and consequently the die, are bell-shaped, the gold cannot be removed from the die during the swaging process.

It is finally removed by placing the die with crown attached, in water and bringing it to boiling point, at which temperature the fusible metal melts. This method prevents

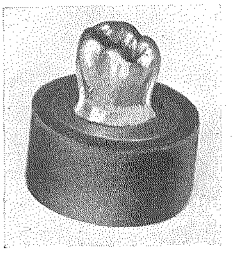


Fig. 765.— Crown Swaged, But Not Removed from Die

contamination of the gold by the base metal, which usually occurs when the die metal is melted in the open flame.

By this method of construction the crown walls are thickened, while in the matrix method the walls are to a greater or less extent reduced in thickness.

FINISHING THE CROWN

The gingival surplus is trimmed to the line of junction of crown with pedestal, the crown boiled in acid and polished. The occlusal or incisal ends should be stiffened interiorly, and the cervical end covered exteriorly with a thin film of high-grade solder.

GENERAL REMARKS

In all cases of pattern construction, a copper band should be carefully scribed and fitted to the natural tooth. This may be wide or narrow, depending on how the pattern is to be formed. On or within this band, the wax, plaster or other material is built and carved as required.

It will be seen that since the pattern is at no time subjected to heat, it may be formed of wax or any material sufficiently resistant to carve well and retain its form in handling.

One who can carve well can produce very satisfactory forms of crowns by this method. One who cannot carve should not attempt this method of construction, for he will most certainly be disappointed with esthetic results.

Certain mechanical aids, however, can be resorted to, which will relieve one of most of the carving, but not of *nice* adjustment of the several parts of the whole.

REPRODUCING NATURAL TOOTH FORMS IN INLAY WAX

One of these mechanical aids that may be applied in various ways consists in pressing the crown of a natural tooth, or a typically formed artificial tooth, into moldine, the surface of which should be dusted with talcum powder. On removal, a distinct matrix is seen, into which melted inlay wax is poured. Since this wax cools quickly, and when cool is quite hard, the reproduction may be carved to any desired form. At any rate, it furnishes a very good basis on which to build the form desired.

This method is often adopted in forming dummies in wax that are to be reproduced by casting.

In the hands of the writer the swaging of crowns over a die has proven very satisfactory.

CHAPTER XXIX

BRIDGEWORK

Engineering Principles

In scientific fields it is a recognized fact that the use of exact terms encourages the development of exact methods. It is therefore of advantage to the student to become familiar with the terms commonly used in dental bridgework, and their concise meaning as understood and applied in engineering, from which field these terms have been selected and adapted to dental purposes.

A bridge is a structure which spans a space, and which is designed for sustaining or supporting not only its own weight, but additional loads or stresses that may be brought upon it.

A *bridge* consists of a *substructure* and a *superstructure*. The substructure of a bridge is the supporting foundations, while the superstructure is that part which rests upon the foundation supports, spans the space and carries the load.

The term *abutment* is defined as "the terminal mass of a bridge, usually of masonry, which receives the thrust of an arch or the end weight of a truss; in distinction from a *pier* which carries intermediate points . . ." (Century Dictionary.)

APPLICATION OF STRESS TO THE SUBSTRUCTURE OF A BRIDGE

There are five principal types of bridges recognized in engineering, differentiated by the manner in which the weight of the superstructure and load is sustained by the foundation supports.

First, the *arch* bridge of masonry, in which the abutments must not only support vertical stress, but end thrust as well. In a bridge of this type the arch is not a complete factor in itself, but is dependent upon constant end compression between opposing abutments for maintainance of form and capacity for sustaining load. This end compression, which tends to force the abutments apart, is usually provided for by broadening the end terminals of the abutments with flaring walls, and filling the inclosed space between these abutting walls and the principal foundation with earth or rock. The end abutment therefore derives its name from the fact that it *abuts* the bank.

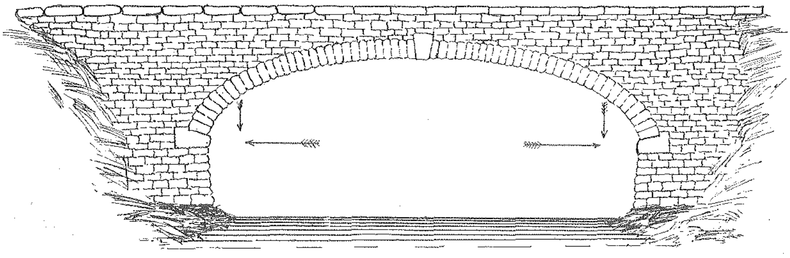


Fig. 766.— A Stone Arch Bridge

The weight of the structure and applied load exerts downward vertical stress and an outward push against the abutments.

GIRDER OF TRUSS BRIDGES

Second. The *girder,* or *truss bridge,* is one in which the structure which bridges the space between the two abutments, or when consisting of more than one span, between an abutment and a pier, is a complete factor in itself, rigid, and capable of sustaining its own weight and of the applied load as well. The span may be solid, consisting of simple, solid girders of wood or iron, or it may consist of several members so united as to act as a solid beam. As an example, the Howe Truss is composed of an upper and lower chord united by

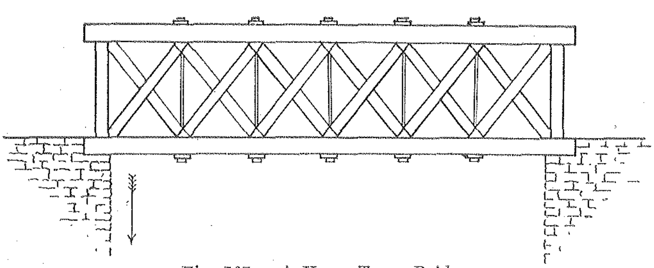


Fig. 767.— A Howe Truss Bridge

vertical and diagonal web members. This truss is so framed that the upper chord is always in compression, the lower always in tension, the vertical members under tensile strain, and the diagonal under compressive stress. The weight of the truss and load exert a downward vertical stress upon the abutments and piers.

SUSPENSION BRIDGES

Third. A *suspension bridge* consists of a platform, hung on cables which span the space and are supported by abut-

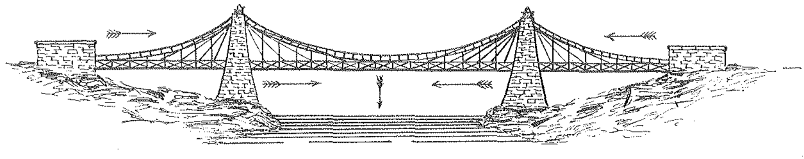


Fig. 768.— A Suspension Bridge

ment towers. The weight of the structure and the load it carries exert a vertical stress and an inward pull upon the abutments.

PONTOON BRIDGES

Fourth. A *pontoon bridge* consists of a platform superstructure, supported by shallow vessels, or boats which float upon, and are anchored in a stream of water. Bridges of this type have no solid or fixed abutments or piers, except the terminal banks, each boat carrying its proportion of weight of the immediate superstructure, and yielding under the immediate load imposed, according to its capacity for displacement of water.

The term "pontic" has been suggested as a substitute for "dummy" in describing a bridge tooth replacement. The term seems scarcely appropriate, since practically all fixed bridges are of the rigid truss type.

THE CANTILEVER BRIDGE

Fifth. A *cantilever bridge* is a structure consisting of two or more rigid trusses which span a space, each of which is supported in or near its center by a foundation pier. That portion of the truss extending from the foundation pier to the abutment bank is called the *shore arm,* while its opposite end, which overhangs the stream, is called the *river arm.*

In a structure of this type, consisting of two trusses which bridge a river, the length or weight of the shore arm is increased over that of the river arm. To counteract the effect of load applied at the terminal end of the river arm, the shore arm is tied down to the bank abutment. This is necessary, since the terminal end of the river arm is unsupported and its stability under load depends upon the rigidity of the entire truss structure.

For the purpose of equalizing stress as well as for convenience in construction, particularly when the space to be bridged is wide, an independent truss is interposed between and supported by the terminal river arms.

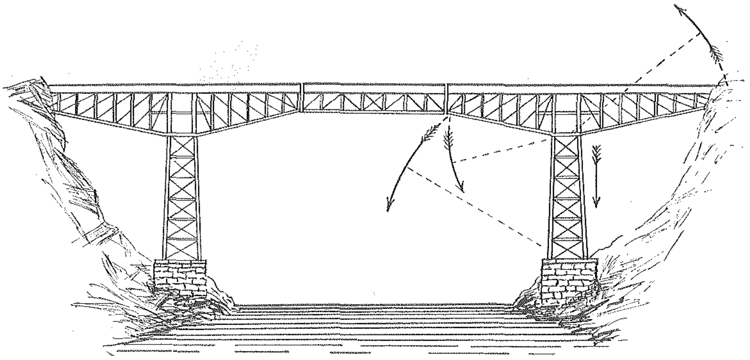


Fig. 769.— A Cantilever Bridge

The stress upon the central foundation of the truss of a cantilever bridge is downward, while that upon the bank abutment, when the weight of the river arm, together with its load, exceeds the weight of the shore arm, is upward.

Dental Bridgework

Bridgework, in its dental meaning, refers to the replacement of some of the lost natural teeth by means of substitutes or dummies, which are attached to and held in position by some of the remaining natural teeth or roots. The teeth or roots so utilized, according to the nomenclature previously outlined, are termed *abutments* and *piers*.

GENERAL CLASSIFICATION OF BRIDGES

Bridges naturally fall into two classes, *fixed* and *removable*. Both types mentioned are capable of division into subclasses, generally similar in form, yet varying in detail, according to the means of retention or attachment employed, the forms of the individual factors or dummies of which they are composed, and the class and arrangement of the materials entering into their construction.

Distinction Between Fixed and Removable Bridges

FIXED BRIDGES

A fixed bridge is so designated because, when permanently set, it cannot be removed by the patient. As ordinarily constructed, a fixed bridge cannot be removed by the operator without more or less mutilation of some of its parts. Occasionally, when a bridge has previously been partially loosened through disturbance of the cementing medium, as from stress of mastication or other causes, it may be removed without mutilation.

FIXED BRIDGES SO CONSTRUCTED AS TO BE REMOVABLE

It is possible, and practicable as well, to construct a bridge of the fixed or stationary type, which can readily be removed and replaced by the operator, but not by the patient. This is a decided convenience, for in case of repair, or if the roots forming the substructure require treatment, removal may be made without mutilation of the substitute, or injury to the supporting roots, and the bridge later returned to and set in position.

A bridge in which the "Corcoran" block and screw is applied is a representative of this type. (See page 835.) Various other attachments have been suggested and successfully used. One of the most practical of these consists of a projection extending from a crown or inlay, which is received in a correspondingly shaped socket in the substitute. An opening extends through both bridge and projection and in this a dowel or screw is fitted.

By reference to "Application of stress to the substructure of a bridge" (see page 783) it will be seen that fixed bridges come under the second classification, viz., rigid truss, vertical stress, no end thrust on abutments.

FIXED SADDLE BRIDGES

Fixed bridges are sometimes constructed with saddles to rest upon and cover the border to a greater or less extent. By some it is thought that two advantages are gained by the use of a saddle in a fixed bridge.

First. It is claimed that the saddle affords some resistance to stress, and thereby relieves the sub-structure or abutments and piers, of some of the extra load they must necessarily sustain, in performing their own work and that of the substitute crowns as well.

Second. That by the use of a saddle, better general contour can be given the individual members of the bridge, and the formation of constricted spaces between the structure and the border, in which food will accumulate, can to a great extent be obviated.

It is the opinion of the writer, based on observation and experience, that the first of these so-called advantages is extremely doubtful. A saddle which bears so firmly upon the mucous, and indirectly upon the bony tissues when in a state of rest as to yield support under the slight movement of the abutment roots in their peridental membranes, will sooner or later result in absorption of the bony tissues. The constant pressure exerted may or may not result in absorption of the mucous tissues. In any event, the slight resistance to stress afforded by these tissues, even though they may not be perceptibly absorbed, is not worth considering.

The second advantage, that of better contour afforded the substitute teeth, however, is unquestionable in those cases where a saddle is applicable. Wide saddles are always objectionable and should never be applied. Even with a narrow saddle, it is sometimes impossible for the patient to maintain correct hygienic conditions around the structure because of the difficulty in removing food particles which find their way beneath it. Discrimination, therefore, should be observed in the application of saddles of any type in fixed bridge work.

INDIVIDUAL SADDLES

More than thirty years ago, Dr. H. H. Keith of St. Louis advocated the use of individual saddles; that is, an individual saddle for each dummy, not greater, usually less in area, than the normal cross-section at the border, of the natural tooth replaced. Within recent years this method has been revived, and is being used by many with very satisfactory results.

The advantages of an individual saddle are threefold, viz.: first, more *esthetic* form may be given the dummy; second, the structure feels more comfortable to the tongue, the dummy being given the approximate lingual contour of the natural tooth, and, third, there is less tendency for food to accumulate in bulk, or become as tightly wedged as when the dummies approach close to or rest against the labial or buccal border surfaces only.

As before stated, a saddle, either continuous or of the individual type, cannot afford any appreciable resistance to masticatory stress, in fixed bridge work, and should not be applied in those cases where the abutment teeth are inherently weak and unable of themselves to withstand the stress. In such case a bridge is contra-indicated.

SANITARY BRIDGES

A type of fixed bridge, commonly known as a *sanitary bridge,* is frequently constructed, in lower restorations of bicuspids and molars particularly, when absorption of the ridge has progressed to a considerable extent, and when the deficient portion of the substitute is not visible when the mouth is opened as in speaking or laughing.

A bridge of this type consists of an *occlusal platform,* attached to abutment crowns or inlays. The buccal and lingual margins of the dummies are rounded in and terminate in a more or less convex surface presenting toward the border. Not more than one-third, usually less, of the buccal and lingual surfaces are developed to anatomic form, the idea being to preserve as much space as possible between ridge and dummies, so that food may be readily removed. In most cases these bridges are constructed entirely of metal. Certain types of replaceable porcelain teeth may, however, be utilized in such structures when conditions are favorable.

EXTENSION BRIDGES

An extension bridge is purely and simply a cantilever bridge. The cantilever principle is often misapplied in bridge work, one abutment root having to carry one, or even two, proximating teeth without any additional anchorage, further than that afforded by contact of the terminal dummy with a proximating tooth. This principle is wrong under any circumstance, even in the attachment of a single dummy to a single root.

When two proximating roots are available as abutments for anchorage, and one dummy extended from the two attached crowns, if it is possible to so unite them that the structure will not impinge upon the soft tissues, and it can be kept clean, this principle may at times be employed to advantage.

Again, in bridges of considerable length, where teeth or roots and spaces alternate, an extension dummy can be applied to fill the terminal space at one or the other end of the structure, thus reducing the number of supporting crowns without curtailing necessary support.

Practically the only advantage of an extension bridge under any conditions is in obviating the crowning or inlaying of a sound and useful tooth. The problem the prosthetist must determine is whether a rigid, well-supported, sanitary structure can be introduced without a terminal support at each extremity.

IMPORTANT FACTORS TO BE CONSIDERED IN PLANNING FIXED BRIDGES

The engineer, in planning and constructing a bridge, can select the material and build the foundations for the structure in whatever location is best calculated for its support.

The prosthetist cannot *build* the foundation for the bridge he constructs. He must select from among the teeth and roots present those which, in his judgment, are most favorably located and best calculated to perform, not only their own work, but sustain the extra stress thrown upon them by the added masticatory area of the teeth supplied.

ABUTMENTS AND PIERS

No engineer will plan or construct a bridge truss with lateral curvature without adequate support. In case a curve in the road is required he will either construct short, straight

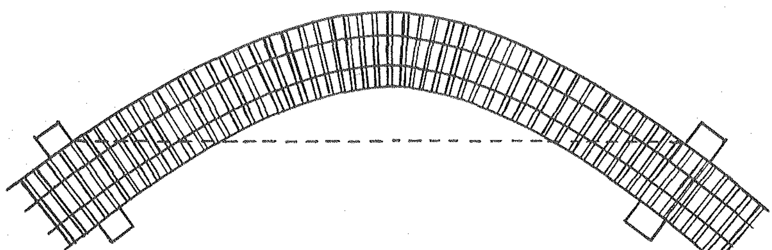


Fig. 770.— Ground Plan of a Curved Truss Supported by Only Two Abutments. Incorrect Because When Load Is Applied to Outermost Curve the Tendency Would Be to Rotate

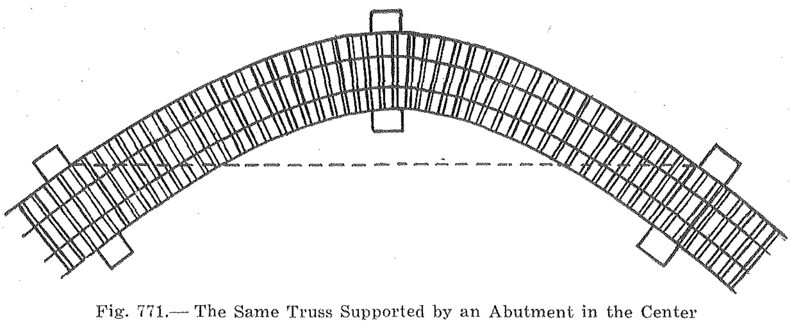


Fig. 771.— The Same Truss Supported by an Abutment in the Center

trusses with piers at each end, and dispose them in curved alignment, or plan somewhat longer trusses of greater breadth on which the required curve of roadbed may be laid out. In any case, change of direction requires that the outermost curve shall have a firm foundation to support it or the structure will fail. Again, in engineering the foundations of a bridge rest upon bedrock or its equivalent, and the abutments are not susceptible to any marked lateral stress or vibration. Neither does the substructure suffer materially under direct stress, being capable of successfully sustaining not only the weight of the constant superimposed structure, but many times more than that of the heaviest intermittent load will be applied.

A bridge designed and built in a manner, or of such materials, that the dividing line between safety and disaster is indefinite, would subject the designer to severest criticism, if not criminal prosecution.

In the construction of dental bridges, the prosthetist is confronted with more serious problems than arise in the engineering field. The foundations of a dental bridge are not firm and unyielding. They are subject to depression under direct and a much greater degree of movement under lateral stress.

The power of resistance to stress, without injury, of the peridental membranes of teeth, varies in different individuals. The dividing line between the amount of stress ordinarily delivered upon the abutment roots under a bridge, and that which will cause permanent injury to the peridental membrane is very indefinite, so close, in fact, that frequently injury beyond repair occurs before the patient is aware of it.

The amount of stress actually delivered upon a bridge to the supporting roots is directly dependent upon two factors; first, the habitual masticatory effort of the individual, and second, the occlusal area of the bridge involved.

This stress cannot be determined, or at least only approximately, nor can the power of resistance of the peridental membrane to withstand stress, without injury, be estimated. The necessity, therefore, of selecting sound, healthy roots or teeth, in sufficient number, and properly located for supporting a bridge, is obvious.

Since the vital factors which determine the possibility of placing a successful bridge depends upon the position and condition of health of the abutments and piers, the utmost care should be observed in their selection.

Long span bridges, extending, for example, from cuspid or first bicuspid to third molar, inclusive, without an intermediate pier, are, as a rule, unsatisfactory. In such case the abutment teeth or roots are required to perform not only their own functions, but sustain the stress delivered upon the intervening teeth as well, for which, physiologically, they are not capable.

A favorable foundation for such a span would be, cuspid and third molar for abutments, and second bicuspid or first molar for a pier.

In case no intervening pier is present, the prosthetist cannot *build* one as can the engineer. A saddle will not fulfill the requirement, therefore, some form of removable denture of the saddle type should be considered, in which the border will receive the burden of stress, the terminal teeth serving principally to retain the appliance in position.

A simple anterior bridge in which the two lateral incisors are to be replaced, the two central incisors serving as abutments, will frequently prove successful. A structure of this type is classed as a cantilever bridge.

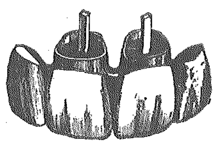


Fig. 772.— A Simple Anterior, Cantilever Bridge

A simple anterior bridge, involving the replacement of the four incisors, the two cuspids serving as abutments, is not usually successful, when the anterior curvature is considerable, even though the incisive stress is moderate. In such case the line of force against the abutment roots is outward instead of apically as it should be.

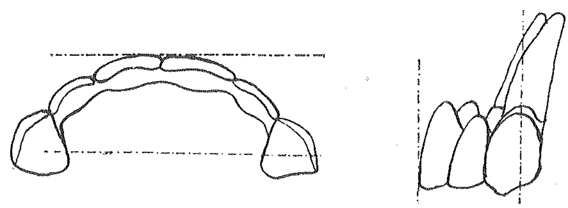


Fig. 773.— A Simple Anterior Truss Bridge, Cantilever Type. Incorrect Because of Lack of Central Support

The cantilever principle, however, can frequently be employed to advantage by extending the bridge distally at each end, to include the first bicuspids. When extended, the cuspid and bicuspid crowns should be so united as not to impinge on the soft tissues. This may be done by joining them at their contact surfaces, leaving the interproximal space free and open.

Again a frequent combination consists of cuspids and second bicuspids utilized as supporting roots, the four anterior and the two first bicuspid teeth being replaced. This is a complex bridge of stable form based on the cantilever principle and when conditions are favorable will prove successful.

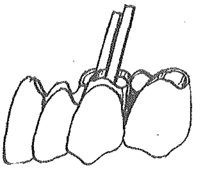


Fig. 774.— Same Bridge as on Preceding Page Extended to Include First Bicuspids, Thus Forming a Complex Structure

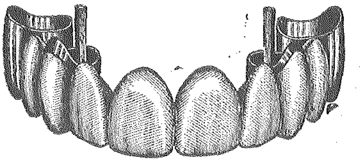


Fig. 775.— Complex Bridge, of the Cantilever Type, of the Cuspid and Second Bicuspid Series

A complex bridge, extending from the first bicuspid on one side to the corresponding opposite tooth, with a sound and healthy central incisor present to serve as a pier, might possibly prove successful if the stress of occlusion is light. Under these conditions, however, a fixed bridge is usually contra-indicated.

Frequently the space resulting from the loss of one tooth or of two teeth that proximated, can be successfully filled by a fixed bridge of the cantilever type, that is, having only one fixed abutment. To support the extension, a lug is attached to and carried beyond the terminal end of the dummy, on a line with or slightly below its occlusal surface. This lug rests in a depression, in an inlay carried by the proximating tooth. Such an attachment converts the extension bridge into one of the regular type, since the tooth carrying the inlay, although not attached, serves as an abutment.

A very common type of simple posterior replacement consists in utilizing the cuspid and first molar as abutments, the two bicuspids being supplied. Again, the first bicuspid and second molar may serve as abutments, carrying the second bicuspid and first molar dummies. (See Figure 767.)

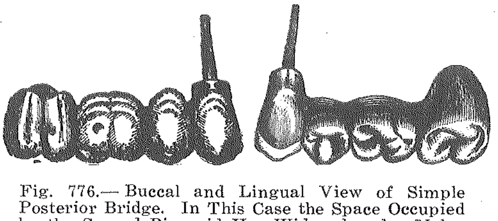


Fig. 776.— Buccal and Lingual View of Simple Posterior Bridge. In This Case the Space Occupied by the Second Bicuspid Has Widened and a Molar Dummy Is Substituted

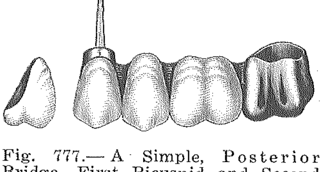


Fig. 777.— A Simple, Posterior Bridge, First Bicuspid and Second Molar Series, in Which Saddle Back Teeth are Utilized for the Substitutes

Sometimes the cuspid and second molar are used as abutments, the two bicuspids and first molar dummies being swung between. In this case the cuspid and second molar must sustain not only their own load, but each perform the work of one and one-half additional teeth. In many instances a bridge of this type will prove unsuccessful.

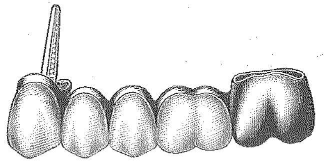


Fig. 778.—A Simple Posterior Bridge of the Cuspid and Second Molar Series. Diatoric Teeth Utilized for Substitutes

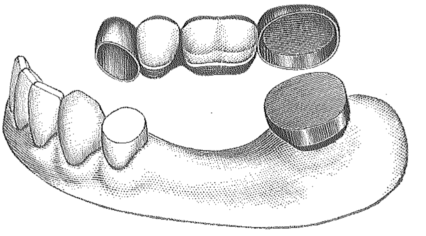


Fig. 779.—A Simple Posterior Bridge of the First Bicuspid and Second Molar Series

A type of structure called an interrupted bridge is sometimes constructed to avoid involving sound proximating teeth. The bridge is converted into a rigid structure by joining the

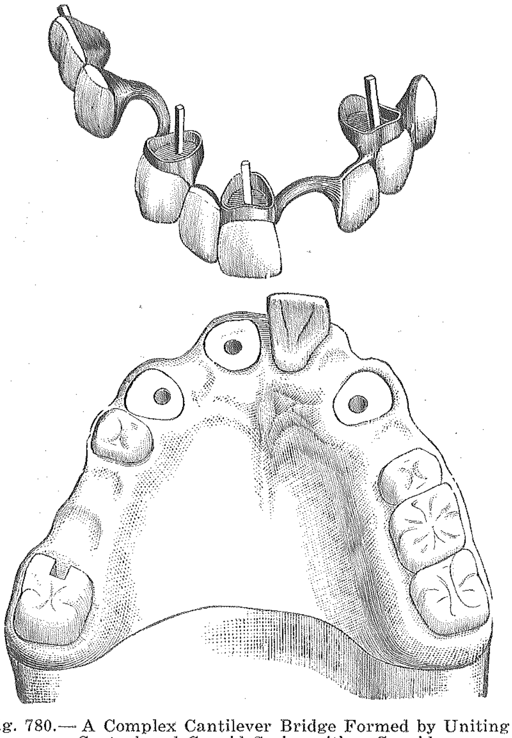


Fig. 780.—A Complex Cantilever Bridge Formed by Uniting a Central and Cuspid Series with a Cuspid and Second Molar Series

several factors with heavy iridio-platinum wire, bent to lie in contact with the tissues, yet so as to avoid contact with the teeth not involved. This type of bridge was suggested by Dr.

J. Leon Williams about 1886 and illustrated in the Dental Cosmos of that year.

Occasionally a full denture bridge is constructed in which practically all of the missing teeth and the natural teeth present are united to form a rigid structure.

Usually bridges of this type are unsatisfactory. First, because of constructive difficulties encountered; second, because of danger of fracture under masticatory stress, and,

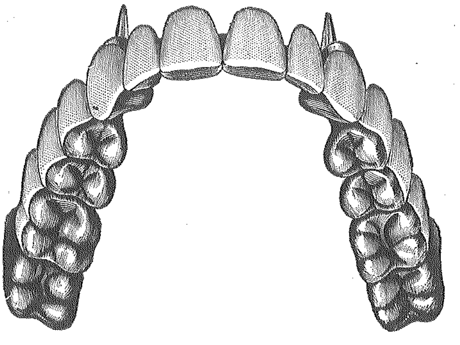


Fig. 781.— A Complex Full Denture Bridge of the Cuspid and Second Molar Series

third, the liability of the abutment and pier roots giving way under the excessive strain to which subjected.

Some form of removable denture will, in most cases, prove very much more satisfactory than a structure of this type.

PREPARATION OF ABUTMENT ROOTS AND PIERS

The abutment and pier attachments of a bridge which rest upon the supporting roots usually consist of crowns. Since these differ in no essential detail from individual crowns, the preparation of roots and teeth for their reception differs but little from the outlines previously given under "Crown Construction." There is, however, one important consideration in bridge work that does not apply to individual crowns which must be carefully observed.

When the supporting crowns of a bridge which rest upon the roots consist of either shell or dowel crowns, the axial surfaces of the teeth involved must be parallel to each other, as nearly as possible. This is necessary in order that the abutment and pier pieces may be withdrawn from and returned to position on their respective roots without hindrance.

In some cases excessive reduction of the axial surfaces of divergent or convergent natural crowns is required to bring them in parallel relation. Frequently, also, the canal, of a root out of general alignment, must be reamed from its face end, apically, to the mesial or distal, to release and receive the dowel of the super-imposed crown.

When such procedures are necessary, extreme caution must be observed to avoid, first, the formation of cervical shoulders on supporting teeth or projecting margins on the substitute crowns, and second, to avoid weakening a root to too great an extent by excessive lateral reaming of its canal.

Various methods have been suggested for overcoming the difficulties of the class just mentioned, one of the simplest and most practical of which can be illustrated in a case shown by Dr. C. L. Anderson of Tomah, Wis. (See page 840.)

This case consisted of an upper bridge extending from cuspid to first molar, inclusive. The divergence of the roots of the two abutments, apico-incisally and occlusally, was so marked that excessive reaming of the cuspid root canal and reduction of the distal surface of the molar would be required to permit the introduction of the bridge. The case was constructed as follows:

The molar tooth was prepared and a shell crown constructed for it by the usual method. A close-fitting cap, extra heavy, was constructed for the cuspid root, in the center of which and in alignment with the root canal was an opening. A lingual half-band disc was conformed to the root cap and on this base a cuspid dowel crown was constructed, being adapted to but independent of the root cap. The bicuspid dummies were united to the molar crown and root cap.

The bridge was set by cementing the molar crown and cap on their respective roots, and immediately forcing the independent cuspid crown in position, its dowel passing into the root canal through the central opening in the root cap.

Another method consists in removing the crown of the inclined tooth, and constructing a cap for or adapting an inlay to the root. The appliance in either case should be supplied with dowels of suitable size and length for anchorage purposes.

On the cap or inlay is fitted and soldered a vertically inclined block, of the Corcoran or Heddy type. It should be placed parallel with the line of axial surfaces of the other involved teeth or roots. To this block is fitted a removable jacket, around and over which a crown, of the anatomic form required, is constructed. By means of an occlusal screw passing through the crown and into the block, or a set-screw passing through the axial wall of the crown and against the block, the removable crown may be firmly locked in position.

Various types of paralleling devices are procurable, with which the alignments of the several canals and tooth surfaces involved may be tested. An instrument made by the J. W. Ivory Company is very convenient for general paralleling purposes, although possibly not sufficiently exact for complicated cases of removable bridgework in which the structure is attached to several widely separated roots or teeth.

INLAY ABUTMENTS

Inlays are frequently used as abutment and pier supports in bridgework. There is a tendency to utilize this form of attachment in extensive cases, oftentimes with disastrous results. The most frequent accidents which occur are dislodgement of the inlay or splitting of the tooth under side stresses.

DISPLACEMENT OF INLAYS

The fact should be kept in mind that the stresses and strains to which an inlay bridge abutment is subjected vary radically from the stress to which the same inlay in the same tooth will be subjected when not so involved.

First, torsional stress is very marked as when the inlay occupies a comparatively central position in the mesial or distal axial surface of a tooth while buccal and lingual marginal ridges of the dummies occupy a position to the outside and inside of the perpendicular line or anchorage of the inlay.

In masticatory effort, the resulting torsional strain invites not only dislodgment of the inlay, but fracture of the tooth itself, particularly in case of weakening of the tooth from caries.

Second, when two inlays carry one or more dummies, and the roots of the teeth diverge or converge relatively to each other, the yielding of either tooth in its socket or the synchronous movement of the two under direct stress exerts a leverage either in the gingival or occlusal areas on the inlays, which, unless very firmly anchored, will result in their displacement.

These observed facts have proven conclusively that the use of inlays as abutments must be confined to favorable cases, and that in practically every instance some form of pin anchorage should be employed.

Various forms of modified inlays or *onlays* are made use of for abutment purposes, among which may be mentioned the Carmichael Attachment, applicable more particularly to the cuspids, and a modified form of attachment for bicuspids as well as cuspids suggested by Dr. E. Kennedy.

In this latter attachment the tooth is prepared and the inlay attached to its mesial or distal half instead of the lingual half of the tooth as in the Carmichael Attachment.

A Classification of Fixed Bridgework

Dr. A. J. Bush, Professor of Crown and Bridge Work in the Ohio University, Dental Department, of Columbus, presented a paper before the National Dental Association at Rochester, N. Y., in 1914, on "A Classification of Fixed Bridgework." In January, 1915, a similar paper was also presented by the same essayist before the National Association of Dental Teachers at Ann Arbor, Mich. (Copyrighted by Dr. Bush.)

In these papers Dr. Bush expressed his views of the fundamental principles on which the present system of fixed bridgework is or should be based. That these principles are logical and in general accordance with the views of the most thoughtful men in the profession is conceded.

The essayist's idea was not to encourage the more extended application of denture restorations by means of fixed bridgework, but to call attention to those principles which, if properly considered and applied, will lead to success in this field.

By means of a series of charts Dr. Bush has shown that, according to location, bridges naturally are resolved into three well-defined classes — simple, compound and complex.

These are further subdivided into series according to the teeth which serve as abutment supports, as central and cuspid series, cuspid and third molar series, etc.

This does not constitute a *new* system of bridgework, but is a presentation in clear and concise form of commonly constructed simple bridges and combinations which have not heretofore been classified.

It is the writer's opinion that for teaching and general descriptive purposes, this classification of fixed bridgework will prove of great value, not only for teaching and general descriptive purposes, but will encourage more careful consideration of the underlying principles which will lead to success in this field.

Permission for the following reprint of the subject matter and the reproduction of the charts has kindly been granted by Dr. Bush to the writer for use in this book.

CLASSIFICATION OF FIXED BRIDGEWORK

". . . Because of the rapid advancement in the practice of crown and bridge work during the last half century and in view of the phenomenal development of bridgework in the last decade especially, most teachers in this field no doubt have found it difficult to preserve the student's mind free from confusion in about the same ratio as the various methods and numerous modifications of procedures have been multiplied.

"While much has been accomplished toward the formulation of principles and requirements governing their indications, contra-indications, adaptation and construction in an effort to place crown and bridge work on a more scientific and teachable basis, yet confusion still confronts our efforts in this direction and the reason becomes very apparent when we stop to consider that every teacher of crown and bridgework in the average dental college essays to teach the average student the principle and requirements, indications and contra-indications and methods of construction of any one of fifty thousand or more possible bridge replacements that may present for solution in any one oral cavity.

MULTIPLICITY OF METHODS

" 'Multiplicity of Methods,' therefore, is no longer an empty phrase and its significance becomes more apparent when it is known that, according to my unabridged classification, one method alone is flexible enough, under ordinary conditions, to be applicable to any one or more 4,410 different conditions which may be present in any one mouth.

"In view of these considerations, we may safely assert that the teaching of crown and bridgework in the modern dental college is a task which has resolved itself into a problem of no small proportions and one which seems of enough moment to demand that every teacher of this subject should at least have given it enough serious consideration to justify his possession of a viewpoint.

PRIME OBJECT OF CROWN AND BRIDGE APPLICATION

"In giving you my view, I assume two things, both of which I believe may be accepted as facts without argument. First, that crowns and bridges are employed in the effort to increase the usefulness of the dental apparatus which has been impaired by the partial or total loss of a few teeth, and second, that the practice of crown and bridgework should be taught in accordance with the correct principles and requirements which govern their employment.

"It is obvious, therefore, that the teaching of the principles and requirements becomes of first importance and serves as the only possible foundation upon which methods of restoration may be correctly taught.

THE BASIS OF SUCCESS

"Every student should be taught that success can be achieved only through a strict compliance with the principles and requirements and conversely that failures are invariably the direct result of their non-observance; that crown and bridgework should not be practiced with the thought of rendering a service to his patients by increasing the functional efficiency of the dental apparatus through the mechanical requirements alone; but, furthermore, that the physiological and hygienic requirements must also be observed, lest this attempt to increase the functional efficiency of the dental apparatus be more than offset by establishing conditions which may prove far more serious to the patient than would be caused by the impairment of the dental apparatus through the physical loss of the few teeth he is striving to replace.

"The greatest proposition that confronts the teachers of crown and bridgework in our dental colleges today, is the problem of teaching a more lively respect for the requirements, to instill into the student's mind a more thorough regard for their importance, a more intelligent conception of their true significance and to bring the student into a fuller realization that the most valuable lesson that can be learned regarding the five requirements is the fact that only one of the five is mechanical.

"My viewpoint relative to this phase of the subject may be best stated by saying that humanity, enlightened by the oral hygiene and prophylaxis propaganda, will sooner or later demand that all of the requirements be observed in the practice of crown and bridgework and that sooner or later teachers in this field will be compelled by a long-suffering public to place less emphasis upon the mechanical and esthetic requirement, except as a means to gain an end, and devote more time to the teaching of those requirements, which, from a humanitarian standpoint are more vital and which in fact constitute the essential consideration underlying the physical diagnosis of oral conditions which demand the execution of these mechanical prescriptions as applied to living tissues, namely the physiological and hygienic.

"A practical knowledge of the correlated sciences of anatomy, physiology, physics, metallurgy, orthodontia, and oral pathology and physiology as viewed and comprehended by the periodontologist, is presupposed as subjects which are fundamental to the study of the requirements and through the combined consideration of which we form our conceptions regarding indications and contra-indications, and, according to my viewpoint, these correlated subjects are so fundamental to the scientific teaching of crown and bridgework that this fact alone would justify our giving them a prominent position in the dental curriculum, even in the absence of any other consideration.

"My viewpoint relative to the teaching of the principles which govern the employment of fixed bridgework, and my idea regarding the best plan of teaching methods, are incorporated in the following classification of fixed bridgework based upon a proposed law or rule which has been formulated in accordance with accepted principles of practice.

ADVANTAGES OF CLASSIFYING FIXED BRIDGES

"In attempting to classify fixed bridgework I have endeavored, *first,* to broaden the foundation upon which the superstructure of our present conception thereof rests, and to establish more thoroughly our comprehension of the principles and their application which constitutes the very superstructure of the foundation itself; *second,* to systematize and facilitate the teaching of fixed bridgework in accordance with the accepted principles of practice which govern their employment; and *third,* to formulate a law that embodies the principles which modern practice has approved, a law which will assist in teaching the proper selection of abutments, according to principle, for the support and retention of fixed bridgework, and one which will likewise, impose restrictions to the employment of those types of construction which are, from the standpoint of principle, indefensible.

"The *terminology* used in the classification is simply a correlation of terms selected from our nomenclature, that constant usage has rendered familiar, and which have been selected because they seem to be the most expressive of any terms available.

"Most writers of dentistry, in referring to teeth of certain position in the arch, have used the terms anterior teeth and posterior teeth as best calculated to convey the idea of the association between object and position, likewise anterior and posterior have been used as the most expressive terms in referring to bridge replacements that supply a missing tooth, or group of teeth, in either of these locations.

"Accordingly, then, fixed bridgework applied and confined within these limits may be divided into *anterior bridges* and *posterior bridges.*

"In referring to Plate 1 (page 807) illustrating possible fixed bridge replacements, it will be observed that the bridges represented as applicable to the various positions arrange themselves into well-defined groups that are characterized by the teeth chosen for abutments in connection with the tooth or teeth supplied. Accordingly, therefore, anterior bridges may be subdivided into a *central and lateral series* and a *central and cuspid series;* likewise, posterior bridges may be subdivided into a *cuspid and third molar series,* and a *first bicuspid and second molar series.*

SIMPLE BRIDGES

"A single bridge of any one of the above series may be said to form a *simple bridge.*

COMPOUND BRIDGES

"Any bridge that can be effected by connecting *unilaterally,* any one of the simple bridges forming either of the anterior series, with any one of the simple bridges forming either of the posterior series, may be said to form a *compound bridge.*

COMPLEX BRIDGES

"Any bridge that can be effected by connecting *bilaterally,* any one of the simple bridges forming either of the anterior series, with any one of the simple bridges forming either of the posterior series, may be said to form a *complex bridge.*

"To recapitulate, first, fixed bridgework may be divided according to extension, into simple, compound and complex bridges; second, simple bridges according to location, may be divided into anterior and posterior bridges; third, according to attachment and teeth supplied, simple anterior bridges may be subdivided into a central and lateral series, and a central and cuspid series; and simple posterior bridges may be subdivided into a cuspid and third molar series, and a first bicuspid and second molar series; and fourth, the simple bridges of the anterior series when joined unilaterally and bilaterally to the simple bridges of the posterior series, form compound and complex bridges respectively. The adjectives

Classification of FIXED BRIDGEWORK	Simple Bridges	Anterior	Central and Lateral Series
			Central and Cuspid Series
		Posterior	Cuspid and 3rd Molar Series
			1st Bicuspid and 2nd Molar Series
	Compound Bridges	Central and Lateral Series joined to Right or Left	Cuspid and 3rd Molar Series
			1st B. and 2nd M. Series
		Central and Cuspid Series joined to Right or Left	Cuspid and 3rd Molar Series
			1st B. and 2nd M. Series
	Complex Bridges	Central and Lateral Series connecting	R. and L. Cuspid and 3rd M. Series
			R. and L. 1st B. and 2nd M. Series
			R. Cuspid and 3rd M. Series with L. 1st B. and 2nd M. Series.
			L. Cuspid and 3rd M. Series with R. 1st B. and 2nd M. Series.
		Central and Cuspid Series connecting	R. and L. Cuspid and 3rd M. Series
			R. and L. 1st B. and 2nd M. Series
			R. Cuspid and 3rd M. Series with L. 1st B. and 2nd M. Series
			L. Cuspid and 3rd M. Series with R. 1st B. and 2nd M. Series

PLATE II

Fig. 782

upper and lower, right and left, are used as prefixes and complete the terminology.

"Again referring to Plate 1 (page 807), it will be noticed that all simple bridges are of comparatively straight alignment and have at least one support or attachment at each end; and furthermore, that all the simple bridges of the various series, in being joined or connected to form compound and complex bridges form extended bridges of curved alignment with one or more intervening piers or attachments.

"In view of this fact, therefore, it seems fitting and much more in accord with the scientific phase of this class of work, that a general law be adopted that will furnish a safe plan for teaching the application of all fixed bridgework in general, and which will serve the same purpose as the various rules that have been formulated from time to time to cover a comparatively small number of cases, more or less typical, all of which are fundamentally based upon the same principles.

PROPOSED LAW

"The *law proposed* is as follows: *All fixed bridgework of straight alignment should be attached to, or supported by, one or more abutments at each end, and should receive additional attachment and support from one or more intervening abutments or piers when of curved alignment.*

"In accordance to the classification and law proposed, the following definitions are derived.

SIMPLE BRIDGE DEFINED

"A *simple fixed bridge* may be *defined* as a bridge used to replace one or more teeth missing from the anterior or pos-

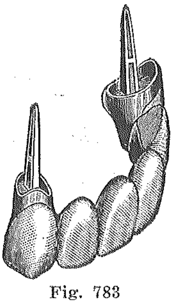


Fig. 783

terior positions of the arch, attached to or supported by at least one or more abutments at each end and is of comparatively straight alignment.

COMPOUND BRIDGE DEFINED

"A *compound bridge* may be *defined* as an extended bridge effected by a simple anterior bridge joined *unilaterally* to a

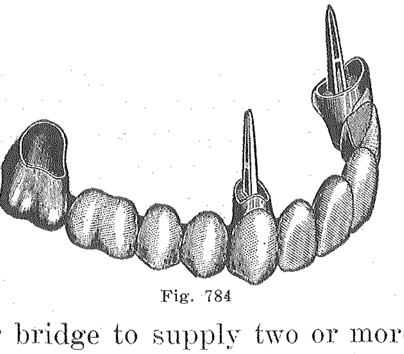


Fig. 784

simple posterior bridge to supply two or more missing teeth from the anterior and posterior portions of the arch, attached to or supported by one or more abutments at each end and one or more additional attachments or supports from one or more intervening abutments or piers, and is of curved alignment.

COMPLEX BRIDGE DEFINED

"A *complex fixed bridge* may be *defined* as an extended bridge effected by connecting a simple anterior bridge *bilaterally* with a simple posterior bridge to supply four or more missing teeth in the arch and is attached to or supported

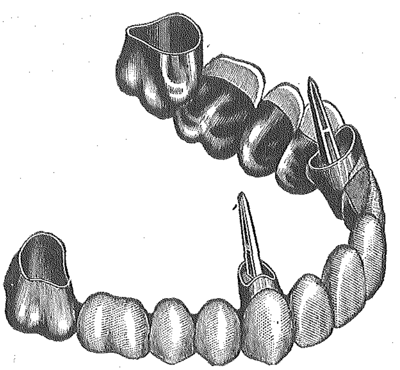


Fig. 785

by one or more abutments at each end and one or more additional attachments or supports from one or more intervening abutments or piers, and is of curved alignment.

Argument in Support of the Classification and Law Proposed

"In support of the proposed classification and in defense of the law which embodies the principles upon which the classification is largely based I wish to quote the following, taken from a former paper:

POSSIBLE MASTICATORY STRESS

" 'If the muscles of mastication are capable of exerting a stress of 275 pounds upon the first molars and if the supporting tissues of the first molars have been capable of developing a structure which will safely bear such a strain, it must be concluded that the development of the muscles and the supporting tissues of the teeth are co-incident and in accordance with physiological laws.

" 'It is also true that this muscular power is normally intended to be exerted within physiological directions, and that the supporting tissues of the teeth are developed and physiologically designed to receive and support this strain only when this muscular stress is transmitted to them in a normal direction and according to physiological principles.

"'The wonderful power that the muscles of mastication are capable of exerting, and the wonderful plan upon which Nature has constructed the human teeth in order to utilize this energy in the mastication of food, and the wonderful design of the tissues which support the teeth while performing these functions, all seem to be in perfect accord with the marvelous schemes of Nature. Yet, it must be remembered that this muscular energy is intended to be exerted only within certain limitations, bounded by the normal, and the design of the teeth renders them efficacious in performing their functions only when muscular energy propels them normally, and that the tissues which support the teeth while performing their functions are capable of yielding normal support only when the muscular stress of mastication is normally directed.

"'Therefore, it would not be in accordance with physiological laws to expect a first molar which, if normally capable of withstanding a stress of 275 pounds, and the supporting tissues normally capable of resisting the stress, to physiologically resist this stress if the direction of the stress be perverted, and the supporting tissues compelled to receive the stress contrary to the direction that they are normally designed to receive it.

"' Hence, it seems obvious that if fixed bridgework be constructed with occlusal and incisal masticating surfaces after Nature's plan and in accordance with physiological law governing normal articulation and occlusion, and if the stress as received by the abutments is normally directed, that such bridgework may be successfully attached to the roots of teeth without inviting pathological manifestations.'

"But, on the other hand, *if fixed bridgework be constructed without due regard for these principles, and the occlusal or incisal surface be so made as to abnormally direct the resultant force to the abutment teeth, or the employment of abutments be such as to subject them to stress perverted through leverage, then will the supporting tissues surrounding the root fail to render support, just in proportion as the stress is perverted and the supporting tissues are obliged to offer resistance in a direction which they were never intended to furnish.*

"Unquestionably, there are many fixed bridges outside the scope of this proposed law and classification which are apparently giving good service, and which, by reason of this apparent service, and their continued employment, have thus, seemingly, been sanctioned as good practice, nevertheless, the soundness of the principles underlying the proposed law cannot be questioned, neither can it be denied that these same bridges in question might have rendered a still greater service had they been effected more strictly in accordance with the principle involved.

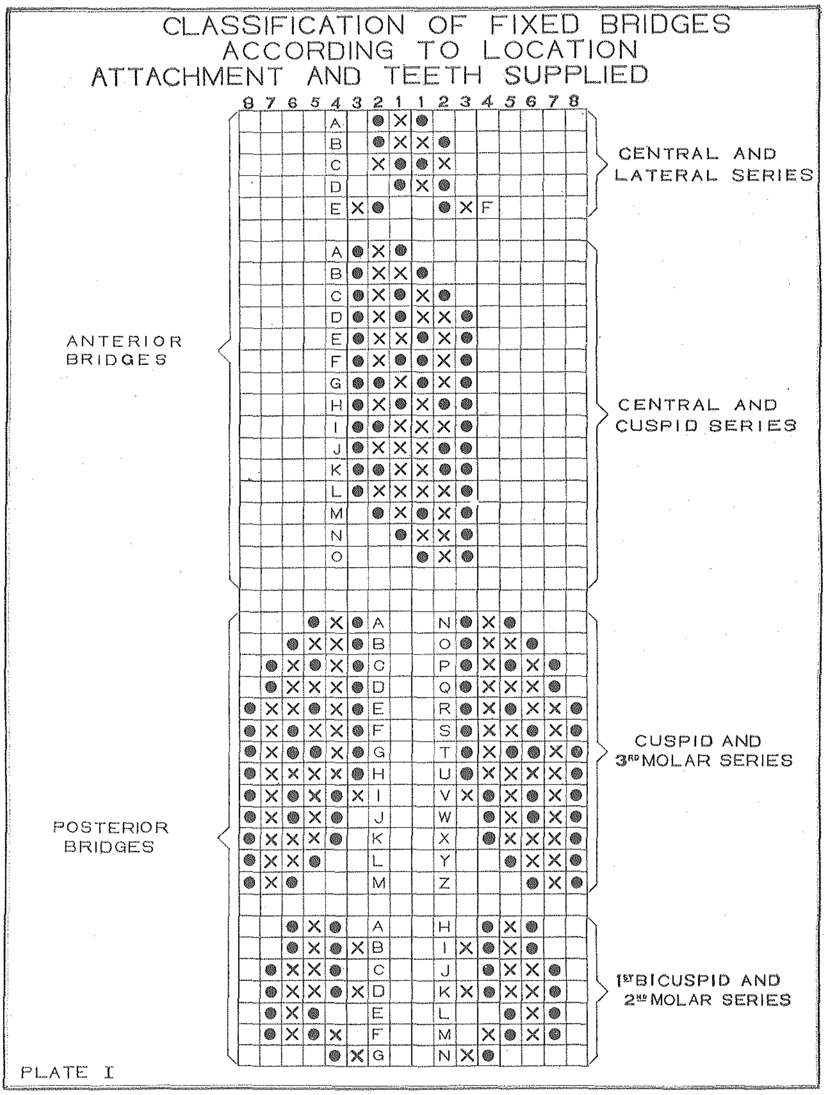


Fig. 786

"Showing series classification of simple bridges according to location, attachment and teeth supplied. The incompleted bridges E and F of the Central and Lateral Series, also G and N of the First Bicuspid and Second Molar Series, when joined, form simple bridges EG and FN, and are classified as anterior bridges and enumerated as belonging to the Central and Cuspid Series — both, however, retain their identity when used to form other combinations and are so enumerated as illustrated in charts 3, 4, 7, 8, 9, 10, 12, 13 and 14.

"The incompleted bridge C of the Central and Lateral Series is not classified as a simple bridge, but when joined bilaterally to the simple bridges of the posterior series it assists in the formation of complex bridges and is so enumerated as illustrated in charts 9 and 10. Likewise, incompleted bridges I and V of the Cuspid and Third Molar Series and B, D, F and I, K, M of the First Bicuspid and the Second Molar Series are not classified as simple bridges, but when joined unilaterally and bilaterally to the simple bridges of the anterior series they assist in the formation of compound and complex bridges and are so enumerated as illustrated in charts 3, 4, 7, 8, 9, 10, 11, 12, 13 and 14.

"The two groups of simple bridges comprising the two Anterior Series effect eight different combinations when joined unilaterally with the four groups of simple bridges comprising the two Posterior Series, thus forming eight groups of compound bridges. Likewise the two groups of simple bridges comprising the two Anterior Series, effect eight different combinations when joined bilaterally with the various groups of simple bridges which comprise the two Posterior Series, thus forming eight groups of complex bridges.

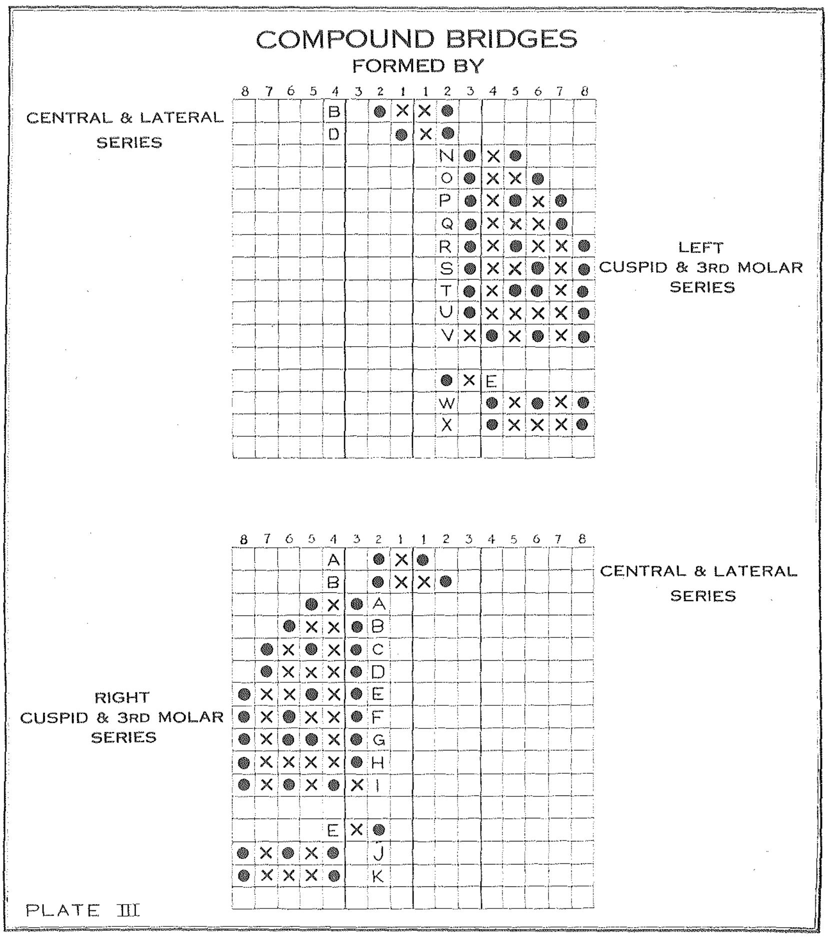


Fig. 787

"Showing bridges formed by Central and Lateral Series joined unilaterally to Left Cuspid and Third Molar Series also Central and Lateral Series joined unilaterally to Right Cuspid and Third Molar Series.

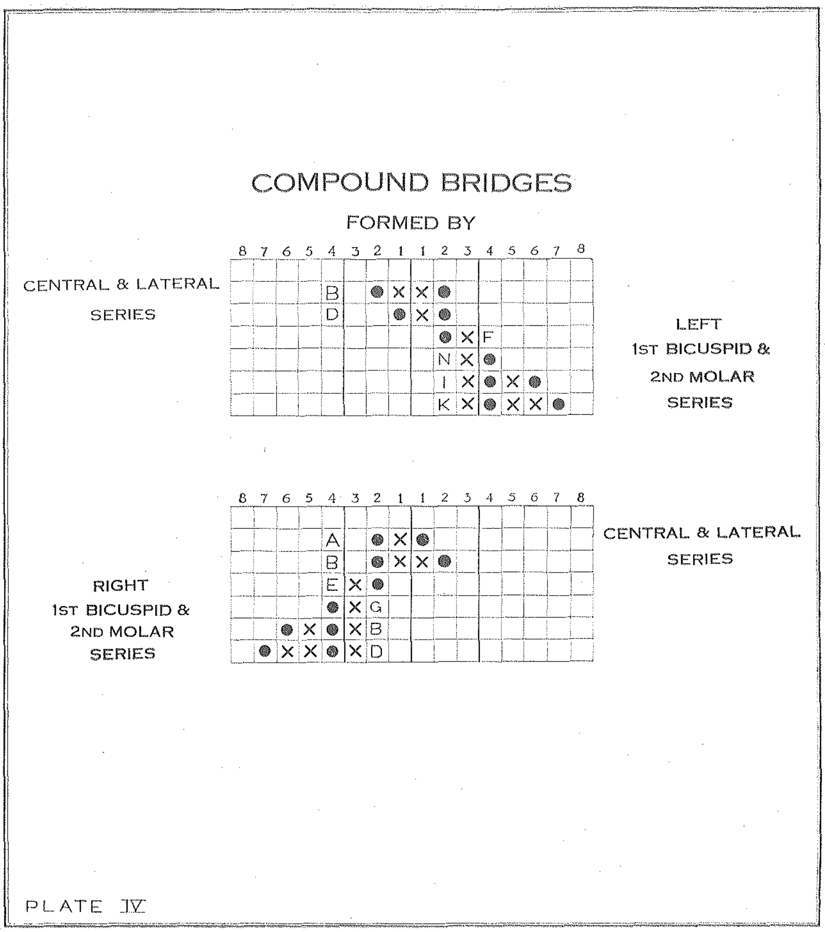


Fig. 788

"Showing compound bridges formed by Central and Lateral Series joined unilaterally with Left First Bicuspid and Second Molar Series; also Central and Lateral Series joined unilaterally to Right First Bicuspid and Second Molar Series.

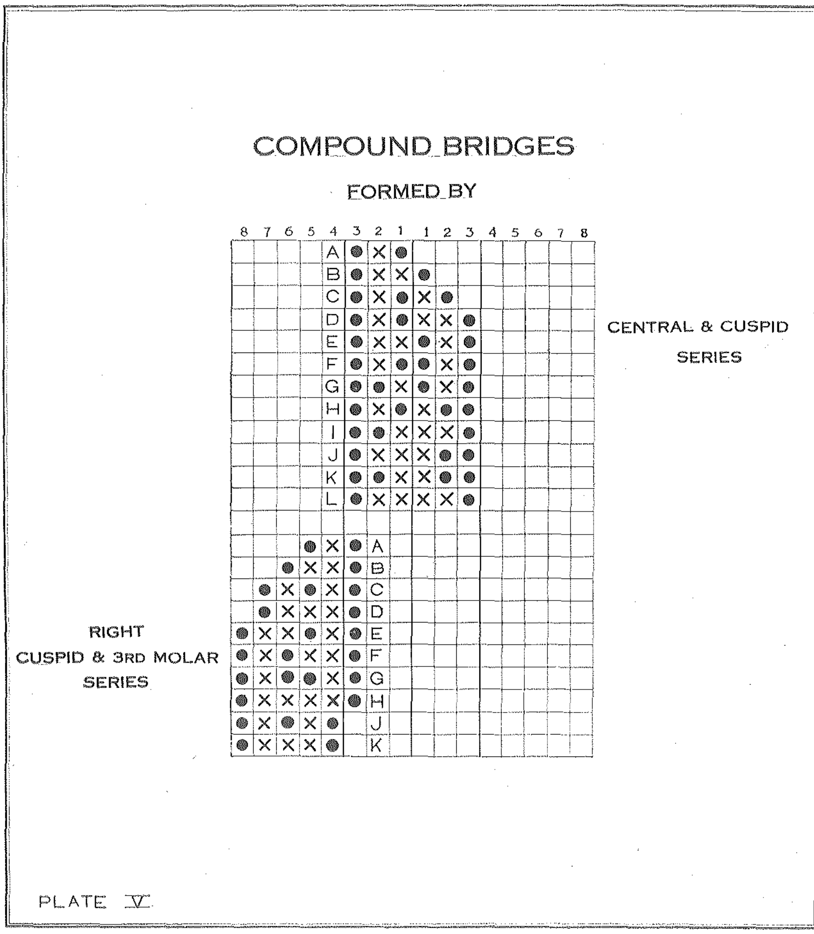


Fig. 789

"Showing compound bridges formed by Central and Cuspid Series joined unilaterally to Right Cuspid and Third Molar Series.

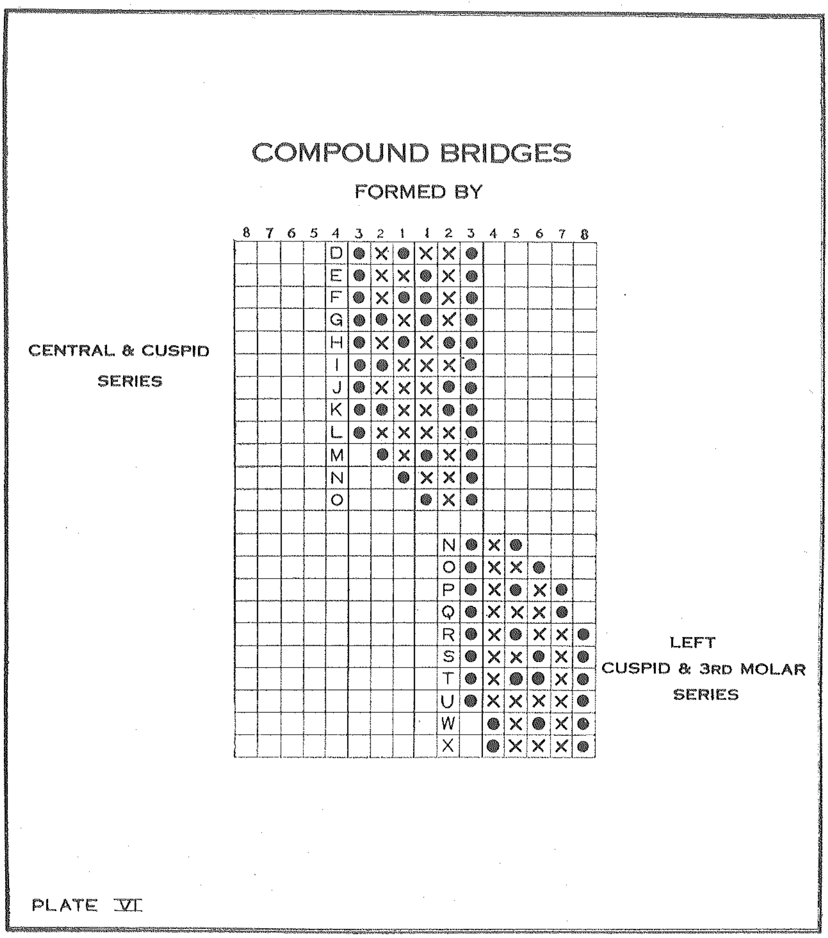


Fig. 790

"Showing compound bridges formed by Central and Cuspid Series joined unilaterally to Left Cuspid and Third Molar Series.

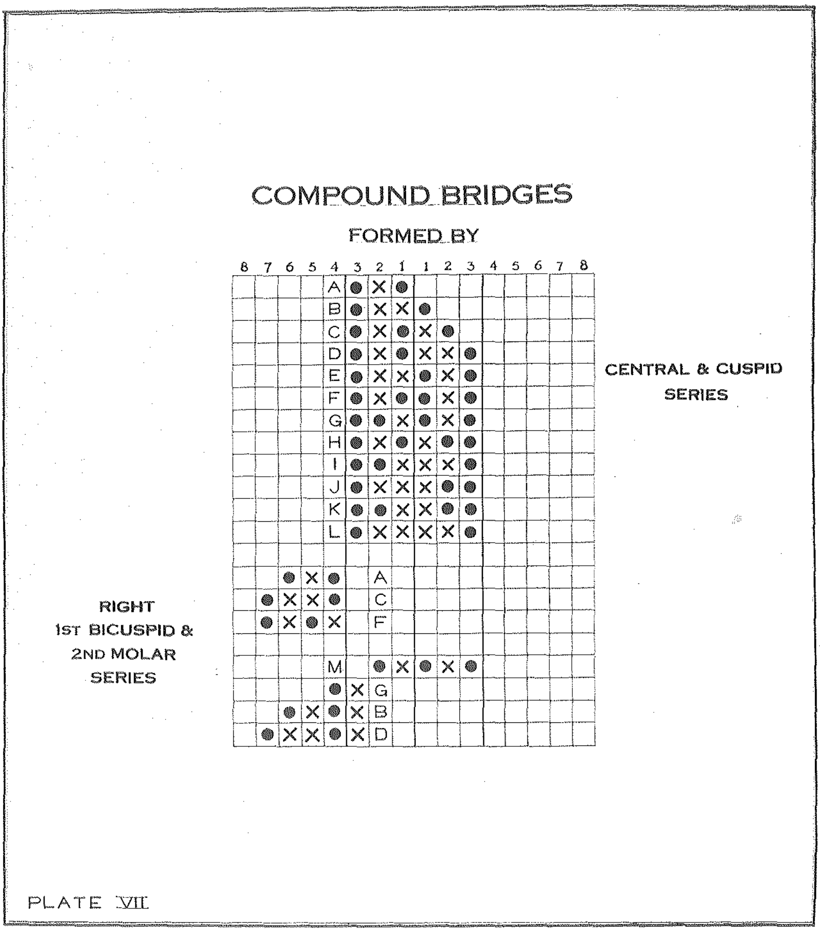


Fig. 791

"Showing compound bridges formed by Central and Cuspid Series joined unilaterally to Right First Bicuspid and Second Molar Series.

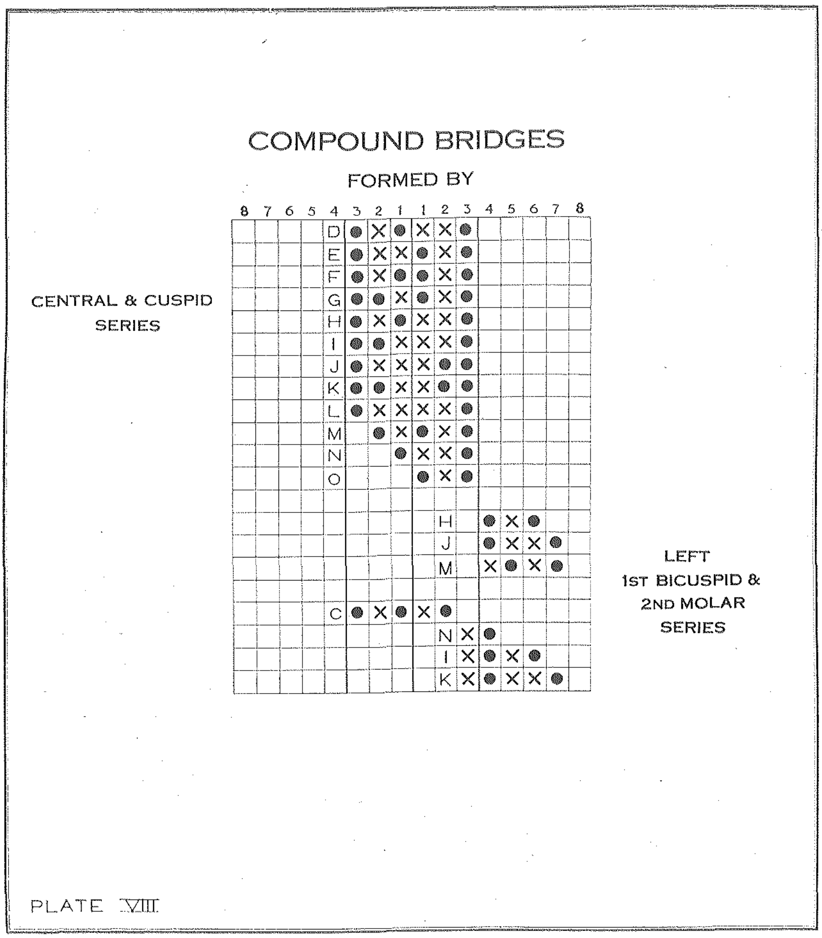


Fig. 792

"Showing compound bridges formed by Central and Cuspid Series joined unilaterally to Left First Bicuspid and Second Molar Series.

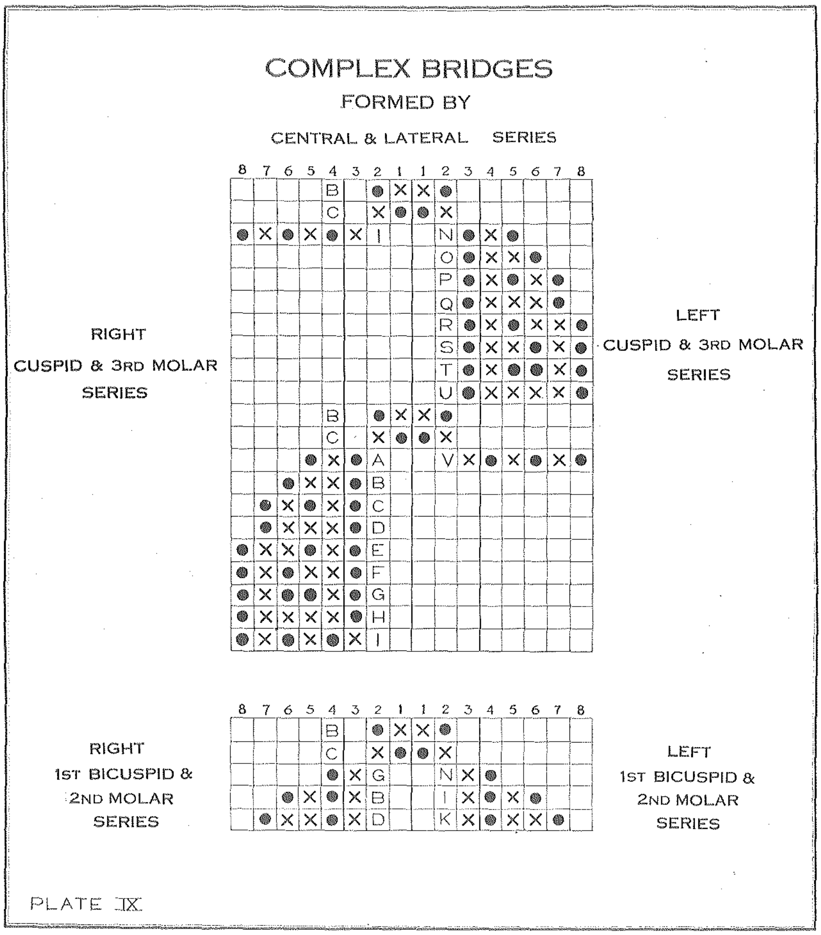


Fig. 793

"Showing complex bridges formed by Central and Lateral Series joined bilaterally to Right and Left Cuspid and Third Molar Series; also complex bridges formed by Central and Lateral Series joined bilaterally to Right and Left Bicuspid Series.

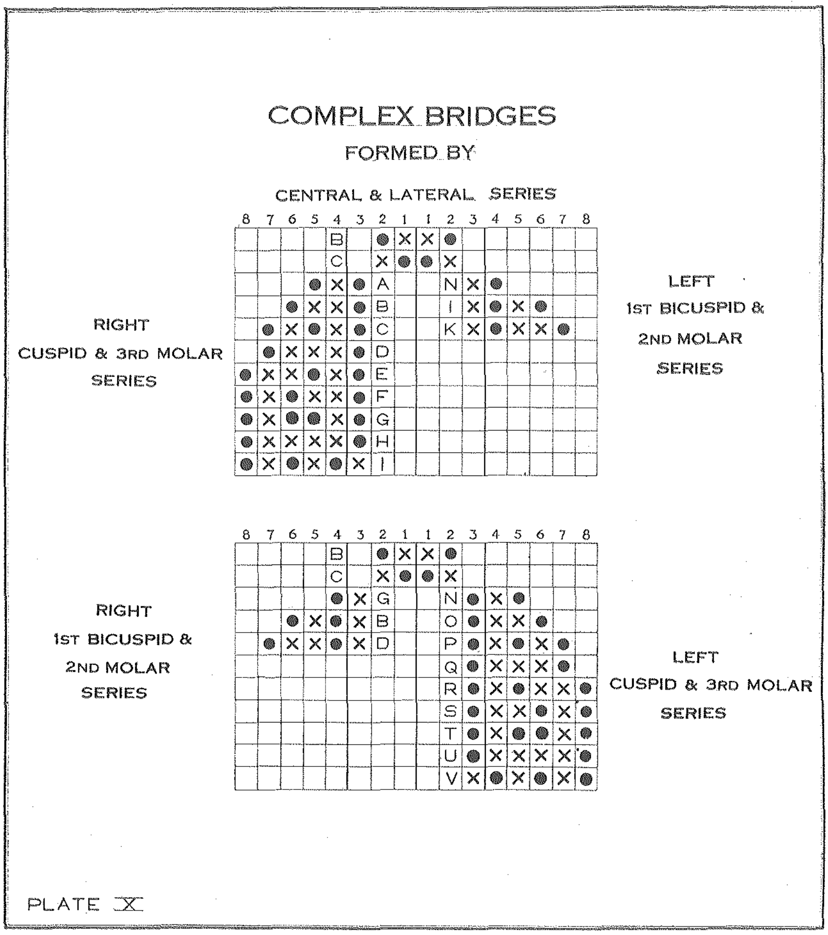


Fig. 794

"Showing complex bridges formed by Central and Lateral Series joined bilaterally to Right Cuspid and Third Molar Series and Left First Bicuspid and Second Molar Series. Also complex bridges formed by Central and Lateral Series joined bilaterally to Left Cuspid and Third Molar Series and Right First Bicuspid and Second Molar Series.

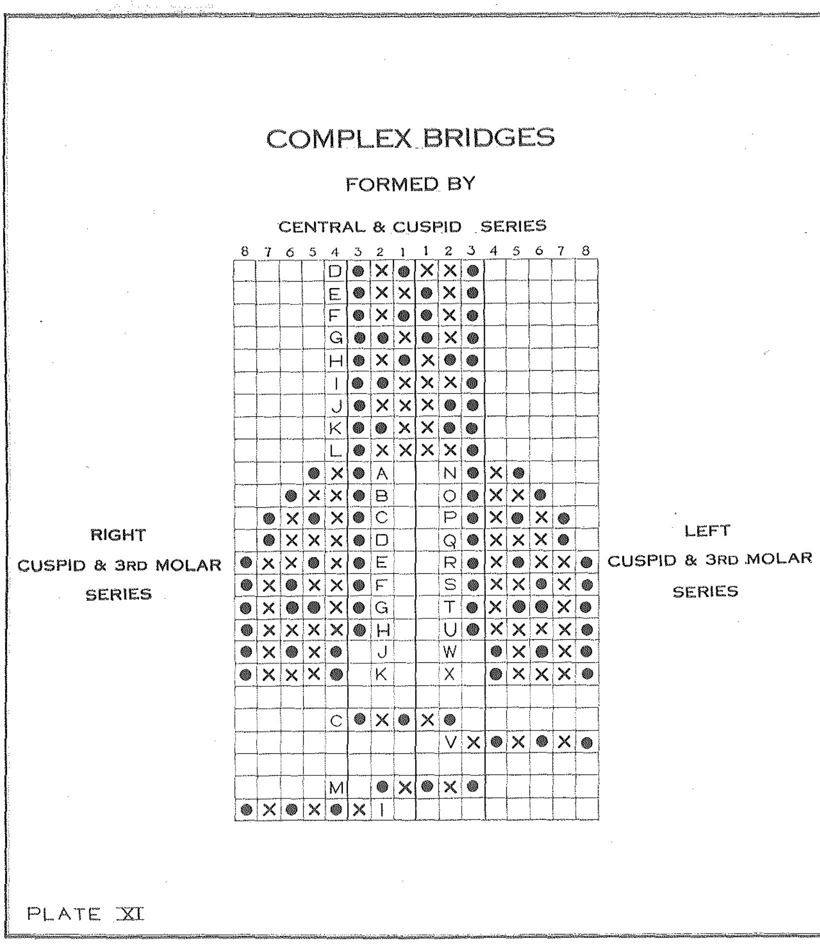


Fig. 795

"Showing complex bridges formed by Central and Cuspid Series joined bilaterally to Right and Left Cuspid and Third Molar Series.

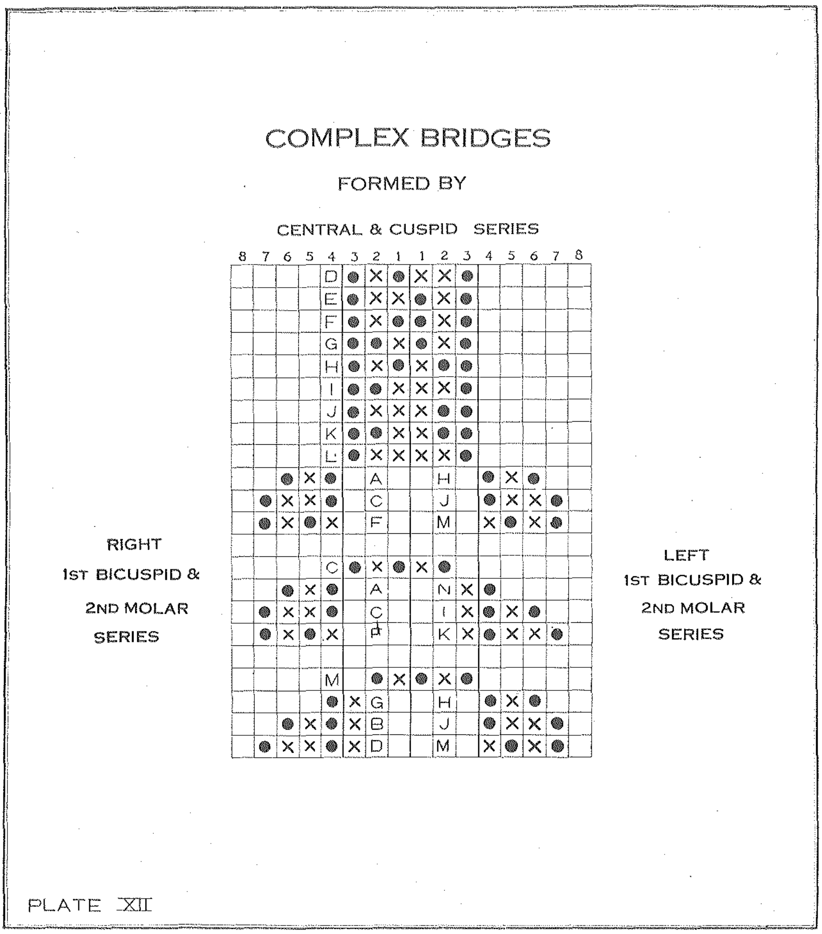


Fig. 796

"Showing complex bridges formed by Central and Cuspid Series joined bilaterally to Right and Left First Bicuspid and Second Molar Series.

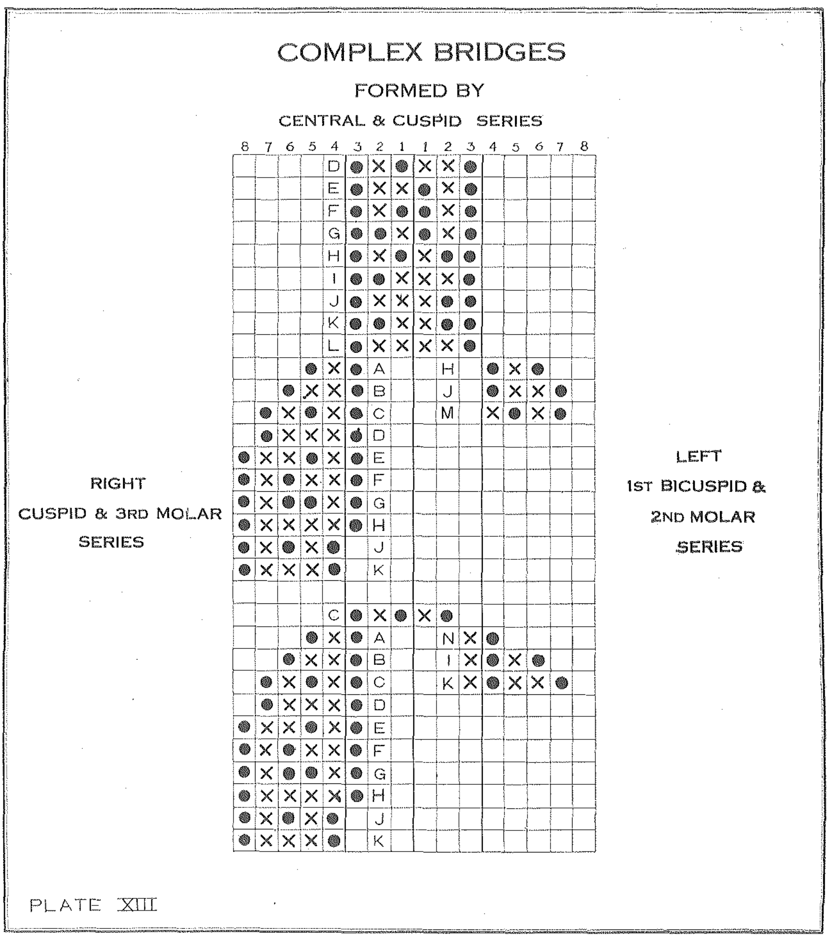


Fig. 797

"Showing complex bridges formed by Central and Cuspid Series joined bilaterally to Right Cuspid and Third Molar Series and Left First Bicuspid and Second Molar Series.

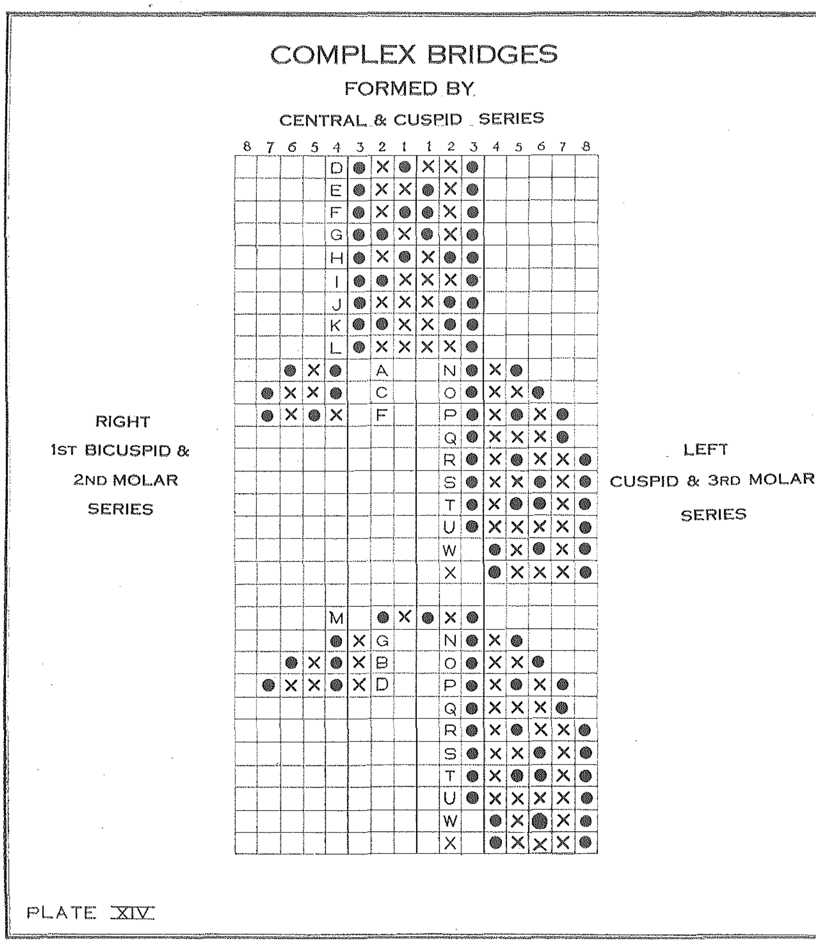


Fig. 798

"Showing complex bridges formed by Central and Cuspid Series joined bilaterally to Left Cuspid and Third Molar Series and Right First Bicuspid and Second Molar Series.

TOTAL NUMBER OF FIXED BRIDGES, UPPER & LOWER, ACCORDING TO SERIES CLASSIFICATION AND LAW GOVERNING THEIR APPLICATION.

SIMPLE BRIDGES		
Central and Lateral Series	6	
Central and Cuspid Series	34	
Cuspid and Third Molar Series	48	
1st Bicuspid and 2nd Molar Series	12	
		100
COMPOUND BRIDGES		
Central and Lateral Series joined to Cuspid and 3rd Molar Series	80	
Central and Lateral Series joined to 1st Bicuspid and Second Molar Series	36	
Central and Cuspid Series joined to Cuspid and 3rd Molar Series	480	
Central and Cuspid Series joined to 1st Bicuspid and 2nd Molar Series	156	
		752
COMPLEX BRIDGES		
Central and Lateral Series connecting Right and Left Cuspid and 3rd Molar Series	68	
Central and Lateral Series connecting Right and Left First Bicuspid and 2nd Molar Series	36	
Central and Lateral Series connecting Right Cuspid and 3rd Molar Series with Left 1st Bicuspid and 2nd Molar Series	108	
Central and Lateral Series connecting Left Cuspid and 3rd Molar Series with Right 1st Bicuspid and 2nd Molar Series	108	
Central and Cuspid Series connecting Right and Left Cuspid and 3rd Molar Series	1840	
Central and Cuspid Series connecting Right and Left 1st Bicuspid and 2nd Molar Series	198	
Central and Cuspid Seriés connecting Right Cuspid and 3rd Molar Series with Left 1st Bicuspid and 2nd Molar Series	600	
Central and Cuspid Series connecting Left Cuspid and 3rd Series with Right 1st Bicuspid and 2nd Molar Series	600	
		3558
Total number of combination		4410

PLATE XV

Fig. 799

"Showing the total number of fixed bridges upper and lower, according to proposed classification and law governing their application.

"While this classification will render no material assistance in teaching the requirements which are fundamental to teaching of fixed bridgework, and which should be regarded as essential regardless of the plan pursued, still it will, no doubt, prove of great help in teaching the principles of fixed bridgework and prove to be of still greater assistance in the teaching of methods.

"To illustrate: the classification recognizes three divisions of fixed bridgework, namely, simple, compound and complex. Therefore, if the student is taught the construction of each according to any one method, he will have been taught according to the classification, the construction of 4,410 possible bridge replacements.

"In a like manner the construction and application of all of the various methods may be taught, and by thus systematizing our efforts avoid the occasions for confusion."

Application of Fixed Bridgework

Success in the field of fixed bridgework, to a very large extent, is dependent upon the correct application and construction of full and partial crowns to the roots, or remaining portions of crowns of natural teeth which, by reason of their position, have been selected to serve as abutment and pier supports for the completed truss or superstructure.

The same general requirements governing the successful application of crowns to individual roots or teeth apply with equal force to those employed as supports for a bridge.

In addition to this, certain hygienic requirements must be observed in bridge construction, in the application of dummies or substitutes for the lost natural teeth, to so form and assemble them that not only the tissues upon which they rest, or approximate, but those around the adjacent crowns may be maintained in a condition of health.

The union of a dummy with a crown in such manner as to form a constricted space or pocket, difficult of access to cleansing appliances, is one of the common causes of failure in fixed bridgework.

Therefore, gingival interproximate spaces, and particularly the embrasures between crowns and dummies, should be left as free and open as is consistent with esthetics, and the required strength of the structure.

A dummy fitted with an individual saddle which rests with firmness upon the border is, in many cases, preferable to a dummy applied to the labial or buccal surface of the border in such manner as to form a deep, constricted, V-shaped space between the two. A ligature passed under the saddle will remove debris from both structure and border, while neither ligature nor toothbrush will prove efficient in the V-shaped space.

Since the function of an individual saddle is not to afford support to a fixed bridge, but to develop reasonable lingual contour to the dummy to which attached, its bearing on the tissues should be restricted to the smallest possible area consistent with desired contour.

By means of the preceding "Classification of Fixed Bridges" it can be shown that it is possible to construct more than fifty-four thousand different varieties of fixed bridges. To attempt to explain in detail the technical methods employed in the construction of each would be a well-nigh impossible task, and entirely uncalled for in a treatise of this character. Fundamental principles for all, however, are essentially the same, therefore, when the student has mastered these principles, which are comparatively few, he should be capable of undertaking the construction of ordinary, as well as complicated, cases.

TECHNIC OF BRIDGE CONSTRUCTION

By way of illustrating some of the preceding principles outlined, the technical procedures involved in the construction of a simple, fixed bridge, extending from right lower cuspid to second molar, inclusive, the second bicuspid present to serve as a pier, will now be described.

In examining the mouth and noting the relation of the teeth to each other in this particular case, it is deemed advisable to place on the abutment and pier teeth the following crowns:

Cuspid root, porcelain face, banded crown.

Second bicuspid and second molar roots, shell crowns, because of restricted space occluso-gingivally.

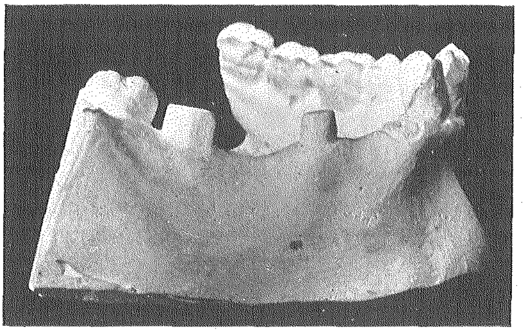


Fig. 800.— Teeth Prepared for Reception of Five-Tooth Bridge

It is further assumed that the teeth have been devitalized and their roots filled, if such procedure is considered advisable.

The enamel is removed from the axial surfaces of the three roots, as previously described for crowns of the types indicated.

In addition to reversing the cone form of the roots, their mesial and distal, axial surfaces must not diverge, but rather converge, from gingival to occlusal surfaces. The necessity for establishing this relation is obvious, since divergence of these surfaces will prevent the removal of the several crowns with the impression, or the return of the finished bridge to place.

The line of direction of the canal of the cuspid root must also be considered. When not in parallel alignment with the axial surfaces of the bicuspid and molar, a like difficulty will be encountered as that mentioned. Since, however, reaming the canal to any extent will weaken the root, in order to establish parallel relationship, it is a better plan to bring such axial surfaces of the bicuspid and molar as diverge from the general direction of the root canal into alignment with it rather than ream the canal to the extent of weakening it.

In practically all other respects, the preparation of the three roots is essentially the same as has been previously outlined for crowns of similar types as those used in the present case.

When root preparation has been completed, the crowns are constructed individually, keeping in mind their correct alignment buccally and the reservation of proportionate spaces for the first bicuspid and first molar dummies.

The crowns are roughly finished, set on their respective roots, a wax bite taken, the face bow applied, the bite mounted on the occluding frame and the occlusion cast developed.

If, in taking the bite, the crowns are disturbed, they are returned to position on their respective roots and a plaster impression secured. Usually, in such case as is being described, the impression can be removed without fracture, the crowns coming away with it. When fractured, however, the broken pieces are assembled, the crowns set in their respective matrices, and all luted firmly with wax.

The object in taking a bite and an impression as well, instead of an impression-bite combined, in modeling compound, as is frequently done, is to secure an accurate relation of the crowns to each other. While it is possible, in some cases, to remove the crowns from their respective roots without changing their relation to each other with a combined bite and impression in modeling compound, disturbance of relation is liable to occur, and therefore plaster should always be used in preference to a material which is liable to distort under stress.

From the impression, a cast is formed which, when hardened, is fitted in the bite and attached to the occluding frame.

By flowing a film of wax in the interior of the shell crowns and in the cap and around the dowel of the cuspid crown, before filling the impression, the bridge, when assembled and waxed together, can readily be removed from its cast without mutilating the latter. The wax within the crowns should be thoroughly removed before investment of the bridge.

REQUIREMENTS OF THE DUMMIES

For esthetic reasons, the first bicuspid dummy should be of porcelain, or at least be porcelain-faced. When considerable absorption of the alveolar border has occurred and the cervical half of the dummy will not be exposed to view in laughing or speaking, a space may be left between this end of the dummy and the ridge for hygienic reasons.

The application of a short dummy in such location leaves the gingival tissues next the crowns which proximate the space, more or less exposed and accessible to the toothbrush and other cleansing devices.

In case it is deemed advisable to extend the dummy to the alveolar border, or saddle the latter, as is frequently done, it should be uniformly reduced on its proximal surfaces, so as to leave the interproximate spaces in the gingival half areas free and accessible for cleansing purposes.

Too often the union between crowns and dummies extends from the occlusal points of contact to the gingivæ, thus precluding the possibility of proper cleansing of the tissues and appliance.

CONSTRUCTION OF THE BICUSPID DUMMY

A dummy may be constructed by any of the several methods outlined, using facings or teeth of the removable type, or a long pin, plate tooth may be employed.

By this latter method a facing of suitable form and color is selected to fit within the space between the cuspid and second bicuspid crowns.

Reduce the mesial and distal surfaces so as to taper somewhat from occlusal to gingival.

Bevel the buccal marginal ridge, or that portion of the facing which corresponds to the incisal edge of an anterior tooth, to allow for an extension of backing to the buccal margin for protection from stress.

The cervical end of the dummy may be finished in three ways:

First, it may simply be rounded and swing clear of the border, so as to leave a self-cleansing space between the border and the structure.

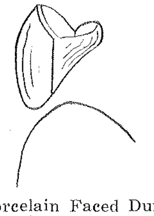


Fig. 801.— Porcelain Faced Dummy Formed with Cervical Clearance Space

Second, it may be adapted by grinding to lay in close contact with the border at its cervico-buccal margin, with more or less of a V-shaped space, opening lingually.

Fig. 802.— Porcelain Faced Dummy Which Rests on Buccal Surface of the Border

Third, a saddle may be adapted to the cervical end, which, when closely fitted to the border, permits the lingual contour of the dummy to be developed, and obviates the formation of the objectionable space referred to.

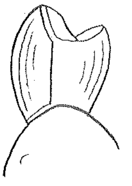


Fig. 803.— Porcelain Faced Dummy with Saddle Which Rests Upon the Border

The type of dummy suitable for each individual case can be determined by setting the facing or crown in correct buccal alignment with the proximating crowns and noting the relation of its cervical end to the border.

In this case, a dummy, to which a saddle is applied, will be considered the most appropriate.

The facing should be ground at its cervical end to fit the inequalities of the border, and its buccal marginal ridge beveled as previously described.

A backing is now applied to its lingual surface, extending from the ridge lap to, or slightly beyond, the bucco-occlusal margin. When the ridge lap of the porcelain does not fit closely to the border except at its cervico-buccal margin, the backing should extend buccally, so as to cover it, usually slightly beyond the cervico-buccal margin.

A piece of thin, pure gold or platinum is burnished to the border, immediately on the area on which the dummy will rest, and is trimmed to the approximate outline of the dummy base.

The facing to which the backing is attached is set in correct alignment with the proximating teeth on the saddle, and the two are attached with wax.

Sufficient bulk of wax is now added, in which the occlusal surface of the dummy can be carved.

When carved to desired form, a counterdie can be constructed by the indirect method by casting over moldine as described.

Develop the cusp by swaging in the usual manner. Trim peripherally, soften the wax and adapt to the dummy, return the latter to the cast and by trimming and adjustment develop correct occlusal relation.

Remove the dummy from the cast and wax to the desired axial form.

The facing is now removed from the assembled dummy, carbon points are inserted in the holes left by the withdrawal of the pins and the dummy, minus the facing, is invested in a casting ring, and the operation completed by the casting process.

By using a heavier gauge of metal for the saddle, to prevent warpage or contraction in fusing the metal, the lingual contour of the case can be developed by soldering.

When this plan is followed the mesial and distal margins of the saddle should project slightly beyond the wax so as to be caught in the investment.

After the metal structure is completed, the carbon points are drilled out and the facing fitted ready for cementation in position, after the bridge is completed. The pins of the facing should, in all cases, be roughened before cementation to afford maximum anchorage in the cement.

The dummy is now rough dressed to the desired form, returned to place between cuspid and second bicuspid crown and waxed in position.

VARIATIONS IN THE FORMS OF DUMMIES

Various other forms of dummies can be applied with equal facility to the case under consideration. For example, a Steele, or an Evslin facing, or a partial crown of either type, may be used. Again, a Goslee or a Gardiner partial crown is equally applicable, either with or without a saddle, providing sufficient space exists to permit the introduction of a rigid metal structure beneath.

CONSTRUCTING THE MOLAR DUMMY

To illustrate still another type of dummy frequently used, the technic of an all metal replacement for the first molar will be described.

A mass of casting wax is warmed and pressed into the space between second bicuspid and second molar, and the occlusion developed in the usual manner.

The gingival half of the block of wax is excised, the occlusal portion being carved to correct peripheral outline.

Since the object in applying a dummy of this type is to gain space for cleansing purposes, the buccal and lingual surfaces of the dummy should be rounded inward, so as to form

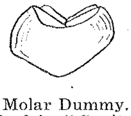


Fig. 804.—All Metal Molar Dummy. A Type of Dummy Frequently Used in "Sanitary Bridges"

a convex, or even V-shape, to the surface which looks toward the border. By avoiding the formation of a flat or a slightly convex surface to this portion of the dummy, practically all parts are rendered accessible to the toothbrush and cleansing appliances.

When carved to correct outline form, the wax is removed, invested and cast in the usual manner.

Another method whereby practically the same form of dummy may be produced is by carving the cusp in some suitable medium, developing a counterdie and swaging the occlusal surface and occlusal third periphery from gold plate in the counterdie.

This is trimmed to proper depth, the border margins contoured inward slightly with pliers, the interior of the partial crown filled in with plate scrap, building it high in the form of a mesio-distal ridge, and filling in the voids with solder to the required contour.

After developing the dummy, by whatever method employed, it is rough finished, and fitted in position between the second bicuspid and second molar crowns.

ASSEMBLING THE BRIDGE

Before the final waxing of the several parts of the bridge, the dummies are laid aside, the three crowns warmed sufficiently to soften the film of interior wax, and removed from the cast. By observing care in removal, their cervical matrices on the cast will not be appreciably disturbed. The wax is cleared from the interior of the crowns, after which they should be boiled in acid, washed thoroughly, and returned to position on the cast. A little sticky wax, applied at two or three points along the gingival margins, will hold them firmly in position while assembling the bridge.

The dummies are now adjusted and luted firmly with hard, sticky wax, applying it in sufficient quantity to firmly unite them to the crowns.

Before final removal from the cast, the occlusions should be tested, the general alignment of the crowns and dummies noted and the assembled bridge, as a whole, inspected, to see that every part is in exact relation.

In grinding and adjusting porcelain facings in a bridge, special care should be taken that a very slight space exists between them, or between the porcelain and proximating metal crowns. The metal backings of the facings, however, should, whenever possible, rest in close contact with each other and with adjacent metal crowns.

This is necessary, in order that shortening of the bridge may not occur as a result of contraction of both investment and solder, as the latter cools.

On removal of the bridge from the cast the joints between the several dummies should be flushed with wax to prevent the ingress of the investment material, the result of which is to exclude the solder, and thus weaken the union between the several parts of the structure.

Finally the cuspid facing is removed from the crown and laid aside until after the several parts are soldered, when it is returned to position and permanently set with cement.

INVESTING THE BRIDGE

A mix of medium consistency of some thoroughly tested investment material should be made. This is placed on a slab or piece of paper on the bench, building it up to one inch or slightly more in thickness, approximately the same width, and somewhat longer than the bridge.

With the point of a small instrument some of the investment is carefully applied to the interior of the cap of the cuspid crown, in the pin holes left by removal of the facing, and in the two shell crowns as well.

The bridge is now laid, buccal side down, on the investment, into which it is gradually settled, to within about one-half inch of the bottom of the mass. If pressed too deeply, the investment, when trimmed, will be weak and is very liable to fracture during soldering.

When hardened, the surplus investment is trimmed away, being specially careful to clear away all obstructions from around the teeth and dummies which might interfere with the direct application of the flame to the solder in the various joints.

The wax is removed, first by picking out the bulky portion, and afterward applying boiling water for the removal of that in the deepest parts.

A thin film of thick borax paste is applied to all parts on which it is desired that the solder should flow, and the investment placed on a gauze over the Bunsen flame.

When heated to a dull red heat along the base of the investment, the case is transferred to the soldering block, the blow-pipe flame applied and strip solder fused and fed into the lingual surfaces and embrasures until the required contour is attained.

FINISHING

The finishing of a bridge of this type is similar to that of a single crown. In bridgework, however, particular care should be taken to finish the metal smoothly in the interproximal spaces. Rough surfaces in any location invite the lodgment of food. Therefore, all file marks should be removed with fine discs, and the finer scratches left by these removed by coarse, followed by fine polishing powders, with felt and brush wheels, on the lathe.

SETTING THE BRIDGE

The bridge when finished is adjusted in position on the natural roots to test its correctness of form, and probable fulfillment of function, after which it is washed, dried, and laid aside while the mouth is prepared for its reception.

The mouth should be syringed with warm normal salt solution, cotton rolls applied to dam against the encroachment of moisture, and the teeth and roots thoroughly dried.

From a thoroughly mixed mass of medium thin cement, the shell crowns are partially filled and some applied around the dowel and on the root cap. The root canal is also filled, using for this purpose a small plugger point, or the regular root canal plugger.

The bridge is now quickly set in position and forced to place with heavy, steady pressure, and the patient instructed to close the teeth with force. If occlusion is correct, the

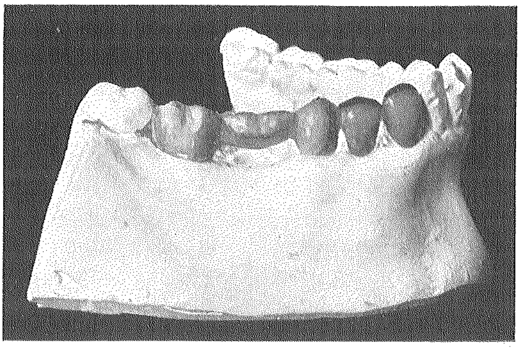


Fig. 805.— Bridge in Position on Cast, Showing Considerable Interproximal Space to the Mesial and Distal of First Bicuspid Dummy

mouth is opened and the parts guarded from moisture until the cement has had time to become fairly hard.

Removing the excess cement requires care and close attention not only from beneath the gingival, but from the various surfaces of the structure against which it may have become lodged. If not removed at this time it may remain adherent for a long time, particularly in protected locations, as in the interproximal spaces, where, although it may not prove a direct irritant, will invite the accumulation of food.

Finally the bridge is tested with carbon paper to disclose any points of interference in lateral mandibular movements. If any are present they are reduced with stones and the roughened surfaces again polished.

The Carmichael Attachment

An attachment often applied to good advantage in fixed bridgework is that known as the *"Staple Half Crown,"* "Carmichael Attachment," and under various other names.

This attachment is in reality a shallow inlay, covering a considerable area of tooth surface from which the enamel and a superficial layer of denture has been removed.

Anchorage of the attachment to the tooth is secured by means of interior, peripheral ribs in the metal structure, formed during constructing, which fit within corresponding grooves in the prepared tooth surface or shallow cavity.

The particular advantages of this attachment, when properly constructed and applied, are as follows:

First, it can be applied to the lingual surface of a vital tooth without endangering the pulp.

Second, a secure attachment to the tooth can be developed without involving much of the labial or buccal surface.

Third, the joint between the attachment and cavo-surface angles is the same as in ordinary inlay work, or gold foil fillings, thus obviating the formation of a shoulder, which, in many cases, particularly in constricted locations, invites the lodgment of food and, subsequently, caries.

Attachments of this type are most applicable to cuspid teeth, although they may at times be applied to central incisors. When slightly modified they may be applied to very great advantage to the bicuspids.

The name *Staple Half Crown* was given this attachment because formerly an iridio-platinum wire staple was applied in the groove in the tooth, a gold or platinum matrix adapted to the tooth and staple and the two attached. The staple thus formed the interior rib alluded to.

Construction

To illustrate the constructive steps, the application of a Carmichael attachment to a cuspid tooth will be described:

With suitable stones and discs the plate of enamel is removed from the entire lingual and proximal surfaces of the tooth, except at the cervical periphery, and the incisal edge beveled at the expense of the lingual surface.

Usually, for subsequent protection of the tooth, removal of enamel on proximal surfaces is carried slightly to the labial of the contact points.

A gingival shoulder is formed by means of square-end burs. This should be carried either under the free gum margin, or terminated a short distance to the incisal of it, to avoid the formation of a joint at the margin.

With a fissure bur, grooves are cut on the proximal surfaces, next the labial plate of enamel, from gingival seat to incisal edge, converging slightly, incisally.

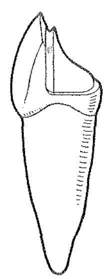


Fig. 806.— Proximal View of Cuspid Prepared for a Carmichael Attachment

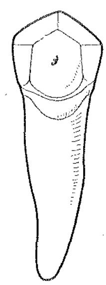


Fig. 807.— Lingual View of Same

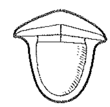


Fig. 808.— Incisal View of Same

These grooves are united by another transverse groove located as close to the incisal edge as possible in order to develop anchorage for the resistance of labio-lingual, torsional strain.

All surfaces, margins and grooves should be so correlated that, when formed, removal of the wax model may be accomplished without distortion.

This requires that all overhanging or rough margins and surfaces be smoothed and all undercuts obliterated before forming the model.

A modeling compound impression enclosed within a band or half thimble cup is secured, of surfaces and margins of the tooth involved.

From this an amalgam, or a modelite, die is developed, which, when hardened, is smoothed, and on this the pattern is developed in inlay wax.

The wax should be forced into all grooves and against all cavity surfaces, particular care being taken to adapt it closely to the margins and against the beveled incisal edge. It is then carved to restore the tooth to its original form.

Usually it is best to test the wax model on the natural tooth to see that it fulfills requirement, when, if found satisfactory, it is invested and cast, preferably in a good grade of platinized gold.

FINISHING

When cast, it is washed, heated and dropped in acid, the nodular surfaces corrected, after which it is fitted to the tooth and the margins disced to coincide with the tooth surfaces.

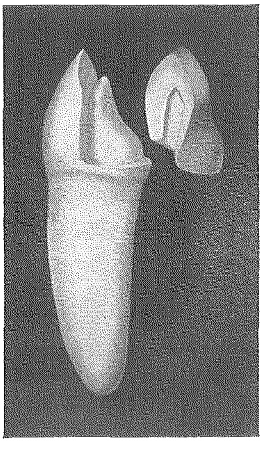


Fig. 809.— Carmichael Completed, Ready for Attachment to Bridge

When the other abutment and pier structures are completed, all are placed in position, an impression and bite secured and the Carmichael attachment is treated in the same manner as a full crown.

MODIFIED TECHNIC

Another method of construction consists in applying a piece of 34 or 36 gauge gold or platinum to the die, and by burnishing, form a matrix which fits accurately within grooves and against the reduced surfaces of the tooth.

When perfectly adapted and trimmed to correct peripheral outline, sticky wax is flowed over the lingual side of the matrix to prevent distortion, after which the latter is removed, invested, the wax burned off and high-grade solder flowed on the gold to develop required lingual contour.

Still another method consists in applying inlay wax to the burnished matrix, developing the wax to correct form, investing and casting against the matrix. By this method the surfaces which rest against the tooth are free from nodular imperfections, resulting from casting the entire appliance.

MODIFIED CARMICHAEL APPLIED TO CUSPIDS AND BICUSPIDS

An application of the Carmichael attachment applied to cuspids and bicuspids, suggested by Dr. E. Kennedy, is as follows:

The enamel and a layer of dentin is removed from a portion of the lingual, proximal, and labial or buccal surfaces of the tooth, extending from incisal, or occlusal, to gingival areas. In bicuspids, an occlusal step, having a decided dove-

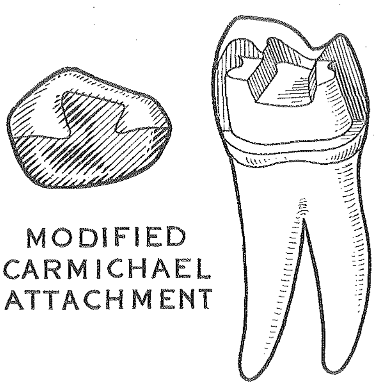


Fig. 810.— Modified Carmichael in, and Removed from, Position

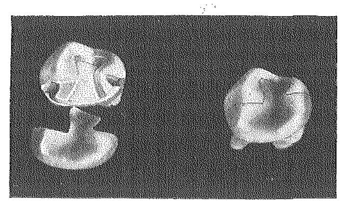


Fig. 811.— Preparation for Modified Carmichael in Bicuspid

tail shape, is formed, while the gingival area terminates in a right-angle shoulder.

The axial surfaces of the tooth should present a slightly conical form to permit the removal of the wax pattern.

Grooves are now cut in the lingual and labial, or buccal, axial surfaces in the dentin, for anchorage purposes. The process of forming the wax pattern, casting, fitting and finishing is the same as described in the construction of a Carmichael attachment.

This attachment can be applied to vital teeth and, when properly constructed, affords an anchorage for small bridges equal to that of the average crown.

The Corcoran Attachment

The Corcoran attachment is applied to abutment crowns in those cases where it is desirable that a bridge of the fixed type be removed from time to time for cleansing, or for treatment of the supporting teeth and adjacent tissues.

This attachment consists of a gold block, threaded internally, and which receives a threaded bushing. The bushing also is threaded to receive a headed screw, by means of which the crown is anchored.

In case of wear, both bushing and screw may be replaced with new ones, the parts being interchangeable.

CONSTRUCTION

The root is prepared as previously described, with distinctly conical periphery, and having an interior shoulder.

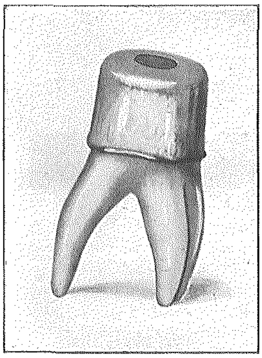


Fig. 812.— Impression Cup as Applied in Taking Modeling Compound Impression of Root Face and Periphery of Molar Tooth

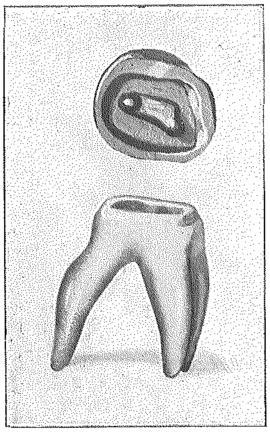


Fig. 813.— Impression Removed

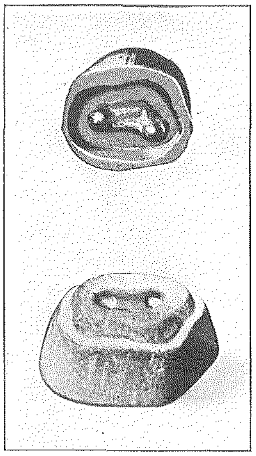


Fig. 814.— Impression Removed from Amalgam Die

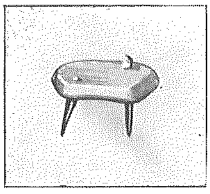


Fig. 815.— Root Cap Constructed

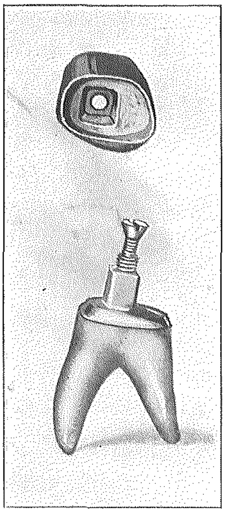


Fig. 816.— Corcoran Attachment, Showing Completed Crown, Block Attached to Root Cap, with Bushing and Screw in Position, But Not Screwed to Place

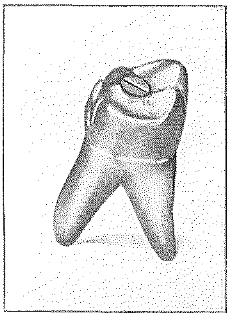


Fig. 817.— Crown in Position on Root

An open band impression is secured in modeling compound, from which an amalgam die is formed.

Over this die a root cap is swaged, through which dowels are passed and attached with high-grade solder.

The central shoulder depression should be filled at the same time, and the cap stiffened by flowing solder over its entire area.

A Corcoran block is now set in position on the cap and attached to the latter with a lower fusing solder than that previously applied.

The sides of the block should be parallel with the long axis of the tooth, or the line of direction of introduction and removal of the bridge.

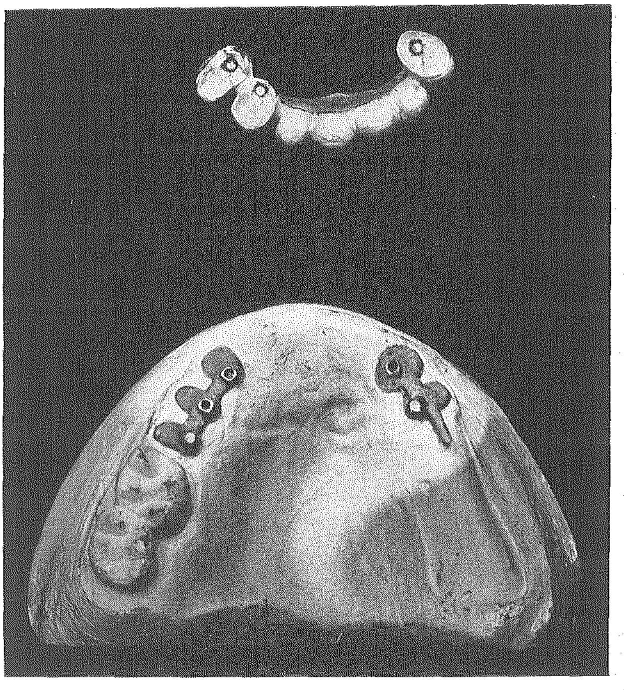


Fig. 818.— A Bridge Anchored by the Corcoran Attachments Removed From Its Multiple Anchorage, Which, In This Case, Consists of Five Roots, Three of Which Carry Blocks

A solid metal crown can be formed on the root cap and around the Corcoran block by applying and carving inlay wax to the desired form and casting.

A countersunk opening, directly in line with that in the block, made through the occlusal surface of the crown, receives the headed screw which anchors the crown to the root cap.

By setting the block somewhat to the lingual, a porcelain-faced crown can be constructed in the usual manner.

To obviate the tediousness of final fitting of the crown to the block, which in all cases must be done in cast work, a

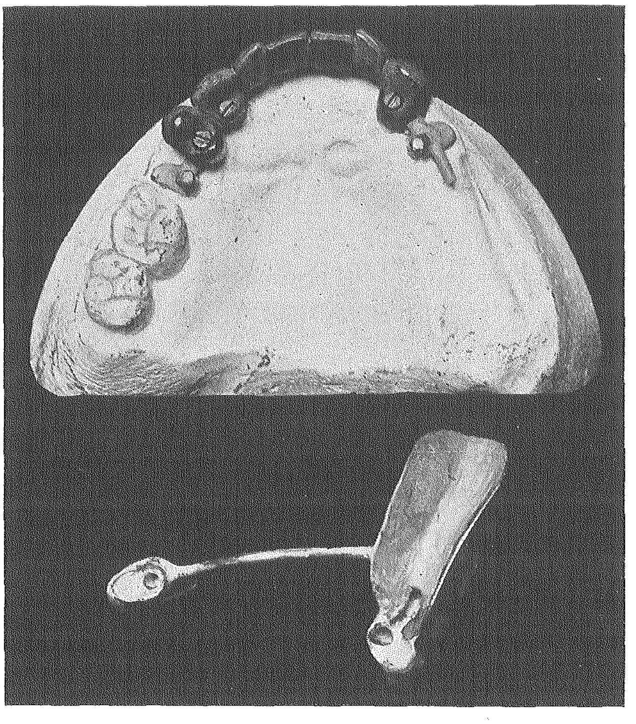


Fig. 819.— Bridge Set in Position and Held by Three Screws. The Two Distal Roots Carry Kelly Attachments and One on Left a Bar for Gilmore Attachment, Enclosed within Partial Denture

boxing, composed of platinum or high fusing gold, is first formed and fitted to the block on the root cap.

Over this the crown is built in any manner that the conditions of the case demand, after which it is removed from the cap, the box covering the block coming away with the pattern crown, and the solder flowed, or gold cast against it.

The crowns and bridge showing application of the Corcoran appliances were kindly loaned for illustration by Dr. H. F. Methven.

Still another modification is sometimes carried out. A disc of gold or platinum, to serve as a crown base, is perforated, fitted around the block and swaged to accurately conform to the root cap. To this the boxing, which encloses the block, is soldered, and on this metal base the crown is built.

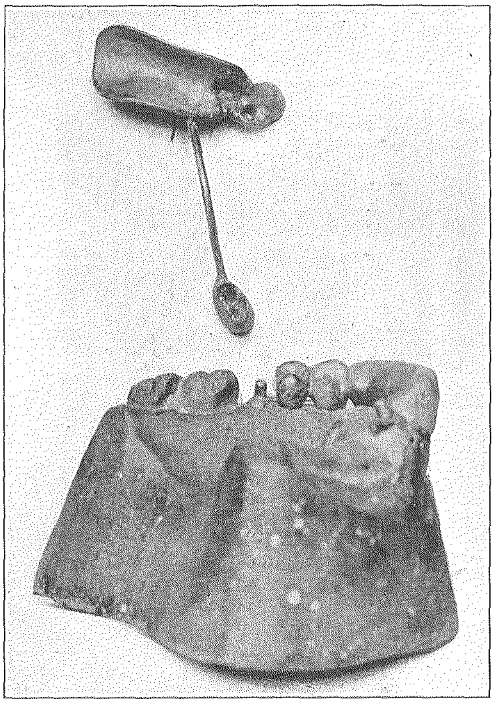


Fig. 820.— Side View of Bridge on Cast, with Partial Denture Above

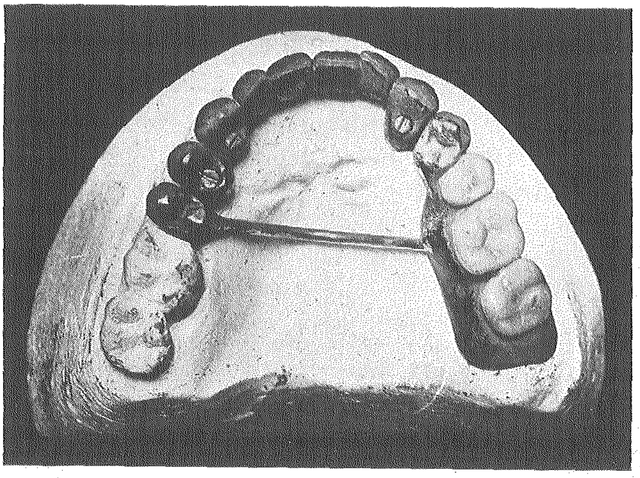


Fig. 821.— Bridge and Denture in Position on Cast

On page 796 reference is made to a bridge constructed by Dr. Anderson, in which the substitute, although composed of two pieces, is of the fixed type when set.

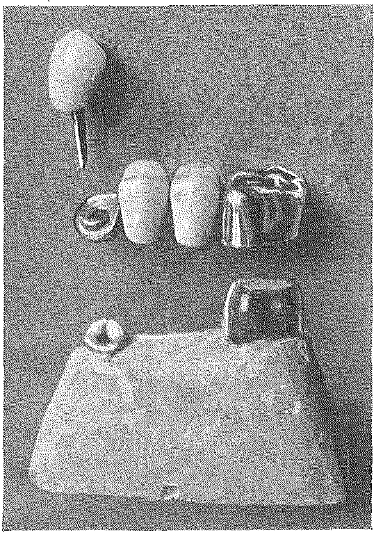


Fig. 822.— Bridge Constructed by Dr. C. L. Anderson. For Description, See Page 796

Mueller of Zurich, Switzerland, suggests a similar method of anchoring a *removable bridge* in position.

He constructs a root cap fitted with a tube, near the apical end of which a slight rib is attached to one side. The dowel of the crown is split, and sprung apart slightly at its apical end. A groove is formed in the dowel at a point which, when the latter is in position in the tube, will fit over the rib in the tube. The split dowel as it passes the rib is sprung together, and as the crown is seated the notch of the dowel receives the rib, and in this manner the crown is latched in position.

The structure is composed of a perforated root cap, through which the independent doweled crown passes.

A telescoping crown or heavy stop clasp is fitted to the other supporting root and the two connected by a saddle, to which the teeth are attached.

The Heddy Attachment

The Heddy attachment consists of a metallic block similar in form to the Corcoran attachment, differing, however, in being solid.

The general steps of root cap construction, as well as that of the crown, are similar to those just outlined. Anchorage of the crown to the block attached to the root cap is secured

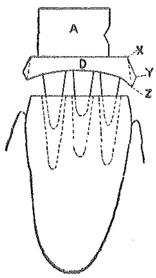


Fig. 823.— Root Cap with Heddy Block Attached

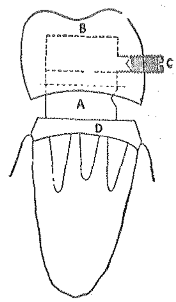


Fig. 824.— Root Cap in Position. Crown Completed, But Not Seated

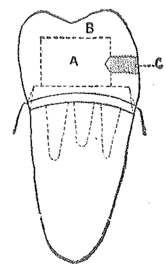


Fig. 825.— Heddy Molar Crown Completed and in Position

by cutting a V-shaped groove transversely across the block, about midway between cap and occlusal end.

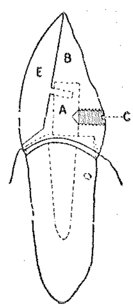


Fig. 826.— Heddy Anterior Crown in Position

An opening is made through one of the axial surfaces of the crown. This is threaded to receive a set-screw having a beveled point.

The crown is locked in position by setting the screw firmly into the V-shaped groove of the central block.

Removable Bridges

A removable bridge, in the ordinary acceptation of the term, refers to a substitute for lost natural teeth, which is held in position and supported by some of the remaining natural teeth or roots, and which can be removed from position and replaced by the patient at will.

For hygienic as well as esthetic reasons, bridges of this type are usually supplied with saddles. These may or may not relieve the abutment and pier roots of a certain amount of masticatory stress. As previously stated, in structures which conform to bridge engineering principles, whether fixed or removable, the abutment and pier roots must resist practically all masticatory stress, regardless of the presence of saddles.

When the structure is so planned that the saddle will receive the burden of stress, the abutment and pier roots being utilized principally for retention purposes, it should be classed as a partial denture.

REMOVABLE BRIDGE ATTACHMENTS

The Roach, Gilmore, Morgan and similar appliances are frequently used in cases of so-called removable bridge work, when, in reality, the structures should be classed as partial dentures, since resistance to masticatory stress devolves upon saddles, and not on the appliances themselves.

Various forms of attachments and many peculiar and ingenious devices have been designed for the retention and support of removable bridges. Many of these, because of the exacting care required in their construction, or of certain weaknesses which developed with use, have been discontinued.

The forms of attachments which have proven most satisfactory and capable of resisting masticatory stress consist of rigid telescoping devices, as cap crowns and crowns fitted with heavy dowels which are received within, and accurately fitted to, tubes enclosed within the roots of natural teeth.

Dr. F. A. Peeso of New York, who is a recognized authority in the field of removable bridge work, applies this principle, or some slight modification of it, in practically all cases where removable work is indicated. Although most satisfactory, these forms of attachment require the use of comparatively rigid gold, and very exact technic in their production, otherwise unsatisfactory results attend their application.

When a removable bridge structure is supported by two of more roots, or teeth, these must be so prepared that the attached crowns or retention devices may sustain a parallel relation to each other.

This is necessary, as before stated, in order that the bridge may be readily removed and replaced by the patient without special care or annoyance.

In addition, a bridge sustained by abutment and pier supports not in parallel alignment must sooner or later, in many cases at least, cause irritation of the enveloping structures of the supporting roots.

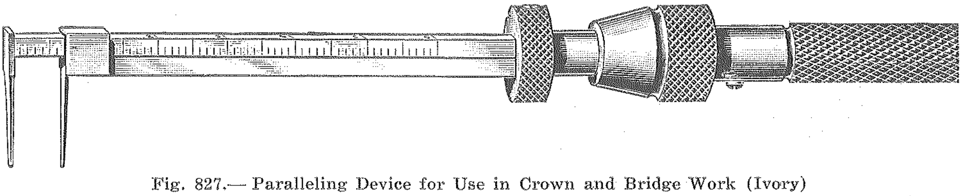


Fig. 827.— Paralleling Device for Use in Crown and Bridge Work (Ivory)

Various devices have been suggested for determining whether, in root preparation, the axial surfaces and root canals are being shaped to meet the requirements.

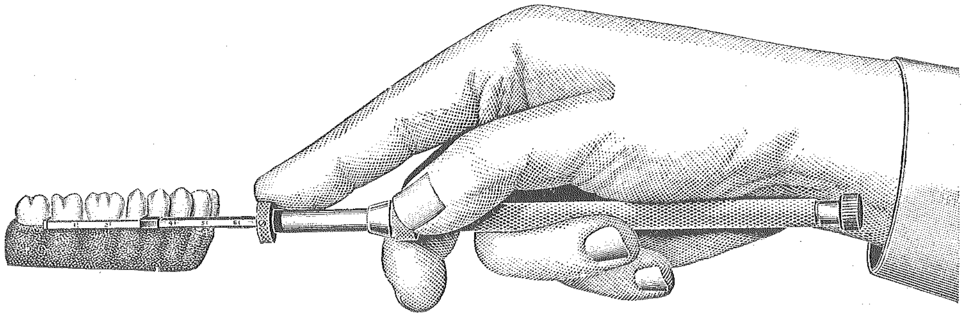


Fig. 828.— Paralleling Device Applied to Test Axial Surfaces of Second Bicuspid and Second Molar

A simple appliance is here shown, with which the general alignment or parallelism of the surfaces and canals involved may be tested.

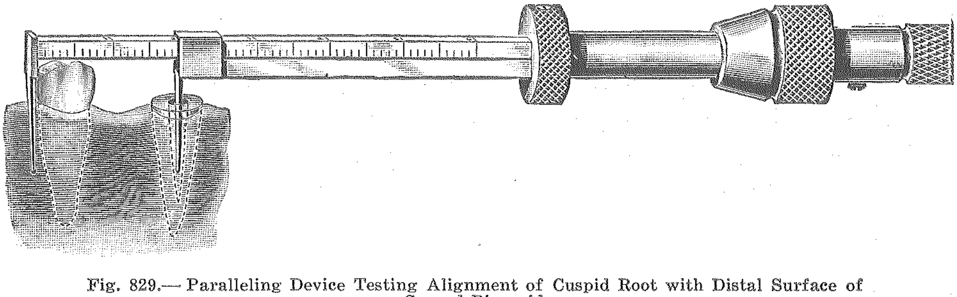


Fig. 829.— Paralleling Device Testing Alignment of Cuspid Root with Distal Surface of Second Bicuspid

When two or more removable crowns with dowels are employed—the dowels fitting accurately within tubes in the root canals—the necessity for establishing accurate parallel alignment of the removable with the stationary parts to which they are adapted is obvious.

THE TELESCOPING CROWN

This form of crown is applicable to bicuspid and molar teeth, when such teeth are properly aligned, or when they can, by suitable preparation, be brought in correct alignment with the other teeth involved.

Briefly, the general steps of constructing a crown by this method are as follows:

The tooth is prepared as for a shell crown, its axial surfaces being slightly but uniformly tapered, and its occlusal end reduced to a flat plane sufficiently to provide ample space between its face end and the occluding teeth for not only the inner cap, but for a thick, heavy, occlusal end to the outer or telescoping crown.

The root cap, as before stated, should be tapered uniformly from gingival to occlusal plane, so as to present the form of a more or less true frustum of a very slightly tapering cone.

Its cervical end is accurately scribed to the gingival margin and in fitting is driven beneath the latter to the full extent permissible by the peridental attachment, terminating it, however, on the still flaring, conical, axial surfaces of the tooth.

The occlusal margin is trimmed even with the flat tooth plane. To this a disc is soldered, and its margins trimmed even with the axial surfaces of the band, which step completes the assembling of the root cap.

The cap is now mounted on a wooden mandrel, with modeling compound, and its outer surface wrought into a perfectly true cone by means of a fine cut, flat file, after which it is smoothly polished.

On removing the cap from the mandrel, it is cleaned and its inner surfaces are covered with a thin film of whiting and water, in which a little gum arabic is dissolved, to cause the whiting to adhere closely to the metal.

The cap is now imbedded in moldine, occlusal end down, a swaging ring centered over it, and a die cast directly into the cap and ring. By tapping the cap lightly on its sides with a mallet the die is released.

Over this root cap an outer or telescoping cap having the same taper as the latter is closely fitted. It should, in fact, be driven onto the root cap, while the latter is on the die, thus insuring close adaptation between the two.

Its gingival end is trimmed so as to terminate close to, but not pass beneath, the gum margin. Its occlusal end should be covered with a disc similar to that which completed the root cap.

When in position and its inner surfaces are in friction-tight contact with the axial surfaces of root cap, its occlusal end should not rest upon the latter, a space of about one-sixty-fourth of an inch between the two being reserved for the bridge to settle as the contact surfaces become worn. This insures close gripping contact between the root cone and the inner walls of the telescoping crown under continued use.

The root cap is returned to position in the mouth, a bite and impression taken and casts developed and mounted on the occluding frame.

The occlusal end and axial surfaces of the outer cap are covered with inlay wax, melting it on to insure close union.

The wax on the occlusal end is now softened and the occluding teeth pressed into it and subjected to lateral movements as well, after which these surfaces are carved to required form.

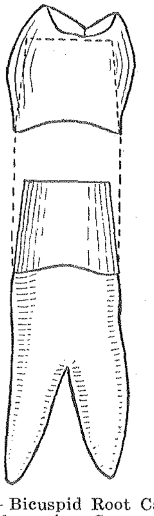


Fig. 830.— Bicuspid Root Cap, with Telescoping Crown

The axial surfaces are developed by addition or reduction of wax as indicated and the crown given its anatomic form.

The outer cap, or crown proper, is now removed from the root cap, and after smoothing the wax, is invested and cast the same as any ordinary cast crown.

THE SPLIT DOWEL CROWN

The split dowel crown, combined with a tubed root cap, is frequently employed in conjunction with the telescoping crown in removable bridge work.

Crowns of this type are more particularly applicable to cuspids and large-sized, single-root teeth. They may, however, be applied to roots of any class, under favorable conditions. The general constructive steps are as follows:

The root is prepared as for an ordinary cap crown, except that the lingual side is not reduced to the margin of the gum. In fact, it should project one-sixteenth of an inch beyond the margin, so that the half band of the crown base may not encroach upon the latter.

A band, usually of coin gold, or plate equally as hard and high fusing, is formed and fitted beneath the gum margin. The incisal end of the band is trimmed even with the face end of the root, to which a disc of gold of similar character is attached, either with high fusing solder or by sweating.

The cap is perforated for the reception of a tube which serves the double purpose of anchoring the cap to the root, and for the reception of the crown dowel as well.

The size of the dowel having been decided upon, a hardened steel mandrel of corresponding diameter is selected, and around this a piece of coin gold plate is formed into a tube and soldered with high grade solder.

A reamer of the exact size as the dowel is now passed into the tube and its inner walls reamed true, and to exact size.

One end of the tube is closed with a small disc of gold plate, the peripheral surplus trimmed even with the outer surfaces of the tube, and its corners chamfered or rounded slightly.

The dowel is formed from half-round clasp metal wire, as follows:

A piece of half-round wire, slightly larger than the dowel and about one and one-half inches long, is bent in the form of a loop, the two ends bent to lie in close contact from their terminals inward, for about one-fourth inch, the remainder of the loop being open.

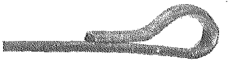


Fig. 831.— Method of Soldering Half-Round Wire for Dowel

A little coin gold is now applied in the V-shaped space, next the contact area, and the two ends united by fusion. It is necessary to use coin, or equally high fusing gold, to effect this union, to avoid the split portion of the dowel from being united in subsequent soldering operations.

The loop portion of the half-round wire is now carefully battered down with a small rawhide mallet, in a half-round, grooved anvil, until the flattened surfaces of the wire are in contact.

The doubled wire, with ends united, now presents the appearance of a round wire, about three-fourths of an inch long. This is passed through gradually decreasing holes in the draw plate, until it is brought to very nearly the required diameter to enter the tube.

The final reduction to exact size is accomplished by placing the wire in a pin vise, resting it in a grooved block, and with a fine cut, flat file carefully reducing it under rotary action.

It should be tested from time to time in the tube, and when it just begins to enter the latter, the file marks are removed with fine flour of emery cloth or crocus. The soldered end of the dowel may be placed in a true running lathe chuck, and the final finish given by applying the fine polishing cloth against it by means of a flat stick, or by laying it on the flat, fine file and running the lathe at high speed.

The dowel should fit the tube with friction-tight contact, yet not so tightly as to preclude its ready introduction and removal. When properly reduced the folded end of the dowel is cut off, thus leaving the two halves of the dowel held by the soldered portion.

ASSEMBLING THE PARTS

An opening is made in the root cap for the reception of the tube, as before stated. This opening, although in some cases it may be located directly in line with the canal, is usually made a little to the lingual, and the canal reamed accordingly, so that the dowel may not interfere with proper adjustment of the facing.

In this case, as in that of all cap and dowel crowns, the entrance to the root canal can be reamed out slightly and the margins of the cap around the tube opening depressed into the countersunk area. This adds strength to the attachment between cap and tube, and further permits the tube opening to be countersunk for the more ready introduction of the dowel.

The cap is set in position on the root, the tube passed through it, into the root canal, which previously has been enlarged to receive it, and an impression taken to secure the relation between the two.

When secured and a small investment model formed, the two are united in the same manner as an ordinary cap and dowel. The tube should be filled with investment previous to soldering to prevent its becoming filled with solder during this operation.

CONSTRUCTING THE CROWN BASE

Usually a lingual, half-band cap is adapted to the root cap to serve as a crown base and to which the split dowel is attached. Such a cap affords resistance to outward displacement, and obviates the presence of a second band beneath the gum margin.

For convenience in construction a full band is adapted to the periphery of the root cap, to which a disc, or *floor,* is conformed and the two united with high grade solder on the lingual, but not on the labial half of the cap.

After uniting the band and floor of the telescoping cap and completing its adaptation to the root cap, the floor is perforated for the reception of split dowel of the crown. This should be in perfect alignment with the opening in the tube of the root cap.

The telescoping cap, or crown base, is adjusted to the root cap, the dowel having been cut to suitable length, its free or divided end is inserted in the tube to full depth, a small impression taken to secure correct relation between the two, and in which they are placed previous to running up the cast in investment.

Since subsequent soldering operations must follow, the union between cap and dowel should be made with high grade solder, or the special plate recommended for this purpose in the section on metallurgy.

The labial half of the band is removed and the terminals of the lingual half neatly finished against floor. This may be easily accomplished if, when soldering, care was observed to prevent the labial joint area from filling with solder. Weinstein suggests notching the incisal edge of the band before soldering, the break in the continuity of surfaces thus preventing the solder being drawn to the labial.

When the several steps have been carried out accurately, the floor of the crown base will rest firmly on the root cap, its

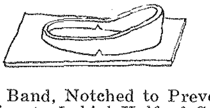


Fig. 832.— A Band, Notched to Prevent Solder Flowing to Labial Half of Cap

lingual half band in close contact with that of the cap over which it telescopes, while the dowel fits with almost friction-tight contact within the tube.

On this base a crown of any desired type is built to meet the requirements of the case, which, when completed, would be called a *half band, split dowel crown.*

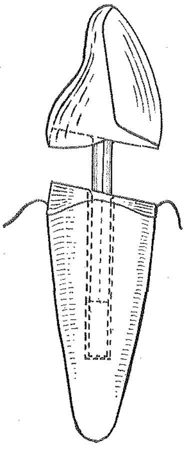


Fig. 833.—Half Band, Split Dowel Crown, Partially Removed from Position on Root Cap

CONSTRUCTING THE SADDLE

The saddle may be swaged by methods outlined under partial denture construction or a wax model of the desired form may be developed and cast. When the latter plan is followed, ample though not very large sprues should be provided for the ingress of gold into the matrix, two or three being sufficient for the purpose.

When constructed, the saddle is adjusted to the border, the two complete crowns being in position on their respective roots, and an impression taken by the pressure method as described on page 499.

The crowns should come away with the impression, or, if not, they are set in their respective matrices and a cast of some reliable investment material formed.

The saddle and crowns are now firmly united, and if not previously provided for, attachments should be made for vulcanite anchorage. These attachments, however, are omitted when the structure is to be composed entirely of metal and porcelain.

The now assembled and united metal framework is returned to the mouth for final bite and impression. The metal structure is correctly placed in its matrix in the impression, the root caps removed and set in their respective crowns and a cast of one of the hard materials formed.

ATTACHING THE TEETH

Plain or gum section teeth may be ground to position and attached to the saddle in the usual manner, or some of the replaceable type of teeth are frequently used. When this plan is followed, gold sockets are adapted to the bases of the several teeth, the teeth with sockets attached, waxed in position, the porcelain removed, the case invested and the union of sockets to saddle accomplished by flowing plate or high grade solder between to complete the contour of the case.

FINISHING THE CASE

The steps of finishing are similar to those followed in regular bridge or partial denture work, the idea being to remove all surplus material, remove sharp margins that may, by their presence, produce irritation, and finish the case as smoothly and perfectly as the most finished piece of jewelry ever produced.

SETTING THE ROOT CAPS

In cases of the type under consideration, setting the root caps is practically the last operation. This is purposely delayed until this time, so that, should any warpage occur in the

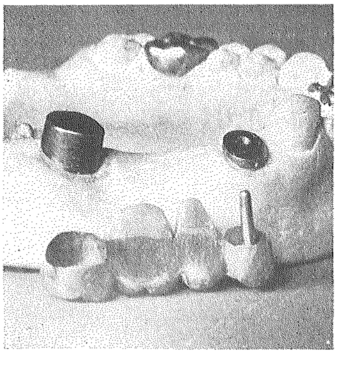


Fig. 834.— Bridge Composed of Half Band, Split Dowel Bicuspid Crown, A Telescoping Molar Crown and Two Dummies Completed. Root Caps in Position

final assembling and soldering of the structure, the exact relation between root caps and their telescoping crowns may be preserved.

The caps are set as follows:

The interior of the telescoping crowns is coated with a thin film of oil, the root caps cleansed and dried and set in position in their respective crowns, cement applied in their interior and to the roots, and the entire structure carried to position and forced to place, first with direct pressure and immediately tested with the occluding teeth to see that it is correctly seated.

GENERAL REMARKS

The details of this most excellent system of removable bridge work has been presented in book form by Dr. F. A. Peso, a man most eminently qualified by years of successful experience to present it in a clear, logical and practical manner. He is, in fact, responsible for the development of the finer and more accurate details, a neglect of which would result in indifferent success, or total failure.

Coin gold, because of its hardness and comparatively high fusibility, is recommended for root caps, tubes and telescoping caps as well, and highly platinized gold for split dowels.

In initial operations, when possible, the joints are *sweated* to obviate danger of fusion in subsequent operations. When union cannot be thus effected the highest fusing solder possible to use on the plate with safety is employed, for reasons before stated.

The Inlay Clasp Attachment

A combined inlay clasp attachment, suggested by Dr. H. J. Goslee, can at times be used to advantage in removable bridge work when stress of mastication is not excessively heavy. This can best be illustrated by describing the application of such an attachment to a crown, in this case a lower first molar.

The tooth is prepared slightly cone shape, to which a deep root cap or thimble is fitted, similar to that used in the telescoping crown. Inlay wax is now applied to the occlusal and axial surfaces and carved to meet anatomic and occlusal requirements.

From the axio-occlusal third of the crown, the wax is removed from the axial surfaces to form a shoulder depression for the reception of the clasp. A dovetail depression, similar to an occlusal step cavity, is cut in the occlusal surface of wax. The axial walls of both inlay step and outer surfaces of reduced portion of the crown are rendered parallel or slightly convergent to permit the withdrawal of the wax pattern for the clasp attachment later on.

The crown, minus the portions removed, is cast, and finished. Wax is filled in the removed areas and carved to complete the anatomic form of the crown, after which it is carefully separated, invested and cast. When made sufficiently rigid and wide, and the walls of the crown which it embraces are formed practically parallel, this attachment grasps the crown very firmly.

An attachment of this type may be combined with another of similar style, or combined with the telescope, or the half band dowel crown, in the construction of small bridges.

A tube attached to the inlay seat of the crown, extending toward or into the pulp chamber, for the reception of a split dowel anchored in the inlay, will add greatly to the stability of the appliance.

The Split Dowel, Lingual Half Crown

This attachment is really a removable Carmichael attachment, combined with a split dowel, applied to a partial, artificial crown. The writer is unable to state who first suggested

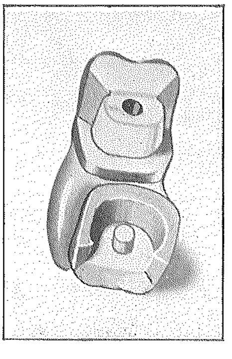


Fig. 835.— Lingual View of Crown. Cervical View of Lingual Half Crown

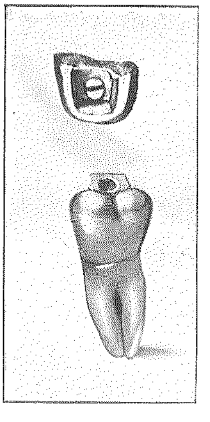


Fig. 836.— Buccal View of Crown. Cervical View of Half Crown, Showing Split Dowel. Slightly Modified

it as a removable bridge anchorage. When accurately constructed, in well-selected cases, it is a very rigid and serviceable attachment. It is particularly applicable to bicuspids and molars.

CONSTRUCTION OF THE HALF CROWN

The crown, or remaining portion, is reduced to the gingiva, the peripheral ring of enamel removed and the root end prepared decidedly cone shape, and for which a root cap is swaged, by methods previously outlined. By preparing the pulp chamber walls with a slight flare outwardly, an inside shoulder may be developed on the root cap, which will hold the latter in position, regardless of the pronounced flare of the root periphery.

One or more dowels are passed through the cap and into the root canals and attached as in any similar case.

Usually a porcelain facing is ground, backed and applied to the root cap in proper alignment with the proximating teeth. The backing should be extended so as to protect the buccal marginal ridge of porcelain from stress.

Inlay wax is melted against the backing and on the root cap in excess of what will be required to form the lingual shoulder, and when hardened is carved somewhat in the form of a half cylinder, or very slightly tapering cone, or rectangular block, the axis of which lies parallel with the long axis of the tooth.

The backing itself should be thickened with wax, especially the beveled portion extending over the marginal ridge. Usually the outer half of the buccal cusps are developed in this wax.

The sides of the cylinder terminate within the mesial and distal surfaces of the crown, the angle between the backing and half cylinder being grooved to form a sort of dovetail, by means of which the lingual attachment is locked in position.

The occlusal end of the cylinder is reduced sufficiently to allow space for a thick occlusal cap to the attachment.

The gingival end of the cylinder is squared and a flat cervical shoulder is thus formed on which the lingual half of the crown may rest.

The cylinder, as before stated, should converge somewhat from gingival toward occlusal areas, to permit the pattern for the lingual half crown to be removed.

A closed end tube, of suitable size to receive the split dowel, and somewhat longer than required, is heated and pressed into the occlusal end of the wax cylinder, until its closed end rests on the crown base. Care should be taken to adjust it parallel with the line of direction, of introduction and removal of the half crown.

The facing is now removed and carbon points inserted in the pin holes, the case invested and cast, after which it is finished with plug finishing burs, stones, discs, etc.

The carbon points are drilled out, the facing fitted in position, its pins roughened, when it can be temporarily set in position with gutta percha while finishing the crown. This is essential, for if the metal parts are polished without the facing being in position, the point area between porcelain and backing will be impaired.

Later on in soldering the assembled bridge, the facing is removed when, after completion of the metal structure, it is permanently set with cement.

CONSTRUCTION OF THE LINGUAL HALF OF THE CROWN

A split dowel, slightly longer than required, is adjusted to the tube within the cylinder, the surfaces of gold against which the lingual half crown rests are coated with a thin film of oil and inlay wax applied in sufficient bulk to complete the required contour. By means of a metal matrix slightly longer than the crown, an excess of softened inlay wax can be applied and forced into every angle, groove and irregularity. On removal of the matrix the excess can be carved off and the crown developed to required anatomic form.

The carved model of the half crown is carefully removed, care being taken to bring the dowel away with it without distorting the relation between the two. Should it become loosened, the wax immediately around it must be melted and the model returned to the metal parts for final adjustment, when it may be removed, invested and cast.

FINISHING THE ATTACHMENT

The natural contraction, together with the more or less nodular surfaces present, demands the exercise of the greatest care in finishing, to avoid cutting away unnecessary gold, before the actual points of interference are discovered.

When an amalgam die has been formed on which to construct the root cap, the crown can be returned to it, and by tapping the lingual half crown in the direction of the long axis of the tooth and removing, burnished spots will disclose the points of interference.

These attachments are used in conjunction with and without saddles, if conditions demand their application in such manner.

MODIFICATION OF THE TELESCOPING MOLAR CROWN

A modification of the telescoping, shell molar crown, combined with split dowel crown, is sometimes employed in extensive bridges of the compound or complex types. It is not adaptable to simple bridges for the reason that the abutment being in nearly straight alignment, torsional strain will unseat the appliance.

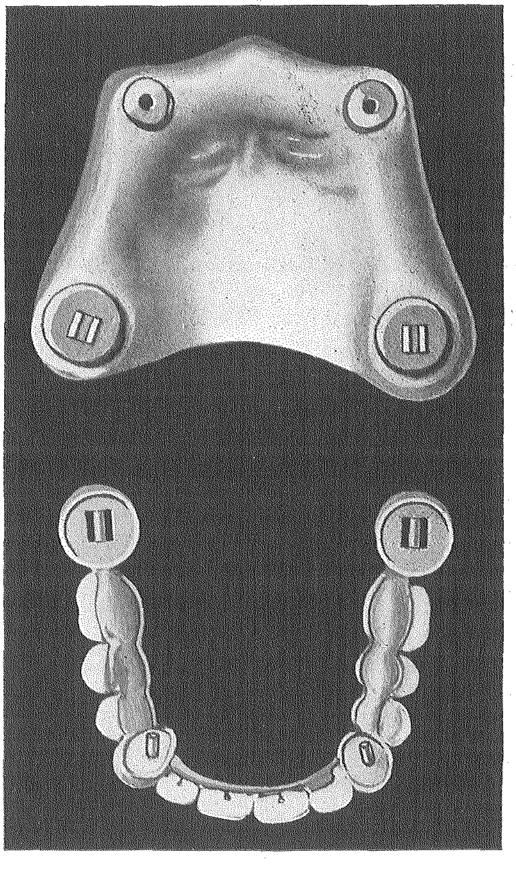


Fig. 837.— Occlusal View of Cast with Root Caps in Position. Cervical View of Bridge

Instead of a deep root cap with a telescoping cap of practically the same depth adapted to it, the molar root is reduced to within a short distance of the gingiva and fitted with a doweled cap having practically parallel sides.

On the top of the cap a Gilmore attachment is soldered, the flanges presenting occlusally.

A crown is constructed the base of which rests upon the root cap and telescopes over it slightly.

In the central portion of the crown base is a recess which receives the flanges of the Gilmore attachment, while extend-

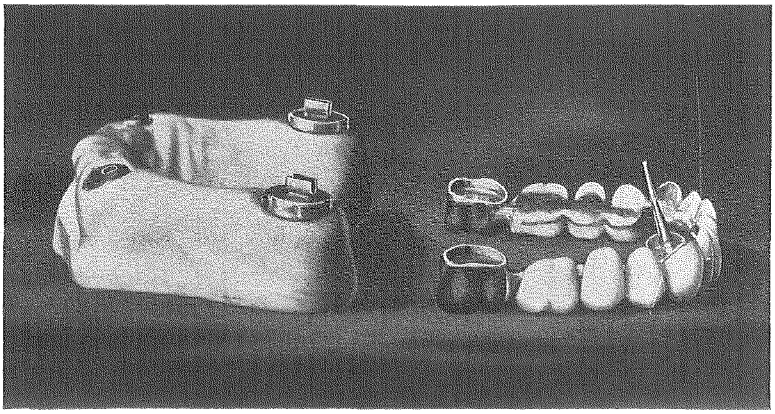


Fig. 838.— Buccal View of Cast and Bridge

ing across the recess and fixed within the body of the crown is a 14-gauge bar.

This bar is so adjusted that, when the crown is seated on the root cap, the flanges of the Gilmore attachment grasp it and thus aid in retention of the appliance.

The appliance here illustrated is the work of J. B. Rideout of Minneapolis, who kindly loaned it to the writer.

Still other combinations of the various attachments mentioned are possible, depending upon the ingenuity of the prosthetist and his skill in carrying out the ideas conceived.

Repairing Crowns and Bridges

The most common accidents which occur to crowns and bridges, when permanently set and subjected to use, are fracture of the porcelain teeth or facings and fracture of some portion of the metal structures.

When a crown or bridge can be removed from the supporting roots or teeth, without injury to itself or to them, repair can be most easily accomplished out of the mouth.

Since, as is most frequently the case, removal of a crown or bridge is accompanied by more or less mutilation of the metal parts, or subjecting the foundation supports to undue strain, the general method of procedure is to repair such cases, if possible, without removal.

The replacement of dislodged facings can frequently be accomplished quite as well in the mouth as by removal of the substitute, with some of the available *repair outfits.* Some of the common methods of repair will now be outlined.

REPLACING PORCELAIN FACINGS — THE ASH FLAT BACK REPAIR FACING

One of the simplest methods of replacing a flat back porcelain facing where the pins of the fractured facing remain with and project from the old backing is accomplished by grinding and fitting to the metal parts an Ash flat back repair tooth, shown under "Various Forms of Teeth."

When the pins are short and practically headless, they may be threaded and a small washer attached to each to increase their hold in the cement which fills the dovetail space within the porcelain.

In case the tooth pins have broken or are weak, with suitable drill and tap, threaded holes may be made in the labial or buccal face of the old backing to coincide with the opening in the porcelain and a screw wire of iridio-platinum or platinized gold inserted for anchorage purposes. The pins should be as long as the depth of dovetail space in the porcelain will receive, or they may be cut somewhat long, and after being inserted in the backing, bent inwardly toward each other to form a sort of staple anchorage.

When the pins are adjusted, cement is applied to both backing and facing, and the latter forced and held in place until the cement has hardened, after which the surplus is removed.

THE DIMELOW FACING

A facing of this type is applied in repair work as follows:

The porcelain, if any remains of the old facing, and the pins, are removed from the backing.

A facing is selected and ground to meet requirements. A very small quantity of wax is melted on the old backing in that area which corresponds to the position of the pinholes in the facing.

While the wax is soft, the facing is moistened and pressed firmly against it. On removal, the position for the pinholes will be indicated by the raised points of wax which entered the holes. These points are carefully marked on the backing with a sharp-pointed instrument. A bi-beveled drill is selected, corresponding in size with the openings in the porcelain, and with this the holes are drilled in a linguo-gingival direction to correspond with the angular inclination of the holes in the facing. See Figs. 382-383.

Two small pins made of threaded clasp metal wire, which will fit the holes closely, are cut of suitable length, extending to the full depth in the holes of both backing and facing.

Cement is applied in the holes of both backing and facing and over the contact surfaces, the pins set in position in the backing, and the facing adjusted and forced to place.

THE STEELE REPAIR OUTFIT

This set of appliances, consisting of drills, taps, headed screws, and a screwdriver, is intended to be used in conjunction with the Steele facing in repair work. The method of application is simple.

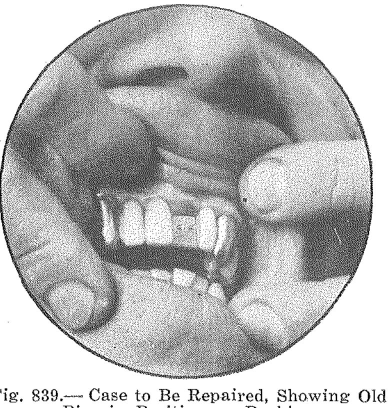


Fig. 839.— Case to Be Repaired, Showing Old Pins in Position on Backing

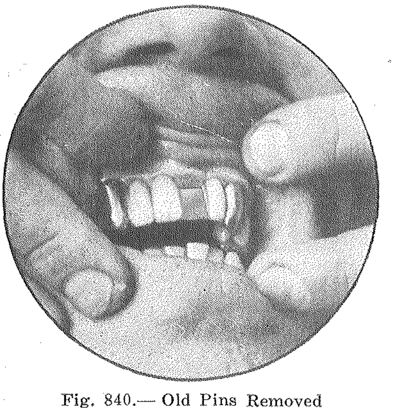


Fig. 840.— Old Pins Removed

The old pins and any of the old facing present are removed and a Steele facing of suitable form and color selected and ground to meet requirements. It will usually be found more convenient, and a better repair can be made by selecting a facing slightly wider and longer than the space it is to fill, and adapting it by grinding rather than to select one that will drop in position without fitting. A little wax is applied in the central area of the backing extending from the crown base to near the incisal edge.

Fig. 841.— Grinding the Steele Facing to Meet Requirements

This should be melted against the backing, and while soft the selected facing, having been ground, is pressed firmly against it, being careful to see that it is in correct alignment.

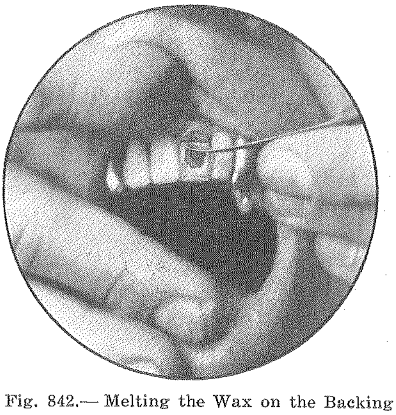


Fig. 842.— Melting the Wax on the Backing

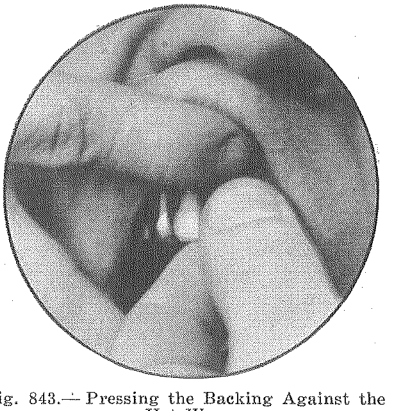


Fig. 843.— Pressing the Backing Against the Hot Wax

On removal of the facing a ridge will be seen on the wax where it entered the slotted groove of the porcelain.

With a sharp-pointed instrument two points are marked on the backing, one near the crown base, the other near the incisal termination of the wax ridge. These points indicate the position for the pins. The incisal point should be marked slightly within the ridge.

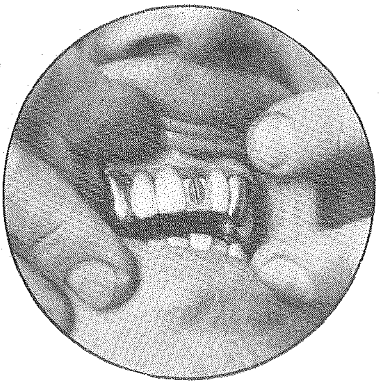


Fig. 844.— Facing Removed, Showing the Ridge of Wax Where It Entered the Groove of the Facing

Holes are now drilled for the reception of the headed screws at the points indicated.

Since the holes must be very small and the drills correspondingly so, special care must be exercised to avoid breaking the drill in the backing, an accident which is very liable to occur.

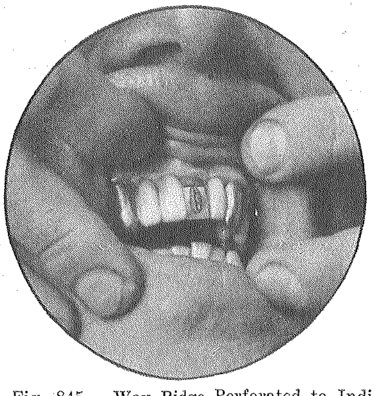


Fig. 845.— Wax Ridge Perforated to Indicate Position for the Screws

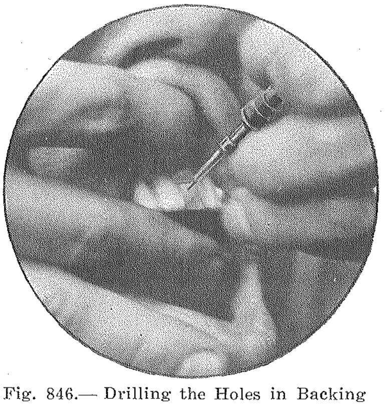


Fig. 846.— Drilling the Holes in Backing

The holes are now threaded with the tap for the reception of the screws, and the latter set in position.

The facing is applied, passing it over the screws from an incisal direction. If, in its passage to place, interference occurs, locate the cause, which is probably due to setting the screws too deeply in the backing, thus bringing their heads too close to the interior wall of the slot of the facing.

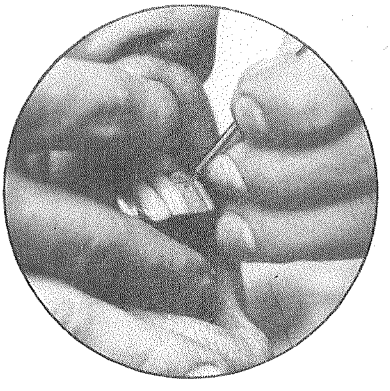


Fig. 847.— Tapping the Holes with the Screw Tap

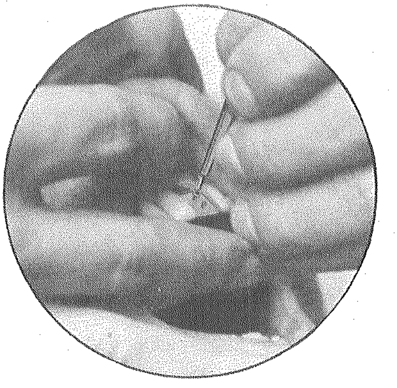


Fig. 848.— Setting the Screws

If too long, they may prevent the facing resting against the backing. The screw heads should be so set as to permit the backing sliding readily to place yet close enough to avoid any labial movement of the facing from the backing when once seated.

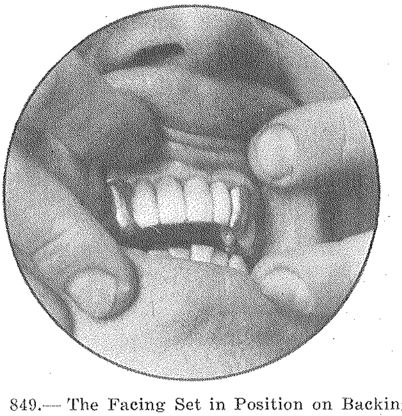


Fig. 849.— The Facing Set in Position on Backing

Cement is now applied around the pins, over the backing, in the groove of the facing, and the latter is forced in position.

THE BRYANT REPAIR OUTFIT

This set of appliances consists of threaded taps, a taper reamer, a split end, screwdriver, and taper nuts, which, in the replacement of a flat back, porcelain facing, are used as follows:

The old pins are removed, a layer of wax is applied to the backing, into which the pins of the selected facing are pressed, to indicate the position for drilling the holes.

The holes are drilled entirely through the backing with a bi-beveled drill a little larger than the diameter of the platinum pins.

The facing, which should be slightly larger than actually required, to permit of reduction for exact fitting, is ground to place.

The lingual ends of the holes in the backing are enlarged with the taper reamer by means of the right angle hand piece. They should be large enough to receive the taper nuts so that the small ends of the latter may approach close to, but not project through, the labial surface of the backing. Should the small ends pass through the labial of the backing, they must be reduced by grinding, or the facing cannot be drawn tightly against the backing.

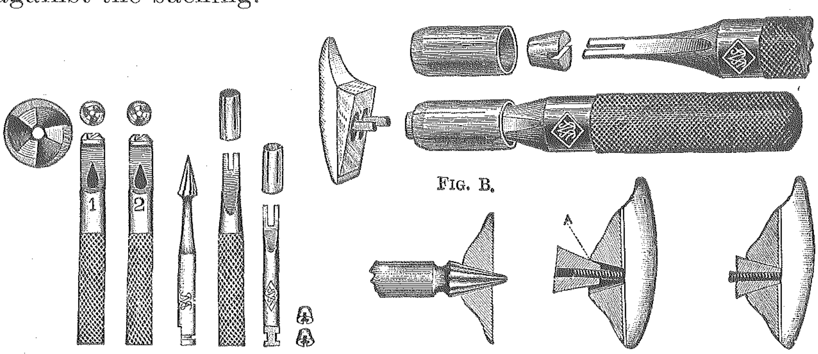


Fig. 850.— The Bryant Repair Outfit, Showing Taps, Reamer, Screwdriver, Nuts, Etc.

Threads are cut on the pins, first using No. 1 tap, which cuts a partial thread, and followed by No. 2 tap, which cuts the thread to full depth.

The pins should be oiled and the taps applied carefully to prevent the pins being twisted off during the cutting of the threads.

Cement is now applied to the backing, and the facing adjusted in position.

A nut is dropped into the small sleeve of the screwdriver, small end outward, applied to one of the pins and tightened, after which the other is applied in like manner.

This step should be carried out quickly, before the cement has preceptibly hardened, otherwise the nuts cannot be forced into close contact with the backing and the facing will soon become loosened.

The facing should be held by positive mechanical anchorage, developed by jamming the nut tightly against the walls of the opening in the backing, on the lingual side, while the porcelain should rest firmly against the backing labially.

The cement is used only as a sealing agent, to close the space between porcelain and metal.

When hardened, the surplus cement is cleared away, the projecting ends of the nuts on the lingual surface reduced with stones, and the rough surfaces polished with fine discs.

Long Pin Facings Used in Repairs

METHOD OF REPLACEMENT SUGGESTED BY DR. R. W. STARR

When the backing of a crown, or a bridge dummy is exceptionally thick, so that the pins of the facing will not readily engage with the Bryant nuts, as ordinarily applied, the mode of attachment may be varied as follows:

Place a piece of platinum foil between and around the pins of the selected facing, and bend them down in close contact with the foil, so that they lie parallel and touch each other.

Invest the porcelain and unite the pins with solder. Flatten them somewhat by filing, and square up the sides of the rectangular projection which they now form.

Remove the old pins from the backing, apply wax and press the partially prepared facing into it to secure an impression of the ridge formed by the united pins.

A groove is cut in the backing, of the same dimensions as outlined in the wax, of sufficient depth to receive the folded pins and let the facing rest firmly against the backing.

The facing is now ground to correct position, which previously could not be done, because the facing was prevented from coming in contact with the backing on account of the pins.

Drill a hole through the backing, locating it in the center of the groove which receives the pins.

Apply a thin film of oil to the backing, in the bottom of the groove, and to the sides of the opening through the backing.

Melt a little sticky wax to the pins, opposite the opening in the backing, and set the facing in position.

A piece of iridio-platinum or clasp metal wire, about 16 g., previously threaded, and slightly longer than required, to pass through the backing, is heated, and passed through the opening, from the lingual, until it enters the wax and rests against the pins.

The heated screw wire melts the wax, which, when cold, unites it with metal ridge of the pins, and the two may be removed in a labial direction in correct relation to each other, after which they may be invested and soldered.

Fig. 851.—Left, Pins Bent and Screw Attached. Right, Backing Slatted and Drilled for Reception of Facing

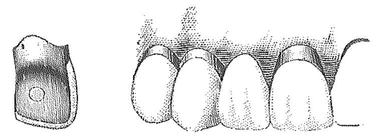


Fig. 852.—Left, Facing in Position. Surplus Screw and Nut Reduced and Polished. Right, Labial Appearance of Facing

The lingual end of the hole in the backing is enlarged with a taper reamer, to receive a taper nut, formed to fit the screw.

Attachment of the facing to backing and reduction of surplus screw and nut are accomplished in a similar manner as described under the Bryant System.

RIVETING THE FACING TO BACKING

When the pins of the new facing are long enough to extend through the old backing and permit of spreading, the facing may be attached by riveting.

Mark position on backing, and drill holes which correspond closely with the diameter of the pins, countersinking their lingual ends slightly.

Grind facing to meet requirements, and if the pins are excessively long, cut them so that they will extend but slightly beyond the lingual surface of the backing.

The ends of the pins should be squared and their centers depressed with a delicate, bi-beveled drill, to prevent the point of the riveting punch from slipping when applied. A sleeve

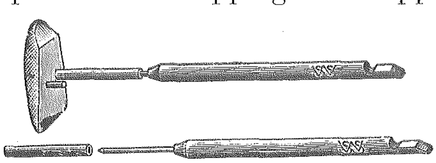


Fig. 853.—Sleeve Drill Separated, and in Position, for Countersinking Ends of Pins

drill, designed for this purpose, can be used to good advantage, and is, in fact, indispensable.

The Shriver riveting punch, one beak of which is supplied with a cup for holding a rubber pad, or modeling compound, for producing pressure on the porcelain, the other fitted with a round end and a pointed end punch for compressing and spreading the pins is used as follows:

Cement is spread over the backing and the facing pressed to place. The padded beak of the punch is applied to the

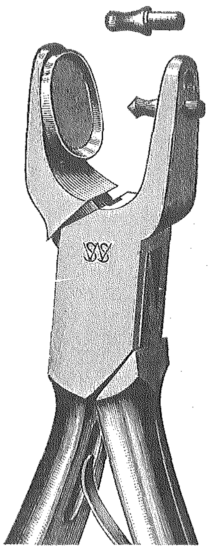


Fig. 854.— Riveting Punch, Showing Cup Beak and Two Riveting Points (Shriver)

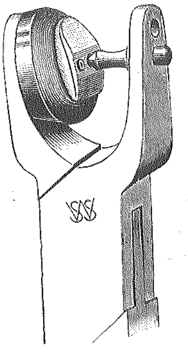


Fig. 855.— Riveting Punch as Applied in Heading a Pin

facing, the round punch applied to the pin, being careful to center it so that the pin may not be bent to one side, and pressure made to compress the pin upon itself. This step shortens the pin and increases its diameter and causes it to fill the

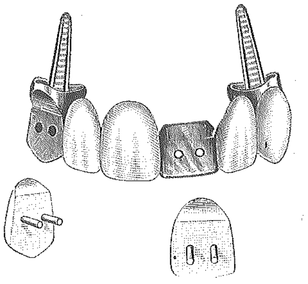


Fig. 856.— Backings of Cuspid Crown and Central Dummy Drilled for Reception of Long Pin Facings

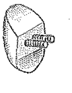


Fig. 857.— Pins of Facing Threaded for Reception of Nuts

hole in the backing, just as a rivet is compressed endwise, to fill the hole before the head is formed.

The pointed punch is applied to spread the end and form the head of the rivet, after which the round end is again applied to smooth any roughness raised by the point, while any surplus that remains is removed with discs.

When modeling compound instead of rubber is used as a pad, it should be softened, placed in the cup, the punch adjusted in position and slight pressure applied to secure an impression of the labial surface of the tooth, when it is removed and chilled, after which the steps are carried out as described.

An ordinary plate punch, modified as suggested by Dr. George Evans, may be used instead of the Shriver Punch if desired. To the beak in which the hole is located, a lead block

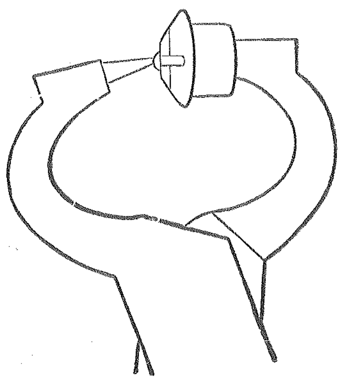


Fig. 858.—Ordinary Plate Punch Converted Into a Riveting Punch by Application of Lead Block to Right and Heavy Pin to Left Beak

is applied for producing pressure against the facing, while a larger pin replaces the ordinary pin in the other beak. The method of application is similar to that described.

With either method, in addition to gripping the handles while compressing the pin, pressure should be made lingually to keep the facing firmly seated against the backing.

A slight side to side movement of the handles will aid in compressing and heading the pin as well.

REMOVING A BANDED DOWEL CROWN

When, for any reason, it becomes necessary to remove a banded, dowel crown which is to be reset, care should be taken to avoid mutilating the root cap.

The most convenient method is to release the crown from the dowel which constitutes the main anchorage. This may be done by drilling through the lingual surface of the crown, in an apical direction, to the root face, alongside the dowel.

With a fissure bur, the first opening is enlarged, cutting around the dowel in such manner that the latter will project beyond the root face, thus facilitating its removal later on. Figs. 1049 and 1050.

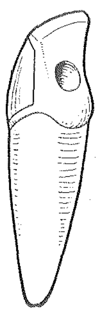


Fig. 859.—Lingual View of Central, Showing Opening Through Which Dowel Has Been Released

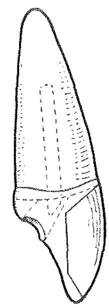


Fig. 860.—Same Tooth, Proximal View. Dotted Line Shows Direction of Opening

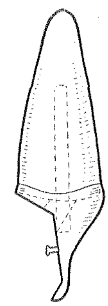


Fig. 861.—Proximal View of Incisor. Release of Dowel from Labial Side

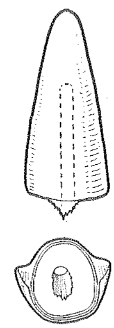


Fig. 862.—Cervical View of Crown. Proximal View of Root, Showing Projecting Dowel

When the facing is fractured, release of the crown can be most readily accomplished by entering the crown base from the labial surface and cutting around the dowel as described. Fig. 1051.

A single crown, when thus freed from its dowel, can be removed without difficulty, but when attached to a bridge the other abutment crowns must also be released before removal can be effected.

REPLACING A FACING ON A CROWN REMOVED AS DESCRIBED

The best and quickest method of replacing a facing on a crown is by removal of the bulk of old backing, grinding and backing a new facing, adjusting and waxing it in position, investing and soldering in the usual manner.

Usually, after the backing is removed, the root cap should be returned to position, a new dowel fitted, and impression to secure correct relation of the two taken, or the two waxed together, removed, invested and soldered, after which the facing is adjusted.

When the facing of the removed crown is present, the latter having been removed by releasing the dowel from the lingual side, a dowel is fitted, its incisal end being allowed to project beyond the opening, after which it is waxed in correct relation, the crown removed, invested, and the two united with solder.

Before investing the crown, the opening around the dowel, in the crown base, should be covered with a small disc of platinum foil, to complete the floor of the root cap, and form a metallic surface against which the solder may flow.

REMOVING DOWELS FROM ROOT CANALS

Various devices have been suggested for removing dowels from root canals. When applicable, appliances of this type relieve the tooth from both excessive cutting and strain.

LITTLE GIANT POST PULLER

The Little Giant Post Puller, designed by Dr. F. H. Skinner, consists of a clamp, having thin yet strong beaks, for

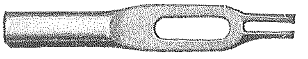


Fig. 863.— Shoulder Pin of Post Puller

grasping the dowel, together with a shoulder post for resting upon the root face.

By turning the screw, the shoulder post is brought in contact with the root face, while the clamp and dowel are moved incisally.

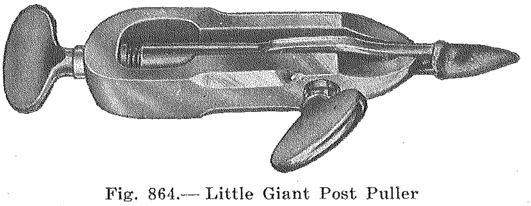


Fig. 864.— Little Giant Post Puller

To apply the device, the entrance to the root canal must be enlarged sufficiently to permit the clamp beaks to enter and grasp the sides of the dowel firmly.

THE S. S. WHITE CROWN REPAIR OUTFIT

The devices in this outfit, intended for removal of dowels from root canals, consist of trephines for gaining space around the dowel within the root, and at the same time reducing the dowel to a definite size to correspond with the opening in a threading die.

After space is gained, threads are cut on the projecting, formed end of the dowel, to which the inner barrel of a device, much like a jack screw, is applied. By turning the milled nut of the outer barrel until it rests against the face end of the root, the inner screw, which is attached to the dowel, is moved incisally, bringing the dowel with it.

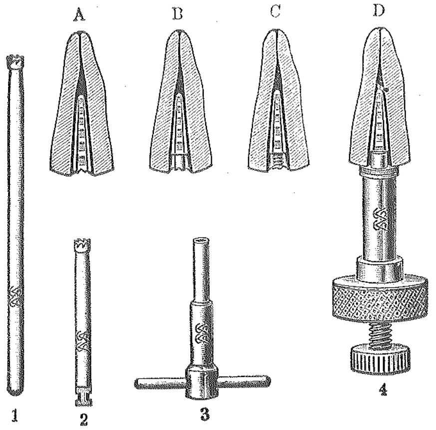


Fig 865.— Crown Post Puller. (S. S. White)

REMOVAL OF A DOWEL FROM THE DEEPER PORTIONS OF A CANAL

When a dowel is fractured within the canal, some distance from the face of the root, the appliances described are unsuited for its removal, and some other means must be employed.

A method which will result in but little sacrifice of tooth structure consists in squaring the end of the dowel, applying a delicate bi-beveled drill to its center and drilling inward a short distance, removing the drill, and with a square end bur reducing the periphery of the dowel by end cutting.

These steps are repeated until, by careful cutting, the entire dowel is removed. Careful manipulation is required to prevent the drill cutting from center to periphery of the dowel.

When the dowel is very small, a fine fissure bur can be passed around it, dividing the cutting as much as possible between tooth structure and metal to avoid weakening the root and excessively enlarging the canal, or in some cases the dowel itself may be gradually cut away with small fissure burs.

This is a most unsatisfactory method of removing a dowel, yet at times it is the only means of clearing the canal.

REMOVING A SHELL CROWN BY SLITTING

The quickest method of removing a shell crown is by slitting one of its axial walls, introducing an instrument in the opening and prying the crown walls away from the tooth, thus breaking the adhesion of the cement.

A fine fissure bur may be used for cutting the slot from gingival to occlusal areas. This method results in loss of substance of the crown wall, and where the crown is to be replaced the space must be filled in with a strip of gold of corresponding width of the slot, or the crown when joined will be too small.

By means of a *crown slitter*, the walls may be divided without loss of gold, and when properly contoured and soldered the crown will fit as before.

This appliance is a plier-like device, one beak carrying a sharp, cutting blade, the other being somewhat broadened

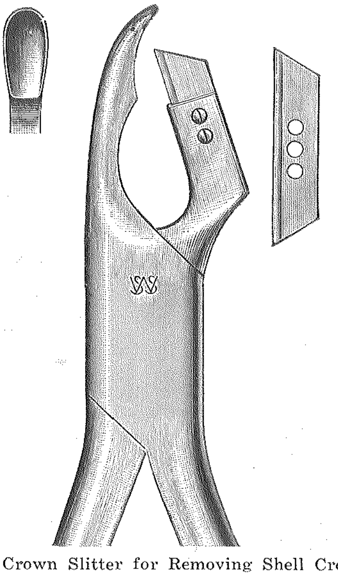


Fig. 866.— Crown Slitter for Removing Shell Crowns

and curved, for resting upon the occlusal surface of the crown.

By introducing the point of the blade against the cervical margin of the crown, the other beak on the occlusal surface, and closing the handles, the wall is readily slit.

REMOVING A SHELL CROWN BY LEVERAGE FORCE

A shell crown can, in most cases, be removed with very little mutilation by the following method:

Drill a hole at a convenient point, just beneath the occlusal surface of the crown, extending it through nearly to the opposite side.

In this hole, which should be about the size of an engine bur wire, a long-handled instrument is inserted to serve as a lever.

Brace the tooth with the finger, on the opposite side from the opening, and exert pressure on the handle in an occlusal direction. This forces the inner point of the instrument against the end of the tooth, or body of enclosed cement, breaks adhesion and releases the crown.

REPAIRING CROWNS THAT HAVE BEEN SLIT IN THE MANNER DESCRIBED

When, in removal, a crown has been mutilated by slitting or by cutting with a bur, the first step in its repair is to remove all cement by boiling in acid. Such portions as fail to come away readily by this means should be removed by scraping and the crown again treated with the acid as before.

This is necessary, because, if not all removed, the oxide of zinc in the cement will, under heat of the blowpipe, be resolved into metallic zinc, which will unite with the gold, forming a low alloy, and cause the latter to fuse, or *burn,* as it is usually expressed.

After cleansing as described, the band ends, or axial walls, are contoured to correct form, wax flowed in any existing space between the ends, trimming it to exact internal contour, the interior of the crown filled with investment, the wax removed, flux applied and solder flowed into and over the joint.

The same method may be employed in closing the drill hole near the occlusal surface, or when waxed, invested and the wax removed, a piece of platinum foil may be pressed in the opening in the crown to the investment, and solder applied to fill the depression and restore axial contour.

REPAIRING A FRACTURED BRIDGE

When the metal part of a bridge is fractured at some point between the abutments, it may be repaired in two ways:

First, remove the parts, saw off the intervening dummies, replace the abutment crowns in position, secure a bite and impression, construct and mount casts on the occluding frame, readjust and wax the dummies in position, remove and invest the assembled bridge, and solder.

Second, when fractured in only one place, remove the broken parts, cleanse thoroughly, press some softened modeling compound on the border between the abutment crowns, return the two parts to position, pressing the dummies into the modeling compound interposed between their cervical ends and the border; instruct the patient to close, thus *biting* the bridge into correct occlusal relation.

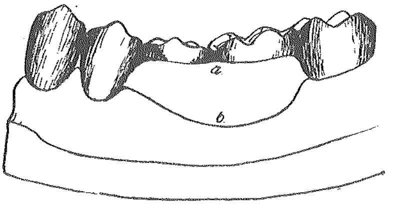


Fig. 867.—Sanitary Bridge. To Secure Relation of Parts, When Structure Is Fractured at A, Interpose Modeling Compound Between A and B

Pressure should be made on the buccal surface of the bridge to prevent outward displacement while the patient is forcing it to place.

When compound is chilled, secure an impression of the bridge in its reassembled relation, remove, invest, and solder.

CHAPTER XXX

PORCELAIN CROWN AND BRIDGE WORK

Porcelain Crown Work

In addition to the many varieties of crowns it is possible to construct by means of facings, partial and full crowns of porcelain as shown, still another type of crown can be constructed and applied in certain cases to advantage. This is ordinarily known as the *baked porcelain crown,* because it is subjected to the process of *fusion* or baking by the prosthetist in his laboratory.

Crowns of this type may be subdivided into three general classes, viz.:

First—A crown supported by and built upon a permanent substructure of metal, usually composed of a cap and dowel of platinum, to which a facing is attached, the lingual portion of porcelain being applied and fused to the cap and affixed facing by the prosthetist.

Second—A crown supported by, and built upon, a permanent platinum cap or base, the entire crown portion being built up and contoured in porcelain body and afterward fused.

Third—A crown built upon and around a cap of platinum foil, which when the crown is fused is removed.

The two former crowns are usually designated as *banded, baked porcelain* crowns, the latter as a *porcelain jacket crown.*

The introduction within recent years of many new and excellent forms of replaceable facings and partial crowns of porcelain, together with improved methods of technic, have to a great extent rendered unnecessary the baking of crowns and bridges, except in special cases.

As a preliminary consideration the fact should be kept in mind that porcelain is strong only in bulk; therefore, in constricted spaces it is liable to fracture under stress.

Again, the porcelain used in inlay, crown, bridge and continuous gum and denture construction is less dense and more friable than that of which porcelain teeth is composed; therefore the former material will not stand the stress, bulk for bulk, that tooth body will resist, without danger of fracture.

Occasionally, however, cases present where a specially baked substitute will fulfill esthetic requirements more satisfactorily than will one constructed by any other method.

INDICATIONS FOR USE

Baked porcelain crowns can be successfully applied in any location where sufficient space is present for a reasonable bulk of porcelain and where the metal structure can be well adapted to the supporting roots.

Crowns of this type are, however, specially indicated when departure from the ordinary anatomic form of the tooth is required, provided such departure will not tend to weaken the crown when constructed.

The porcelain jacket crown is admirably adapted to peg-shaped lateral incisors and frequently to other classes of teeth as well. The placing of a crown of this type on a vital tooth in no way endangers the pulp, providing, of course, proper tooth preparation can be successfully accomplished without serious inconvenience to the patient.

THE BANDED BAKED PORCELAIN CROWN

This crown consists of a rigid root cap of platinum or iridio-platinum, a dowel of iridio-platinum, a tooth facing applied to the dowel by soldering, while its lingual contour is developed by application and fusing of porcelain to facing and root cap.

CONSTRUCTING THE ROOT CAP

Methods vary as to root-cap construction for crowns of this type. The following technic is adopted by many because the metal band on the labial or buccal surface may be entirely obscured by the facing and applied porcelain.

Prepare the root as for an ordinary cap crown described on page 600.

Construct a band of 29 or 30 gauge *iridio-platinum*. Platinum may be used, but it is liable to stretch under stress.

Cut the strip about 1-20 of an inch longer than the actual root measurement, to allow for a lap joint.

Bend one end at right angle to the band, turning over the amount of surplus allowed. The other end is then brought under the bent portion and butted tightly against both the turned portion and band end proper. Solder with high-fusing platinum solder.

Place on a round mandrel and tap lightly to flatten and form a continuous, curved inner surface to band, being careful not to stretch or elongate the metal.

Reduce the excessive thickness of the joint, from the outside, by filing or with engine stones.

Fit the band to root, scribing and trimming the cervical end until perfectly and uniformly adapted to the gingiva, when it is driven to correct position under the gum.

Trim the incisal end of the band to coincide with gingival curvature, allowing it, however, to project slightly beyond the gum margin, lingually.

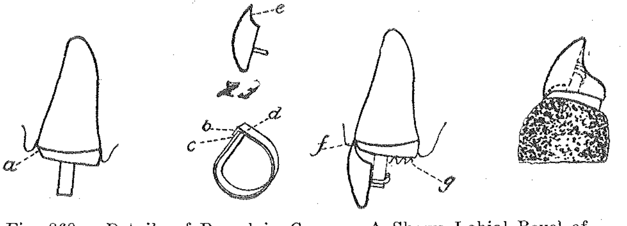


Fig. 868.— Details of Porcelain Crown. A Shows Labial Bevel of Cap; B C D, Lap Joint; E, Ridge Lap of Facing Concaved; F G, Parts Assembled

Drive the band to position on the root, and face the latter to the incisal end of the band.

Remove the band and further reduce the outer or labial third of the root face to a point about where the cervical margin of the band will rest.

Thin the band by grinding, along the labial area corresponding to the reduced root, being careful, however, to leave its extreme cervical margin full thickness.

Return it to the root and with a square end plugger in the automatic mallet, reflect the thinned labial portion over against the root face.

Adapt a disc of 30-gauge iridio-platinum plate to the incisal end of the band, being careful to develop a perfect joint between the two.

Perforate the cap for reception of the dowel, locating the opening far enough to the lingual to avoid interference of the facing from the projecting dowel. When the opening does not coincide with the root canal, ream the latter to correspond.

No. 16 or 15 gauge iridio-platinum, round wire, is usually employed for dowels in central and cuspid teeth, while 17-gauge is used in upper laterals, lower incisors, and when two dowels are applied, in bicuspid teeth.

The opening in the root cap should be slightly smaller than the diameter of dowel, the entrance to canal countersunk slightly, the dowel forced through cap as previously described, relation between the two secured with wax, after which they are removed from root, invested and soldered with medium or high-fusing platinum solder.

Pickle and cleanse the cap and by grinding reduce the labial portion of the cap along the angle, between band and disc, so as to produce a decided bevel in this area. This is necessary in order that the facing, when reduced to a thin edge by grinding, may cover the labial surface of the cap.

Return cap to root, take impression and bite, remove, develop casts and mount on occluding frame.

Select a facing slightly lighter in color than the natural teeth, yet containing the proper basic colors, because, when thickened by the addition of lingual porcelain, its depth of color will be increased.

Grind the ridge lap of the facing somewhat concave, so that it may clear the cap at all points, except along the extreme labial margin, which should be brought to a thin, delicate edge, to rest closely in contact with the cervical margin of the band.

Flatten the pins so that the flattened surfaces lie parallel with the dowel in order that they may present a broad surface bearing when adapted to the latter.

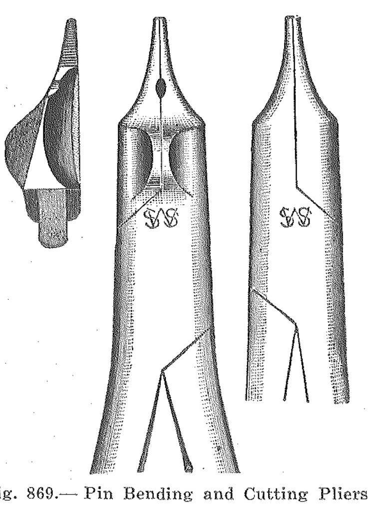


Fig. 869.— Pin Bending and Cutting Pliers

The pin bending and cutting pliers here shown is a most useful instrument for this and many other purposes in crown work.

Set the facing in correct alignment and wax in position. Test its length under lateral movements of the frame and if interference occurs grind away the points of obstruction.

When ground to meet requirements, the facing is again returned to the cap, the flattened pins adapted closely to the dowel, wax applied, the assembled parts removed, invested, and soldered with medium or low-fusing platinum solder.

Care should be taken, in removing the assembled cap and facing, to avoid marring the cast, since, during constructive stages, the crown must be returned to it, from time to time, for testing contour development.

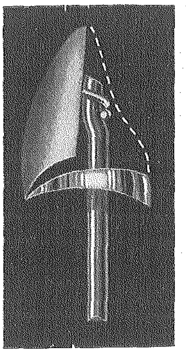


Fig. 870.— Cap, Dowel and Facing Assembled, Ready for Application of the Porcelain

Since the porcelain cannot be perfectly protected from the blow-pipe flame, the investment should be raised to a full red heat before soldering the pins to dowel, otherwise fracture of the porcelain is very liable to occur.

When soldered, the crown should be boiled in acid and thoroughly washed, after which the dowel is grasped in a pin vise to serve as a handle when it is ready for the application of the body.

APPLICATION OF THE PORCELAIN BODY

A small quantity of well mixed *crown and bridge porcelain body,* of medium thick consistency, is taken up on the point of the spatula and placed on the end of cap close to the ridge lap of facing.

Draw a serrated instrument across the pin vise, when the vibration thus produced will cause the granules to settle closely together, and as the water is expelled from the mass it is absorbed by a clean linen napkin or with bibulous paper.

Special care should be taken to fill the space between ridge lap of facing and cap during the first application of body, for if not packed densely at this time it may be impossible to introduce it after the first baking.

The crown may be developed to practically the required contour during the first application of the body. When fused, additions are made where needed to correct loss of contour occasioned by shrinkage of the mass in first baking.

An effort should be made to complete the crown in two fusings. When a third or fourth baking is required the quality of the porcelain rapidly deteriorates.

Dr. F. T. Van Woert has found that by compressing plastic, comparatively dry porcelain to a certain degree by means of a screw press, shrinkage of the mass during the first bake is reduced to one-tenth instead of one-fifth, as usually occurs.

By means of a metal matrix slightly larger than the crown is to be, in which the root cap is placed, the porcelain is applied to it, under pressure, and condensed.

The actual dimensions of the crown having been previously determined, a double end caliper, the beaks on one end of which register one-tenth more than the others, is applied to the crown from time to time, while carving the compact mass to form.

The crown, when carved, ready for the first bake, is one-tenth larger than actually required, but in the first fusing is reduced to actual dimensions.

It is possible by means of these ingenious devices to complete a crown in one baking, while another advantage of great importance is that there is less distortion and greater density of the mass when fused.

The details of fusing porcelain will be given under Porcelain Bridgework.

Finishing the crown consists in polishing such portions of the cervical margins of the platinum cap as may be exposed after fusion of the porcelain is completed.

In setting crowns of this type, special care should be taken to avoid the use of the mallet, as a sudden blow is liable to fracture the porcelain.

Modified Forms of Porcelain Crowns

Various modifications of the baked porcelain crown are constructed, some of which are as follows:

A lingual half band crown, the dowel and facing being attached to a half band diaphragm, instead of the regular form of root cap.

A bandless crown built upon a disc of platinum; usually the root is faced so as to present a decided labial and a lingual plane. The dowel and disc are united, while the facing is ground to rest upon the cervical margin of the disc and is soldered to the dowel.

Bicuspid and molar crowns are frequently constructed by capping the roots as described and fitting dowels in the

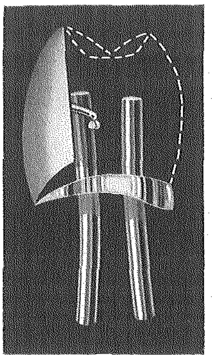


Fig. 871.— Essential Parts of an Upper First Bicuspid Crown Assembled, Ready for Application of Body

root canals, to the outer or projecting ends of which the facings are attached. In such cases it is advisable to solder some auxiliary projections on the root caps in the form of loops or pins to afford additional anchorage for the porcelain.

Frequently entire crowns, without facings, are thus built up on root caps so constructed.

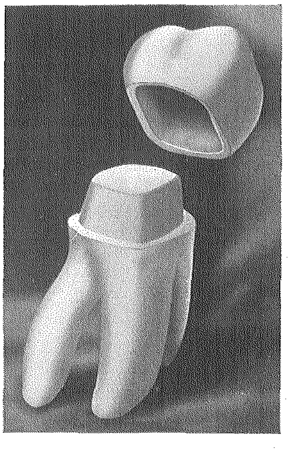


Fig. 872.— Preparation of a Molar Tooth for a Full Baked Porcelain Crown. The Foil Cap Is Constructed and the Porcelain Applied and Baked in a Similar Manner to the Steps Just Described

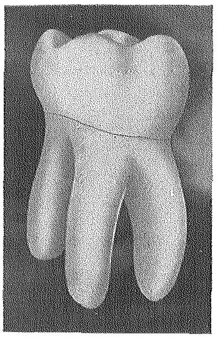


Fig. 873.— The Finished Crown in Position

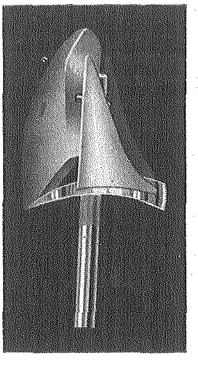


Fig. 874.— Proximal Flanges of Iridio-Platinum Added for Strengthening Crown and Aiding in Holding Contour of Porcelain During Baking. Suggested by Dr. C. A. White

Flanges of iridio-platinum are applied to the root cap, extending incisally or occlusally, to give additional strength to the porcelain and assist in developing contour.

The Porcelain Jacket Crown

The porcelain jacket crown, as before stated, is specially indicated in the restoration of peg-shaped lateral incisors.

The reason for this lies in the fact that an anomaly of this type usually has a small, sometimes distorted, root, in which the placing of a suitable dowel is questionable. Oftentimes it is impossible to successfully remove the pulp and fill the root canal in a satisfactory manner. The crown, also being undersized, requires but little preparation for the reception of a shell crown of porcelain.

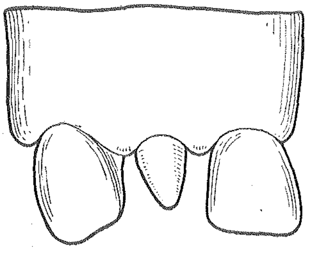


Fig. 875.— A Case Showing Peg-Shape Lateral Incisor Before Preparation

This form of crown can be successfully applied to various other classes of teeth, both vital and non-vital, and when properly constructed and permanently set, fulfills esthetic requirements in the highest degree.

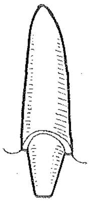


Fig. 876.— Labial View of Prepared Tooth, Showing Gingival Shoulder

TECHNIC OF CONSTRUCTION

Prepare the tooth so that it presents a perceptible cone form, thinning it on labial and lingual surfaces so as to give space for a uniform layer of porcelain.

The mesial and distal surfaces need not be reduced to the same extent as the labial and lingual surfaces, yet they must also converge slightly from gingival to incisal areas.

The sides of the cone should terminate in a distinct cervical shoulder, located just beneath the free gum margin.

TAKING IMPRESSION OF TOOTH

Construct a reasonably close fitting copper band sufficiently long to handle easily, and adapt to the periphery of the tooth. It should not encroach on the peripheral shoulder at any point nor upon the gum margin, but should pass between the latter and the undisturbed peripheral enamel ring.

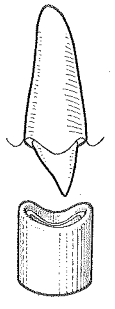


Fig. 877.— Proximal View of Tooth. Impression Taken and Removed

Fill the band with softened modeling compound and apply to the prepared tooth, at the same time closing the incisal end of the band with the finger to prevent escape of impression material.

Apply sufficient force to secure an impression, not only of the axial surfaces of the tooth, and flattened cervical shoulder, but of the root periphery as well.

Chill the compound, remove the impression and trim off gingival surplus.

CONSTRUCTING THE DIE

Apply a section of rubber tubing to the band periphery and pack the impression with amalgam, building it up suffi-

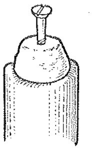


Fig. 878.— Impression Filled with Modelite

ciently to afford a firm base for attachment to the cast, or plaster base.

Modelite may be used to advantage instead of amalgam; in which case, before hardening, a small wood screw should be inserted in the base for anchorage purposes.

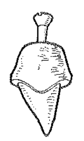


Fig. 879.— Modelite Die of the Tooth

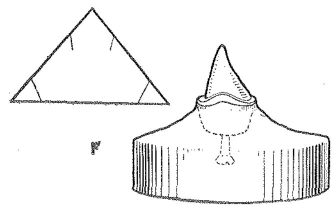


Fig. 880.— Die of the Tooth Set in Base. Triangular Pattern of Foil

Secure an impression in plaster and a bite in wax, of the prepared tooth and of the two proximating teeth also and set aside for later use.

Imbed the die base in modeling compound in a swaging ring and trim so as to freely expose the cervical shoulder.

FORMING THE PLATINUM CAP

Cut a triangular piece of 1-1000 platinum foil of sufficient dimensions to encircle the cervical periphery, and extend somewhat beyond the incisal end of the die tooth.

Anneal the foil and cut off the excess points from the cervical ends of the triangle, as indicated in cut F.

Apply the foil to the die to form a cone, the base of which should extend beyond the cervical shoulder.

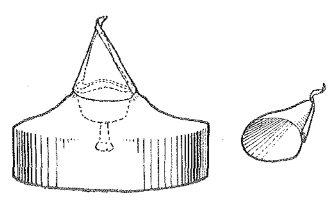


Fig. 881.— Foil Partially Adapted to the Die

Slit the foil near the apex, so that the sides of the triangle may be wrapped around the die.

Before closing the two sides together, the apex of the triangle should be turned over the incisal edge of the die so as to lie beneath them and thus close the incisal end of the cone cap.

With a pair of foil carriers the two sides are grasped and brought together against the lingual surface of the die and there folded together to form a *lap* or *stove-pipe* joint.

At the time of making the folded joint, care should be taken to see that the cone base is embracing the root periphery.

Burnish the now closed cap to the die, carrying the burnisher along the axial surfaces and downward in a cervical direction.

Fig. 882.— Sections Showing Partial and Complete Form of Joint

Trim off excessive surplus, both incisally and cervically, and with a large pellet of absorbent cotton or punk, enclose the entire cap and apply pressure with the fingers from all sides against the axial surfaces, and in a cervical direction as well.

Care should be taken to avoid undue force at all times or the foil will be torn.

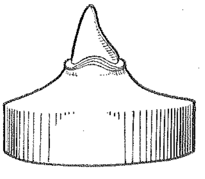


Fig. 883.— Platinum Cap Adapted to Die and Trimmed to Correct Outline Form

When the foil cap is perfectly adapted and its cervical margin trimmed close, but not quite, to the peripheral cervical shoulder, it should be carefully removed and laid aside until the body is applied.

Since the porcelain must be applied and the crown carved so that its incisal edge will come in correct alignment with the proximating teeth, it should be formed on a cast in which these proximating teeth are present.

CONSTRUCTING THE CASTS

The die is now removed from the swaging ring or base in which it was imbedded, the gingival portion of the impression trimmed somewhat freely to admit the die, the latter placed in its matrix and a cast developed in the usual manner.

The bite is applied to the cast, the latter mounted on the occluding frame and the occlusion cast developed.

Trim the plaster from around the cervical end of the die tooth, so as to freely expose the shoulder and permit the foil cap to be set in proper position without interference.

Make a small cylinder of oiled writing paper and apply around the platinum cone, holding it in position with a loosely tied ligature. This is to assist in condensing the porcelain.

APPLICATION OF THE PORCELAIN

High-fusing tooth body (2560 degs.), of suitable shade to match the tooth, is now mixed ready for application.

Usually two shades, sometimes three, are selected and mixed, the darkest being applied to the gingival third, the medium to the middle, and the lightest to the incisal third of the cylinder.

The body should be mixed to medium consistency, and as each portion is applied it should be vibrated to place.

When of medium consistency the sharp lines of demarkation of the two or three colors will disappear during vibration and when fused will show gradual blending of the colors.

As the incisal portion is added, the paper cylinder is flattened mesio-distally to give correct alignment to the incisal portion.

Absorb the moisture that comes to the surface with bibulous or blotting paper, and when compact and reasonably dry remove the ligature and oiled paper.

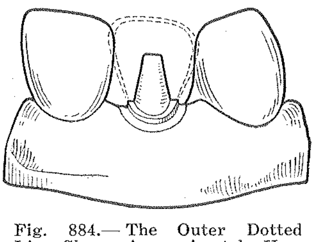


Fig. 884.— The Outer Dotted Line Shows Approximately How Much Larger the Crown Should Be Formed in the Body to Complete It in One Baking

The body is now carved to the required form and such additions made as are necessary.

Particular attention should be given the cervical end, to see that the body comes flush with, but does not overlap, the peripheral root portion of the matrix.

Smooth up all surfaces with a fine sable brush, carefully remove and set on a soapstone base, carved to the general form of the die, but slightly smaller.

The interior point of the support should be sufficiently long to afford a rest for the crown without its weight being thrown on the cervical end.

BAKING THE CROWN

Dry out the moisture in the body very carefully, to prevent flaking, and when ready introduce the crown in the furnace, heat slowly, and bring to a semi-glazed condition.

Since in these cases tooth body is used, a longer time will be required to vitrify the material than is required for continuous gum body.

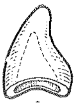


Fig. 885.— The Finished Crown

When fused, the crown is returned to position on the cast, its relations to the other teeth noted, correction made by addition of body to such areas as need further contouring, and the case is returned to the furnace, usually for the final baking, this time bringing the porcelain to a glaze.

If by trial on the cast it is found correct, the crown is moistened, the matrix carefully peeled out of the interior, rough margins are smoothed and the crown is ready for setting.

The "Land" Jacket Crown

Dr. C. H. Land of Detroit was probably the first to introduce a system of practical technic for the jacket crown.

The following outline presents the essential steps of the Land system:

PREPARATION OF THE TOOTH

Remove all of the enamel and prepare the tooth cone-shaped, without cervical shoulder, but in other respects much the same as required for the preceding crown.

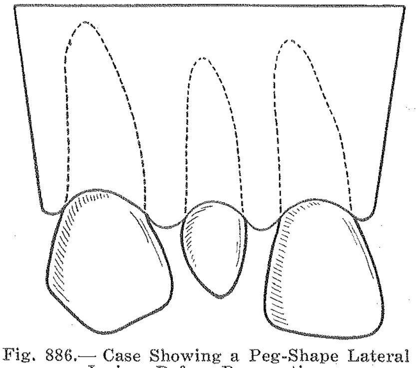


Fig. 886.— Case Showing a Peg-Shape Lateral Incisor Before Preparation

CONSTRUCTION OF THE CAP

Construct and adapt a wide band of 30-gauge platinum to the tooth, scribing and fitting it carefully under the free gum margin as for any banded crown.

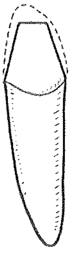


Fig. 887.— Labial View of Prepared Tooth

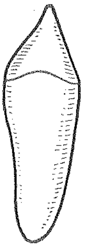


Fig. 888.— Proximal View of Prepared Tooth

The band should extend from the cervix to a short distance beyond the incisal end of the prepared tooth.

Bevel cuts are now made in both mesial and distal surfaces of the band, in line with the labial and lingual planes of the tooth, extending from incisal edge to near the cervical margin.

Bend both labial and lingual sections outward to give space for adapting and burnishing the mesial and distal sections of platinum against these surfaces of the tooth.

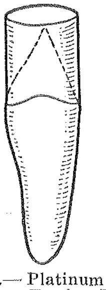


Fig. 889.— Platinum Band Adapted to Tooth. The Dotted Lines Show Where Bevel Cuts Are to Be Made

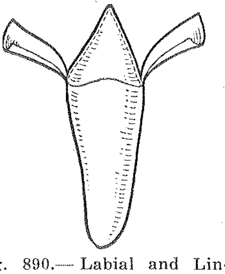


Fig. 890.— Labial and Lingual Sections Bent Outward. Proximal Sections Adapted to the Tooth

When close adaptation of these sections is secured, the edges of the triangular margins may be reduced with discs to permit the other sections of platinum being brought in close contact with the tooth along the joints.

Bend and adapt the lingual section of platinum against this surface of the tooth, removing the excess so that it overlaps the mesial and distal margins of platinum to a slight extent only.

Burnish the joints closely and solder with high-fusing platinum solder.

Adapt and trim the labial section to the sides, and solder in like manner.

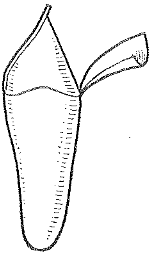


Fig. 891.— Lingual Section Adapted to the Sides

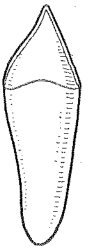


Fig. 892.— The Cap Completed

After soldering, the four angles of the cone cap may be rounded off with discs, to reduce the platinum to uniform thickness.

TAKING BITE AND IMPRESSION

Take an impression and bite of the proximating teeth with cap in position.

Flow a film of wax inside the cap, develop casts, and mount on the occluding frame.

Warm the cap, remove, clear its interior of wax and return to the cast.

SELECTION AND GRINDING OF FACING

Select a facing of desired shade and form and grind to proper alignment.

This step usually requires the concaving of the facing on its lingual side, to a very considerable extent, and the reduction of its ridge lap to a thin margin.

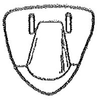


Fig. 893.— Method of Grooving the Porcelain Facing

Frequently, the porcelain must be grooved from cervical near the incisal areas carrying the groove between the pins. In some cases the pins themselves are ground away in order to bring the facing into correct labial alignment. When this is necessary, however, it is best to form a shoulder in the porcelain to rest upon the incisal end of the cap.

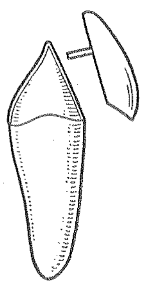
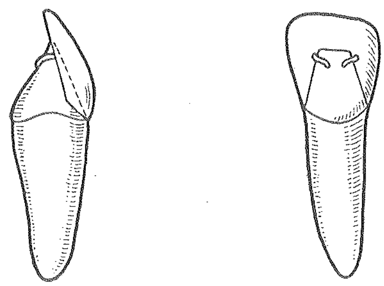


Fig. 894.— Facing Prepared for Adjustment to Cap



Figs. 895 and 896.— Proximal and Lingual View of Facing Adapted to Cap

When ground to correct labial alignment, the pins, if present, are bent in close contact with the cap, the facing and cap waxed in correct relation, when they are removed from the cast, invested, soldered, pickled in acid and washed.

APPLICATION AND FUSING OF PORCELAIN

High-fusing porcelain is now applied around the margins of the facing, next the cap and with vigorous vibration worked into the entire space between the two.

Additions are now made where needed to develop required contour, all surfaces smoothed and with a fine sable brush all particles are removed from the labial surface of the facing and exposed cervical portion of the root cap.

Frequently during the application of the body some of it may become lodged in the interior of the cap, and, if so, should be removed before fusing.

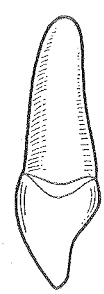


Fig. 897.— The Finished Crown

Set the crown on a soapstone base having a projection for entering the cap of sufficient height to support the crown in an upright position.

Remove the moisture by gradually applied heat, introduce the crown in the furnace and raise the temperature gradually to fusing point, stopping the fusion while the porcelain is in a semi-glazed condition.

Cool slowly and, when in condition to handle, additions of body are made to fill any fissures that may be present, and develop contour where required.

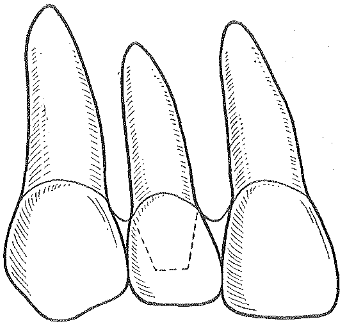


Fig. 898.— The Crown in Position

Since, in a crown of this type, the bulk of porcelain is comparatively slight, and contraction proportionately so, two bakings are usually sufficient to develop required contour, therefore the porcelain should be fully glazed during the second fusing.

Porcelain Bridgework

As previously stated, there is less necessity at the present time than formerly for the construction of porcelain bridges by the baking process.

This is due to the introduction of various types of replaceable, full and partial crowns, which, when properly combined with metal, fulfill esthetic requirements, in many cases, quite as well as do baked porcelain bridges.

Bridges composed of metal, and to which replaceable teeth are adapted, have a decided advantage over those of the former type, in that they are easily repaired in case of fracture of the porcelain parts.

However, cases present when a baked porcelain bridge will fulfill esthetic requirements where one of another type would prove inadequate.

General Considerations

Most of the failures recorded against porcelain, when used in bridgework, are due to its injudicious application.

Certain conditions are often found in the mouth which preclude the introduction of a bridge of this character.

Porcelain is strong only in bulk. In thin, attenuated plates it is friable and breaks readily under stress. The truss or platinum framework must be depended upon primarily to furnish the necessary strength to resist stress. A truss may be constructed that fulfills this requirement and the case still be unsuitable for porcelain if the remaining spaces not occupied by the metal structure are so limited that the porcelain will be spread over the framework in thin layers, especially on occlusal surfaces. The constantly repeated force of mastication, directed against the cusps of porcelain, will fracture and break them away from the truss, even though the latter may be rigid enough to retain its form.

In addition, therefore, to having sufficient space for a rigid truss, there must be sufficient additional space remaining to apply the porcelain in ample bulk to resist stress. It is impossible to state just how wide this space should be. A great deal depends upon the habits of the patient, the amount of force exerted by the muscles of mastication, the length of span and the number and position of abutments and piers.

It may be stated that, as a general rule, there must be a minimum space of at least 5 mm. between the alveolar border and the occlusal surfaces of the opposite teeth in short spans, while longer spans will naturally require more space, since the truss itself must be more bulky.

The length of span is a matter of great importance and should be closely studied. In long spans, where such curvature in the bridge will be required and where only two abutments afford support, a porcelain bridge would most certainly prove a failure. If, however, there is an intervening pier, with sufficient space to insure bulk of porcelain, the case would be suitable for an appliance of this character.

The points to be carefully observed and studied are:

First—The number, position and condition of the roots or teeth that are to serve as supports for the bridge.

Second—The length of span to be covered by the truss.

Third—The amount of space between the alveolar border and the occlusal surfaces of the opposite teeth.

Fourth—The habits of the patient as to the care of the teeth.

Fifth—The amount of force exerted by the muscles of mastication.

Sixth—Study carefully, whether a substitute of any other character might be equally as serviceable if not more efficient than porcelain.

PORCELAIN BRIDGE CONSTRUCTION

The various steps involved in the construction of a porcelain bridge may be arranged in the following order:

First—Preparation of the abutment or pier roots or teeth.

Second—Construction of caps or shell crowns for same.

Third—Taking bite and impression, and mounting casts on occluding frame.

Fourth—Locating position of, and constructing and soldering saddle to caps and crowns.

Fifth—Locating position of, and fitting truss bars in position.

Sixth—Investing and soldering same to caps and crowns.

Seventh—Attaching facings to metal framework.

Eighth—Application of body.

Ninth—Baking.

Tenth—Finishing.

Eleventh—Setting the bridge.

PREPARATION OF ROOTS OR TEETH

The preparation of the roots or teeth for the reception of caps and crowns which are to serve as abutments and piers for bridges differs in no essential particular from the instruction previously given under the heads of *porcelain crowns* and *shell crowns,* therefore it is unnecessary to enter into the details of this procedure here.

CONSTRUCTION OF CAPS AND SHELL CROWNS

When the abutment and pier crowns are to be of porcelain, the construction of the caps is similar to, or identical with, the methods outlined under the head of porcelain crowns.

When platinum shell crowns are constructed for the bicuspids or molars, as is frequently advisable, the details differ in a few essential particulars, from the methods followed in ordinary shell crown construction.

The cusps of crowns, when platinum is used, are more difficult to swage in this material than from 22 k. gold of equal thickness. Therefore, in order to have the needed bulk of platinum in the occlusal surface of a crown, to withstand attrition, two thicknesses of platinum are swaged, separately at first, and then together and solidly attached by soldering.

This is necessary since the interior of such crowns cannot be reinforced with solder, as is done in ordinary crown work, as the latter would be more or less dissipated by the heat necessary to fuse the porcelain.

Special care should be taken to contour the occlusal margin of the band and the corresponding margin of the cusps until they coincide perfectly, then true both contact margins, first with a flat file, following this by dressing on an oil stone until perfect contact is secured, thus obviating the use of much solder in attaching the two pieces together.

The method of constructing a crown of this class in the ordinary manner, and afterward swaging a second piece to the interior to stiffen up the occlusal surface, allowing the margins of the second piece to overlap the joint between the band and cusp, is frequently resorted to with satisfactory results.

To give additional strength to the crown, at the point where the saddle and truss bars join it, a second piece of

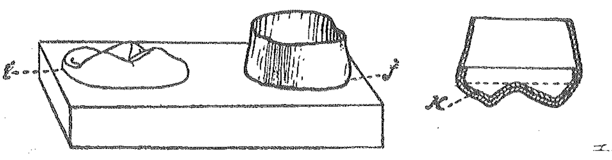


Fig. 899.— On Left, Dressing Down Occlusal Cap and Axial Band on Oil Stone. On Right, Occlusal Cap, Composed of Two Thicknesses of Platinum Plate

platinum plate is often adapted and soldered to this surface, on the outer side of the crown.

The caps and crowns having been constructed and fitted in their respective places, an accurate bite and an impression are secured, the casts constructed, and mounted on an occluding frame.

CONSTRUCTION OF SADDLE

The saddle, although not universally, is frequently used to give the porcelain proper contour on both labial or buccal and lingual surfaces.

Formerly broad saddles were recommended and much used, as previously mentioned, but for reasons already stated their use has been discontinued.

Saddles, therefore, when indicated, should be as narrow as possible, yet sufficiently wide to fulfill the requirements of proper contouring of the case.

The position as well as outline for the saddle can be best determined by waxing the facings in position and trimming the wax to correct form, then trimming the saddle to the line thus indicated. Another method frequently followed is to make the saddle broader than necessary, and after the first application and baking of the body, cut away the surplus margins. This gives good results, but entails considerable waste of material.

The saddle should lap well over caps and against crowns, to insure secure attachment of the several parts. It is cut to proper length and width as indicated by the outline on the cast, and either burnished and conformed to it, or swaged on a Melotte's metal die. Where the surfaces on which the saddle is to rest are very irregular, the latter method is an excellent and accurate one.

When swaged or conformed perfectly to the cast or die, it is attached to the caps and crowns by soldering and the several connected parts are fitted in the mouth for final adjustment of the saddle to the natural tissues. A large round end burnisher, or one of the contra-angled form designed by the author, can be used for this purpose. The saddle should be pressed uniformly against the soft tissues until a slight blanching of the gum is noticeable. This should disappear in three or four minutes and the tissues regain their normal appearance. Too great pressure will produce hypertrophy of the tissues and finally atrophy and absorption, while under a properly adjusted saddle they will usually remain in a healthy condition and in contact with it for a varying period.

At this time the partially constructed framework is in position in the mouth, and the soft tissues in a more or less compressed condition. If removed and placed on the original cast, the saddle would be distorted, since the cast, unlike the gum tissue, is unyielding. Therefore it becomes necessary to take a new bite and impression, and mount the cast as before.

LOCATING AND FITTING TRUSS BARS

In short spans a single bar of 16 or 15 gauge round iridio-platinum wire is usually sufficient to furnish the needed rigidity and support to the bridge. Longer spans frequently require two bars of 16-gauge, or a single bar of 14-gauge.

The position for the truss bar is found by grinding the facings accurately to place and waxing them in position. Varnish the outer surface of the cast with separating medium and build a matrix of plaster against the labial or buccal surfaces of the teeth and cast. When set, remove from the cast, and, if the facings have remained with the framework, remove and place them in their respective positions in the plaster matrix.

The wax is all removed and the plaster matrix carrying the teeth returned to the cast. The truss bar is then bent and conformed to the lingual surfaces of the facings, usually occupying a position between the pins and the ridge lap. By placing in this position, more space is afforded for the porcelain and the liability of its breaking away under stress will be much less than when the bar is placed between the pins and the occlusal or incisal margins of the facings.

Broad surface contact should be secured between the bar and dowels and the several parts held in absolute contact while soldering, so as to insure the greatest possible amount of strength.

The attachment of the bar to a shell crown is usually made by splitting the abutting end and adapting the split portions to the reinforced section of the crown before mentioned; or a hole may be drilled through the axial wall of the crown and the bar bent so as to pass up the inner side of the wall and across the occlusal surfaces, a groove being cut in the tooth, if necessary, for the accommodation of the bar. This affords a firm anchorage to the crown and one that will not pull away, as frequently occurs when the contact of the bar with the crown is limited and superficial.

Round or oval are preferable to square bars, since the sharp angles on the latter seem to induce fracture in the porcelain, under stress.

If square wire is used the sharp angles should be rounded off to obviate this difficulty.

When the bar is accurately adapted, the ends are waxed to the dowels and crown attachments.

In the series of drawings shown in Fig. 900 from a former edition of this text, the construction of a two-bar truss of square wire is illustrated. In 31 *d* the bar next to the saddle is first fitted and attached to cap, dowel and shell crown. The second bar nearest the occlusal surface is next fitted, bending it so as to lie in close contact with the lingual surfaces of the facings as shown in 32 *e*. It can be bent to pass over the pins if necessary, but when possible should pass under them, for reasons before stated. It can be bent irregularly to follow the line of the pins, should they be uneven. The ends of the bars connected with the dowel can be notched as indicated in 34 and the reduced portion bent around it, as shown in 35.

Thirty-three shows imperfect contact of post and bar; 37, a condition in which there is not space enough between the labial side of the dowel and the lingual surface of the facing to receive the truss bar, and, to overcome the difficulty, both dowel and bar are notched. In some cases both bars lie on the same side of the dowel, one upon the other, as indicated in 31 *c*, and again there are cases where, if arranged in this manner, the outer one would be thrown too far occlusally.

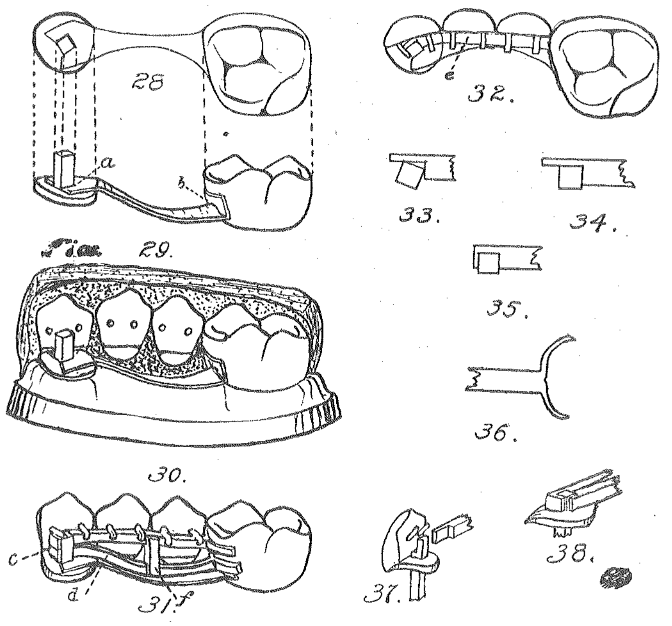
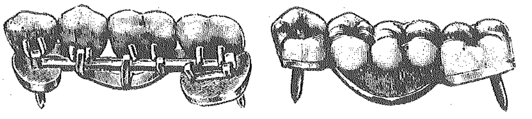


Fig. 900.— Cuts Showing Various Steps in the Fitting of Saddles, Truss Bars, and Teeth of a Porcelain Bridge. In This Case the Molar Is a Shell Platinum Crown

One is then placed on the lingual side of the dowel and the other one on the opposite side, as in 38.

In 36 the method of splitting the bar and bending the split ends so as to partly encircle the shell crown is illustrated. When bicuspids and molar roots carry full porcelain crowns the bars are attached to their caps and posts in the manner described.

The bars, when fitted, are connected by braces, which are cut and accurately fitted in position. Both ends can be notched as shown in 31 *f*.



Cut II Cut III

Fig. 901.— Bridge Before and After Application and Fusing of the Porcelain Body

Cut II shows a single bar truss, with short posts soldered on the molar cap and at intervals along the truss bar, to afford firmer attachment to the lingual body of porcelain.

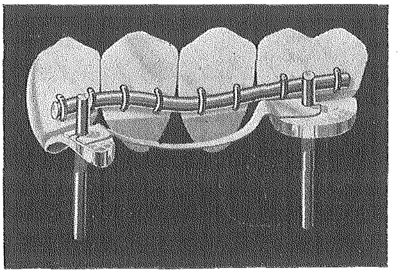


Fig. 902.— Framework of an Upper, Four-Tooth Bridge, Showing Heavy Truss Bar Attached to Dowels of Cuspid and First Molar Crown. Fitted with Narrow Saddle

Cut III shows the piece after the porcelain has been applied and baked.

SOLDERING

The several parts having been accurately fitted they are waxed together, the facings removed, the cap, crown, saddle and truss removed from the cast and invested so that the investing material extends over the bars and holds them firmly in position after the wax is removed. When soldered, the frame is returned to the model and the facings returned to place, waxed in position, the piece removed, again invested, the pins, after having been flattened, bent in actual and close contact with the bar and soldered.

The essential points to be observed in constructing the framework for a porcelain bridge are:

First, be accurate in every detail. Second, develop close joints. Third, flow solder into and between all junctions so as to perfectly unite the several parts together.

APPLICATION OF THE BODY

Before applying the porcelain body, the framework should be pickled, cleansed and roughened on those surfaces against which the porcelain is to be fused to afford some additional attachment of the porcelain to the metal framework.

As mentioned in connection with crown work, a pin vise can be used to good advantage in handling the piece while applying the body.

The body is built on the lingual surfaces of the facings and against the saddle a little at a time, the piece vibrated to settle the granules of powder close together, the moisture is taken up as it appears on the surface, and a rough contour given the piece for the first baking.

All particles of body should be removed from the labial or buccal surfaces of the facings, for if carried through the furnace they become attached and can only be removed by discing or grinding, which destroys the fine glaze on the porcelain.

FUSING THE PORCELAIN

The directions, beginning on page 615, with reference to the fusing of continuous gum body apply with equal force in the fusing of porcelain in bridgework. Usually, the piece, being smaller, can be fused in somewhat shorter time than a

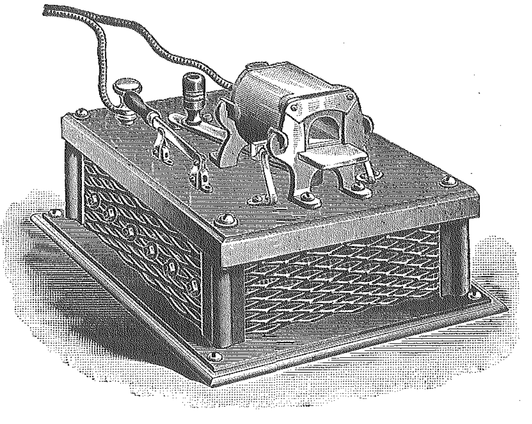


Fig. 903.— Small Electric Furnace Suitable for Porcelain, Crown, Bridge, and Inlay Work (Hammond)

full denture, and since less time is required, greater care must be observed in the latter stages of baking, to prevent over fusion.

When possible to do so, the bridge should be completed in two bakings to avoid friability of the material, which characteristic, as well as a tendency to become porous, develops rapidly after the second fusion.

FINISHING AND SETTING THE BRIDGE

Finishing and setting a porcelain bridge differ in no essential particulars from the steps involved in the finishing and setting of porcelain crowns, the details of which have been given. As previously mentioned, however, the use of the

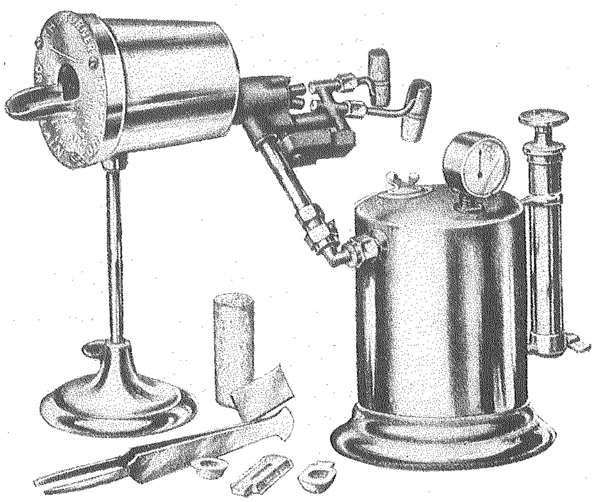


Fig. 904.— Small Gasoline Furnace Suitable for Porcelain Crown, Bridge, and Inlay Work (Turner)

mallet, either hand or automatic, should be avoided in the setting of baked crowns of porcelain, combined with metal, because of the very great danger of fracture.

VARIOUS TYPES OF METAL STRUCTURES

The principal thought to keep in mind in planning a porcelain bridge is to form a rigid metal structure, capable of sustaining all stress to which the bridge may be subjected, without depending upon the applied porcelain.

Therefore, the forms of trusses may be varied according to conditions, as space occluso-gingivally, length of span, position of abutments, width of alveolar border, etc.

Frequently, in the replacement of a single tooth, a truss of the cantilever type may be united with a single crown, the opposite end from the crown terminating in a projection for resting in a grooved inlay in the proximating tooth.

In other cases, instead of a saddle being adapted to the border, a half-round wire is fitted close to, or in contact with, the border crest, against which the buccal and lingual surfaces of applied porcelain may terminate.

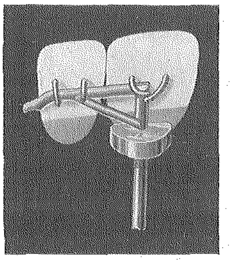


Fig. 905.— Framework of an Extension Bridge, with Supporting Lug to Rest in Grooved Inlay in Cuspid Tooth

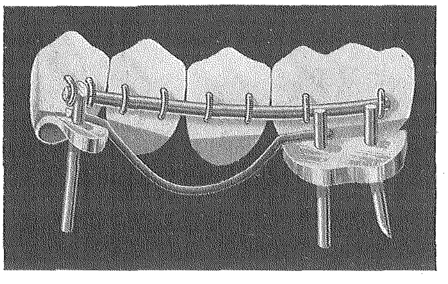


Fig. 906.— Framework of a Lower Four-Tooth Bridge. Heavy Truss Bar for Supporting Teeth. Half-Round Wire to Rest on Border Crest, and Against Which Both Buccal and Lingual Surfaces of Porcelain Will Terminate

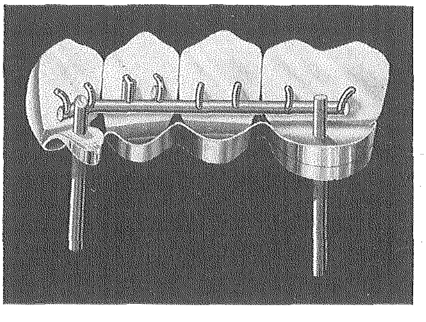


Fig. 907.— Framework of an Upper, Four-Tooth Bridge Fitted with Saddle, to Which a Lingual Flange Is Applied for Support of Porcelain

Again a flange of platinum is adapted and attached to the lingual border of the saddle or wire to add strength to the framework and afford a matrix for supporting the porcelain under stress.

The Peeso and Benson pliers, because of their short beaks and heavy handles, are particularly useful for contouring of

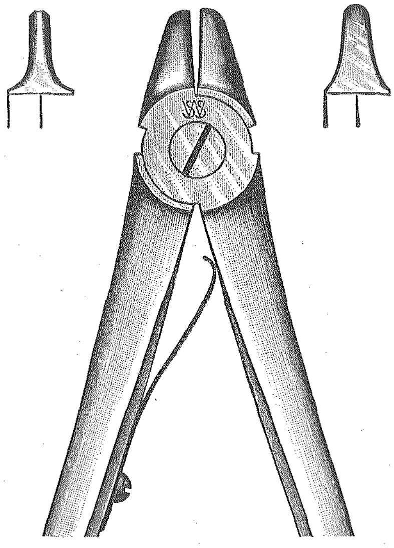


Fig. 908.— The Peeso Contouring Pliers

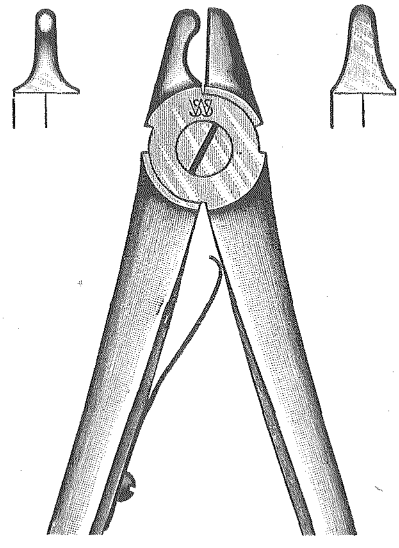


Fig. 909.— The Benson Contouring Pliers

plate and bending of wires in this, as in many other classes of crown and bridge work.

CHAPTER XXXI

INLAYS

Porcelain and Metallic

PORCELAIN

Porcelain, or "chinaware," was imported into Europe principally by the Portugese, who gave it the name of *porcelain,* from its resemblance to the nacre or lining of the sea-shell Porcellana (Cyprea). The shells of this species derive their name from their supposed resemblance to the back of a hog (Porcus). It was at first supposed that porcelain consisted of pulverized egg shells, fish scales and fish glue.

The first authentic record we can find of porcelain being used for dental purposes appears in the "Art of Dentistry," published by Fauchard in 1728. In this he says: "I have thought that advantage might be derived from a regular and unalterable coloration from enamel artificially composed. I have also thought that I might from this not only perfectly imitate the enamel of the teeth, but the gum in cases where it is necessary to replace the teeth in whole or in parts of sets. I have consulted the most able enamelers, and by conversations which I have had with them I have rendered practicable that which I believe no one else has ever thought of; the teeth or dentures made of enamel will endure a very considerable time, since the enamel is a substance scarcely susceptible of change or alteration."

EARLY APPLICATION OF PORCELAIN IN DENTURE CONSTRUCTION

The development of porcelain in its application to dentistry is a most interesting story, an outline of which will be found in the chapter on the "History of Prosthetic Dentistry."

The efforts of the pioneers in the porcelain field until Fonzi's time, 1808, were directed principally to the production of full and partial dentures in a single piece, yet but little progress was made in this class of work until about 1850, when Dr. John Allen introduced the *continuous gum denture.* His work consisted in improving the character of the porcelain then in use, reducing its fusing point and contractile tendency, improving the color of the gum enamel, and of baking the denture on a platinum base to which the teeth were previously attached by soldering. The use of the platinum base obviated the warpage, which invariably occurred when the porcelain was fused on a silex and plaster form.

CORRECTION OF WARPAGE IN THE ALL-PORCELAIN DENTURE

Previous to Allen's improvement, it was necessary, after the denture was baked, to secure an accurate cast of the mouth in plaster, paint the areas to be covered by the denture with red lead or similar pigment, and apply the denture to the cast; the areas of contact between denture base and cast were colored on the base with the pigment, and on removal were ground with small stones. This process of trial and grinding was repeated until finally the entire denture surfaces which rested upon the oral tissues showed *color,* when pressed upon the cast. The same general technic was followed in securing adaptation to the oral tissues, of the old-time dentures carved from the elephant or hippopotamus ivory.

Dentures constructed by this method, while occasionally showing good adaptation and stability, usually required the aid of springs for their retention under masticatory stress.

Basic Ingredients of Porcelain

The basic ingredients in most of the porcelain bodies of today consist of kaolin, silex and feldspar in proportions varying according to the purpose for which the material is intended. The porcelain used for tooth bodies is the highest fusing of any used for dental purposes, the point of vitrification ranging from 2,440 to 2,600° F.

KAOLIN ($Al_2H_2(SiO_4)_2H_2O$)

The word *kaolin* is a corruption of the Chinese word *Kauling,* which means a *high ridge,* and is the name of a hill near Jachau Fu, China, from which a great deal of this material is derived. A fine variety of clay is also found in Germany. Both of these varieties of clay are practically free from iron oxide and other deleterious impurities and are used almost exclusively in the compounding of dental porcelains.

Kaolin is a fine pure variety of clay, or aluminum silicate. It is formed by the disintegration and decomposition of granitic and feldspathic rocks through *weathering,* or continued freezing and thawing. These rocks being granular, take up moisture, and this when expanded by freezing splits off the outer surfaces of the rock. The rain in time dissolves out some of the constituents and washes away the small particles, which, as they are carried down the stream, grind upon each other and become still more finely divided until all semblance of their original form is lost. These particles, mixed with sand, float or are washed down stream and settle in beds. Some of these clay beds are at the present time high above the water line, having been deposited ages ago and placed in their present location by volcanic upheavals.

PREPARING THE CLAY FOR USE

The clay is prepared for use by mixing with water in a tank, agitating and allowing the sand and heavier particles to settle, after which the water is drawn off into another tank, while the finer particles of clay are still held by it in solution.

These finer particles are allowed to settle in the second tank, and when the water becomes clear it is carefully drawn off and the clay allowed to dry. The slab of dry clay is then turned over and the coarser particles which settled to the bottom as the first precipitate are scraped off, when it is ready for use.

FELDSPAR ($K\,Al\,Si_3O_8$)

Feldspar is a double silicate of aluminum and potassium known as Orthoclase. It occurs crystallized in rhombic prisms. There are many varieties of this mineral, but only those that are free from soda or lime are used in compounding porcelain. It is yellowish pink in color in its natural state, but transparent and colorless when fused.

A variety of this mineral suitable for tooth bodies is found in many parts of the United States. The principal deposits suitable for the compounding of porcelain are found near Wilmington, Del.

PREPARING THE FELDSPAR FOR USE

Feldspar is prepared for use by heating to redness, dropping in water while hot, to break it up into small pieces, ground to powder in a special pulverizing machine or with a large mortar and pestle, and under water, to facilitate the grinding. The powder is then run through a No. 10 bolting sieve, placed in closed vessels to keep dry and free from impurities until needed for use. Pulverizing too finely detracts from the translucency of the porcelain when fused.

SILICA ($Si O_2$)

This mineral is a silicic oxide, ordinarily known as quartz. It is one of the constituents of granite rocks; it also occurs free in large masses in many parts of the United States, as well as in many parts of the world.

PREPARING THE SILICA FOR USE

Silica is prepared for use by grinding to a fine powder in a powerful mill constructed especially for this class of work. It is extremely hard and fuses only at very high temperatures, about 2,500° F.

These three materials, kaolin, silex and feldspar, as before stated, are combined in varying proportions to form tooth bodies, and the more fusible continuous gum and inlay bodies.

Properties of the Basic Constituents of Porcelain

Kaolin imparts plasticity to the tooth body, enabling it to be molded into the desired form before baking. It also contracts somewhat in fusing, and as a result draws together the more infusible constituents, thereby impairing density to the mass.

Silex, on account of its infusible property, tends to keep the form into which it is molded, whether inlay, tooth, crown, bridge or denture, from melting down in the heat of the furnace.

Feldspar imparts translucency and also acts as a flux, closely uniting the kaolin and silex. By varying the proportion of this material in compounding the body, a number of porcelains differing in texture and fusibility can be produced.

APPROXIMATE PROPORTIONS OF INGREDIENTS IN PORCELAIN

The manufacturers do not publish the forumlas of their tooth, or other porcelain bodies of the lower fusing types designed to be used in continuous gum and other classes of work. Since it is not necessary for the prosthetist to compound his own porcelain materials, as the pioneers in this field were required to do, still it is essential that he know the elementary constituents and their physical properties in order that the best results may be derived from their use.

The names of Wildman, Hunter and Allen are inseparably connected with the history of continuous gum work and carved block teeth in this country, and to them the profession owes much for improvements in porcelain bodies and technical methods. The period of greatest activity of these early porcelain workers extended from 1835 to 1860. Since the latter date the carving and baking of single and block teeth in the dental laboratory, as was the prevailing custom in their time, has been discontinued because of the continually advancing improvements in these lines of the manufactured products. Continuous gum dentures, however, cannot be made in a factory. The prosthetist, therefore, should be capable of selecting the best material and of manipulating it in the best possible manner to secure artistic and permanent results in the construction of dentures of this type.

The following formulas will show, in a general manner, the proportions of the basic ingredients used in compounding some of the many porcelains:

Dr. Wildman's formula for *tooth body:*

No. 1.	Kaolin	1 oz.
	Silex	3 ozs.
	Feldspar	18 ozs.
	Titanium oxide	65 grs.

Titanium oxide imparts a yellowish tint to porcelain. The oxides of some of the other metals are used for producing various tints, as required; they are mixed in and thoroughly incorporated with the porcelain in process of manufacture, the latter often, after the addition of the metallic oxide, being fused, crushed and pulverized, to more thoroughly disseminate the tint.

OXIDES OF THE METALS USED IN TINTING PORCELAIN

Gold in a state of minute subdivision	Rose red
Oxide of gold	Bright rose red
Purple of Cassius (double oxide of tin and gold)	Purplish red
Sponge platinum and filings	Grayish blue
Oxide of cobalt	Bright blue
Oxide of manganese	Purple
Oxide of uranium	Greenish yellow
Oxide of silver	Lemon yellow
Oxide of zinc	Lemon yellow
Oxide of titanium	Bright yellow

The formula for *continuous gum body* is similar to that of the Wildman tooth body, previously given, except that more kaolin and feldspar are added to reduce the fusing point; this is necessary in order that the teeth, which have previously been attached to the platinum base, will not be fused and lose their shape or color while vitrifying the continuous gum body.

THE CONSTITUENTS OF GUM ENAMEL

The continuous gum body, when applied around the teeth and over the metallic base, gives form and contour to the denture; in color it does not resemble the natural gums, being white, or, when oxide of titanium is present, slightly yellow; the denture must be tinted to give it a natural appearance. A material called *gum enamel,* purplish pink or red in color, is distributed in a thin, more or less uniform layer, over those surfaces representing the mucous tissues and fused to the continuous gum body, thus giving the required color and the proper glaze, to the surfaces of the denture as well.

Gum enamel is made by combining certain compounds in definite proportions with feldspar. These compounds are known as *frits* and *fluxes,* the formulæ of which are similar to the following:

No. 2. Flux.

Carbonate of potassium	1 oz.
Fused borax (powdered)	1 oz.
Quartz	4 oz.

These materials are fused together, then crushed and ground to a fine powder, to prepare them for combining with the following:

No. 3. Gum frit.

Purple of Cassius	16 grs.
Feldspar	700 grs.
Flux (as per Formula No. 2)	175 grs.

This gum frit is fused, crushed and ground to a fine powder, preparatory to the final compounding of the pink gum enamel.

No. 4. Gum enamel.

Gum frit (as per Formula No. 3)	1 oz.
Feldspar	3 oz.

This also is fused, crushed and ground, when it is ready for use. Fortunately, both continuous gum body and gum enamel of excellent quality are procurable at the supply houses, which, by mixing into a paste with water, is ready for immediate use. From the preceding formulas a vague idea can be formed as to the amount of study and effort it has taken to develop suitable materials for use in dento-ceramic art.

CROWN, BRIDGE AND INLAY PORCELAINS

The porcelain most commonly used in crown, bridge and inlay work closely resembles in composition and physical properties that prepared for continuous gum work, except that it is ground a little finer and fuses at a slightly lower temperature. Crown, bridge and inlay porcelain is also prepared in a variety of colors, in order to match the varying shades of teeth in and next to which it may be placed.

HIGH AND LOW FUSING PORCELAIN BODIES

The fusibility of porcelain separates this material into two general classes, the fusing point of pure gold being the dividing line. Those fusing at or above this point are called *high fusing,* and those fusing under this point are denominated *low fusing* porcelain.

The following table, from Dr. W. A. Price's temperature scale, gives the approximate temperatures required to vitrify the principal bodies and enamels, also the fusing point of gold and copper as registered by the same scale:

Consolidated tooth body	2630-F.
S. S. White's tooth body	2515-F.
Dental protective tooth body	2440-F.
Justi's tooth body	2440-F.
Sibley's tooth body	2410-F.
White's porcelain (crown and bridge)	2300-F.
Close's body	2300-F.
Ash's tooth body	2260-F.
Whiteley's porcelain	2210-F.
Brewster's body	2210-F.
Consolidated high fusing	2200-F.
Brewster's enamel	2080-F.
Moffitt's porcelain	2050-F.
Copper	1980-F.
Gold	1950-F.
Ash's high fusing	1900-F.
Downie's	1550-F.
Jenkins'	1550-F.
Ash's	1550-F.
Brewster's low	1500-F.

COMPARATIVE VALUE OF HIGH AND LOW FUSING PORCELAINS

Experience has shown that high-fusing porcelain is a stronger and more permanent material for use in the mouth than is the low-fusing porcelain. For this reason, therefore, it has almost entirely displaced the latter, especially in crown and bridge construction, and in inlay work where the filling will be subjected to any considerable stress.

The principal advantage of low-fusing porcelain for inlay work is in the ease with which it may be fused, and in certain cases because of its more opaque texture, better color results in the matching of the natural teeth are possible than with high-fusing bodies. In the hands of the inexperienced it is doubtful whether the low fusing will yield as good results as will the high-fusing bodies.

Porcelain Inlay Work

The system of inlay work most generally in vogue at the present time consists in preparing the tooth cavity, conforming a matrix of platinum or pure gold to it, or a reproduction of it, fusing the inlay material into the matrix thus formed, removing the matrix from the fused filling and setting the latter in the cavity with cement. Like all classes of filling materials, porcelain has its advantages and disadvantages.

ADVANTAGES

With care, skill and experience, porcelain inlays may, in many cases, be so accurately constructed, and the shades of the natural teeth in which they are placed so perfectly matched, that it will be impossible to detect these restorations from the natural tooth structure, except by the closest scrutiny. The esthetic properties of this material, therefore, place porcelain above that of any other filling material for the artistic restoration of natural teeth. Its insolubility places it above the synthetic cements.

Second, porcelain is a poor thermal conductor, and for this reason, inlays may be placed in cavities of teeth, the pulps of which are sensitive to sudden temperature changes, where metallic fillings could not be tolerated.

Third, patients are relieved from long and tedious sittings in the chair, when for any reason they are physically unfit for lengthy operations.

Fourth, the strain upon the operator is much less than in ordinary filling operations.

OBJECTIONS

The principal disadvantages resulting from inherent defects in the material itself, or from the use in the mouth, may be stated as follows: Friability, constructive difficulties, shadow problem and retention.

FRIABILITY

In thin, attenuated plates, porcelain is friable and very easily broken. It is strong only in bulk, and, therefore, the utmost care should be exercised in the preparation of cavities to so shape them that the inlay, when set, may be subjected to but little, if any, stress. Cavities involving an incisal edge or the proximo-occlusal surfaces of a bicuspid or molar should be so formed that the inlay will have strong, well-defined margins and ample bulk to withstand masticatory action without fracturing. When conditions preclude the formation of cavities in this manner, porcelain is contraindicated.

DIFFICULTIES MET WITH IN CONSTRUCTION

Among the most important difficulties which arise during the construction and in the application and use of porcelain inlays, the following deserve careful consideration:

First, inlay retention, or developing retention form in the cavity, so that the inlay, when formed and set, may not become displaced under stress.

Second, securing correct adaptation of the matrix to cavity walls.

Third, avoiding warpage of the matrix during the fusing of the porcelain.

Fourth, the selection, application and fusing of the several tints of porcelain in proper succession, so that the finished inlay will coincide in color with the natural tooth in which it is to be placed. These constructive problems will now be briefly considered.

INLAY RETENTION

The walls of cavities intended for the reception of inlays of any class must show slight divergence from within outward in order that the matrix, or wax model, may be released without distortion. This applies to both gold and porcelain inlays.

A cavity should be so shaped that when the inlay is constructed and set, the forces to which the latter is subjected will tend to drive it into the cavity rather than out of position. Where an inlay is solely dependent upon cement for retention purposes, particularly when subjected to any appreciable stress, its permanence and value as a filling are questionable.

The usual means of retention capable of being developed in the formation of the cavity are: parallel or slightly divergent, opposing walls, flat seats, and grooves so formed as to permit not only the ready removal of the matrix without distortion, but to allow the inlay, when completed, to go to place without interference.

As a means of retention for porcelain inlays, Dr. F. H. Skinner suggests the following:

Drill one or more small retention pits in gingival wall or incisal step of the cavity, in line with the direction of removal of the matrix.

When the matrix has been conformed to the cavity, that over the retention pits is punctured and the margins turned into the opening.

Each pit is now lined with a small cylinder of foil made by cutting a strip slightly wider than depth of pit and a little more than three times longer than its diameter.

This strip is formed into a cylinder, slit at three or four points around the periphery, so that the sections of foil between may be reflected outward.

The cylinder is passed through the opening in the foil, to the bottom of the pit, the slit sections of the opposite ends turned down on the foil covering the gingival wall, or incisal step of the cavity, and there closely adapted to the matrix.

The cylinder which lines the pit should be pressed outward against its walls so as to form a clear opening into which the porcelain may later find its way.

Sticky wax is now softened and pressed into the cavity, against all matrix walls, and when hardened the foil can be removed without distortion.

The matrix is invested in high-fusing investment material and when set the wax is removed and the porcelain applied for first bake.

If, in applying the wax, care is taken to fill the small cylinders in the retention pits also, to exclude the investment, the porcelain will flow into and fill them.

When the inlay is fused, and the foil is removed, the small projections of porcelain which are seen will fit into the retention pits of the cavity and prevent displacement.

WARPAGE OF THE MATRIX

Platinum foil 1/1000 of an inch thick is most commonly used for matrix construction in porcelain work. Thicker foil, say 1/500 of an inch, while naturally more rigid, when stripped from the completed inlay, results in too much space between the latter and the cavity walls; again, it is more difficult to adapt to small or complex cavities than the lighter gauges. On the other hand, 1/2000 foil, occasionally used, is too easily distorted, both in handling and through contraction of the porcelain in fusing, to be depended upon as a reliable matrix material.

NECESSITY FOR ANNEALING THE FOIL

Unless thoroughly annealed before beginning, kept soft by occasional reheatings throughout the steps of adaptation, and given a thorough final annealing, followed by final pressure swedging with spunk, camphor gum or sticky wax, before applying the porcelain, any of the platinum foils ordinarily used in matrix construction are very liable to spring away from the cavity walls, either before or during the fusing process, and thus present from the very start an imperfect matrix in which to fuse the porcelain.

WARPAGE RESULTING FROM IMPROPER SUPPORT OF THE MATRIX

Warpage of the matrix may also result from its improper support in the furnace while baking the porcelain. Before final adaptation of the foil to the cavity is secured, excessive overlapping peripheral margins and long, angular points must be removed; otherwise one or more of such points may prevent the matrix proper, with the added weight of the porcelain, from resting uniformly upon the muffle slab. Under ordinary temperatures no mishap would occur, but with the platinum highly heated and somewhat soft, contraction occurring in the porcelain contained within it, together with more or less adhesion, developed and active, between the latter and the metal, warpage is most certain to occur. A muffle tray or slab for supporting and carrying the matrix, having a slight depression in its upper surface, can be used to advantage in the fusing of inlays of complicated form. In the depression of the slab, some granular silex is placed, building it higher in the center, if necessary, to meet and support the matrix. On this granular bed the matrix is carefully placed, moving it just sufficiently to develop support at several divergent points, particularly in the center.

WARPAGE DUE TO CARELESS HANDLING

In addition to these causes of warpage mentioned a matrix may be distorted through careless handling in removal from the cavity, or in any of the manipulative procedures up to the time the porcelain is fused within it. The necessity for exercising constant, ever-watchful care in the production and manipulation of the matrix and in applying and fusing the materials is one of the principal reasons why porcelain is not used more extensively than it is at the present time.

FAVORABLE LOCATIONS FOR PORCELAIN INLAYS

Porcelain inlays are indicated in all cavities exposed to view, when proper retention can be secured, and the fillings, when constructed, will have sufficient bulk to withstand stress.

The classification of cavities, ranging from those in which porcelain is most strongly indicated, to those in which it is least required, may be stated as follows:

First—Gingival third cavities in the anterior teeth.

Second—Proximal cavities in the anterior teeth, not involving the angles.

Third—Proximal cavities in the anterior teeth, involving the angles.

Fourth—Cavities in bicuspids and molars, involving a visible axial and occlusal surface.

Fifth—Occlusal cavities in the posterior teeth.

GENERAL RULES IN REGARD TO CAVITY PREPARATION

Cavity walls should be formed at right angles to the surfaces in which they are located.

Opposing axial walls should be formed as nearly parallel as possible, yet be sufficiently divergent to permit the matrix to be withdrawn without distortion.

Gingival and pulpal walls should be flat, and at right angles to the long axes of the teeth.

Cavo-surface angles should be planed true, but not perceptibly beveled as for gold foil or amalgam fillings. This is to avoid the formation of a frail margin to the porcelain.

Cavities occurring in occlusal surfaces should, when practicable, have the cavo-surface angle of their walls laid beyond points of contact or occlusion with the opposite teeth.

This will greatly reduce the liability of margins to fracture under stress.

When an inlay is properly set, under pressure maintained while the cement is crystallizing, the minutest space between the cavo-surface angles and the periphery of the inlay is filled with condensed cement. This supports both enamel margins and those of the inlay, and since condensed cement maintains its integrity much better and solution occurs more slowly than when introduced as an ordinary filling, it is reasonable to suppose, and observation has shown, that cavity margins, though only slightly beveled, will stand for a considerable length of time.

Details of Cavity Preparation

GINGIVAL THIRD CAVITIES IN THE ANTERIOR TEETH

In cavities of this class, as well as in all others, the principles of *extension for prevention* should be carried out as fully as possible.

Undermined enamel should be broken down and the cavity outlines made symmetrical.

The walls should be as nearly parallel as conditions will permit to insure retention of the filling.

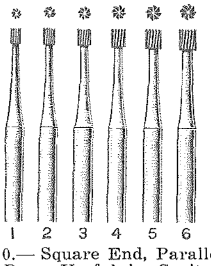


Fig. 910.— Square End, Parallel Side, Burs, Useful in Cavity Preparation

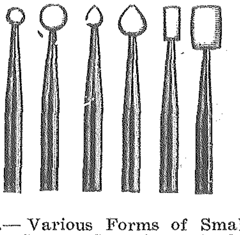


Fig. 911.— Various Forms of Small Arkansas Stones, Sometimes Used in Smoothing Margins

In surfaces where much curvature exists a parallel condition of the walls may be secured, partially at least, by squaring out the dentine slightly below the dento-enamel junction.

The angle formed by the junction of the axial with other walls should not be squared out too definitely.

The cavo-surface angles should be sharp and well defined and but slightly beveled, if at all, in order that the peripheral margins of the inlay will not be frail.

PROXIMAL CAVITIES IN THE ANTERIOR TEETH NOT INVOLVING THE ANGLES

In cavities of this class it is necessary to separate the teeth before beginning operations. These cavities must be

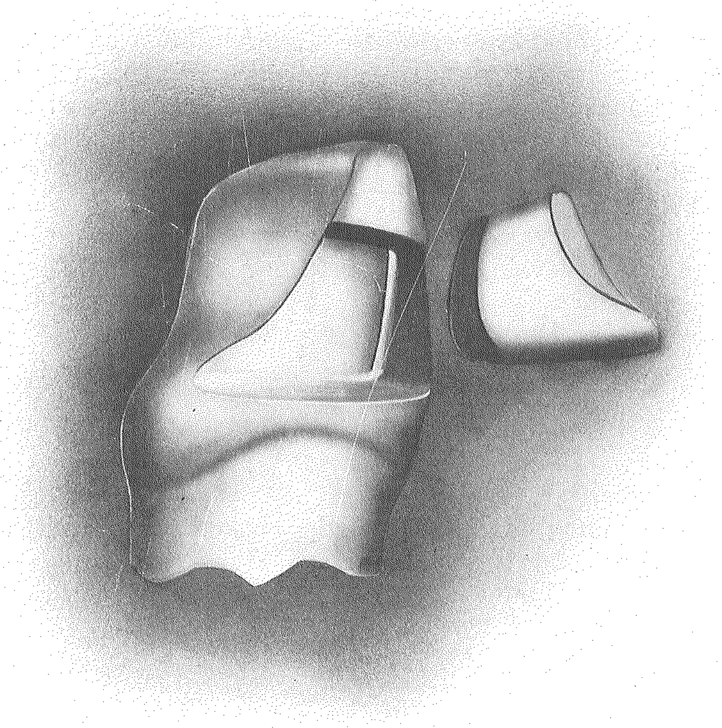


Fig. 912

formed without undercuts. They should be so shaped that the matrix when burnished in position can be removed without distortion. The location of the cavity will determine the direction in which the matrix can be most readily removed, whether labially or lingually. If the cavity of decay has progressed more to the labial than to the lingual, the cavity preparation should be made to allow the removal of the matrix labially. If decay has progressed to a greater extent lingually, the preparation of the cavity should be made accordingly to meet this condition. (See Fig. 912.)

The gingival and incisal walls should be made as nearly parallel to each other as practicable. When the cavity is formed for the introduction of the matrix from the lingual side, the labial margin should be carried far enough labially to insure the porcelain being well exposed to view. This will partially obviate the *shadow problem* that arises in this location. The cavo-surface angles should be prepared as outlined in cavities of the previous class.

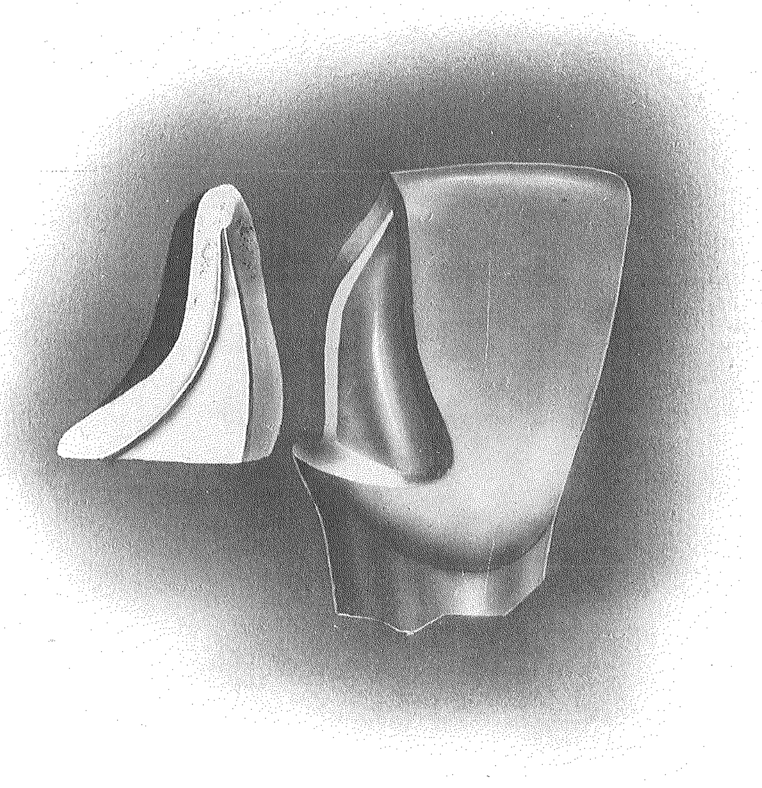


Fig. 913

BUCCAL CAVITIES

The preparation of cavities of this class is similar in most respects to those of the first class mentioned, and the rules there laid down apply with equal force to the class under consideration.

PROXIMAL CAVITIES IN THE ANTERIOR TEETH INVOLVING THE ANGLES

The preparation of cavities of this class requires much thought and skill, since the completed fillings are exposed to a greater or less amount of stress in mastication.

The gingival wall or seat should be made flat and at right angles to the long axis of the tooth.

The introduction of inlays in cavities of this class must naturally be in a labial, lingual or incisal direction, therefore the labial and lingual cavity walls must be formed at least parallel with the long axis of the tooth.

In the upper anterior teeth, when the cavity does not

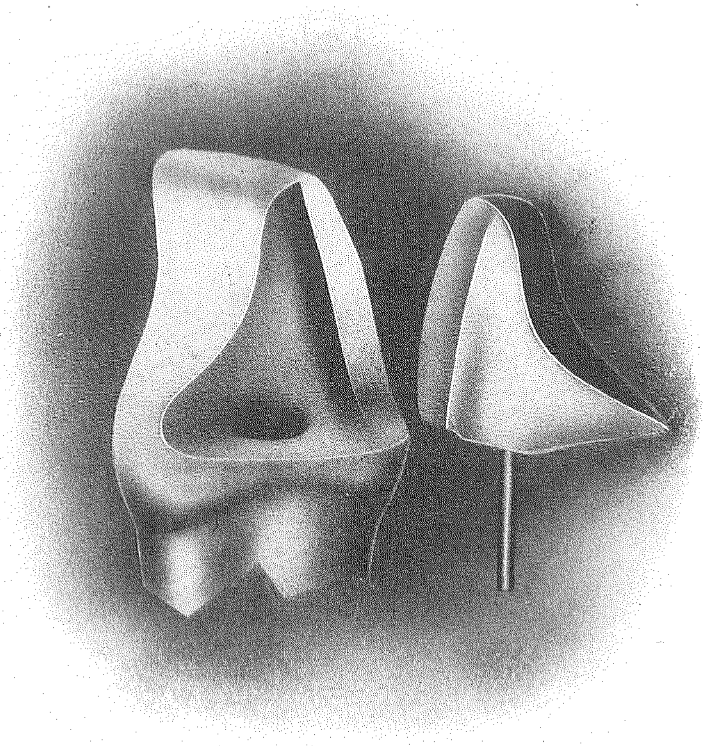


Fig. 914

extend far on the labial surface, preparation can be made as follows:

Square the gingival wall. Cut away the labial and lingual walls to permit of the ready removal of the matrix. Cut a step on the lingual surface of the tooth, extending from the incisal edge to the gingival wall.

This is done by removing a section of the lingual plate of enamel, as shown in Fig 913.

Cut a groove at the junction of the linguo-axio-mesial or distal walls, as the case may be, extending from the gingival wall to the incisal edge, and bevel the several cavo-surface angles slightly.

It is usually best to cut away the labial plate of enamel at the incisal edge to the same extent that the lingual has been carried back, to avoid a long irregular line of junction occurring on the incisal edge.

Fig. 914 illustrates a cavity prepared as directed and the inlay baked around a post which extends into the root canal,

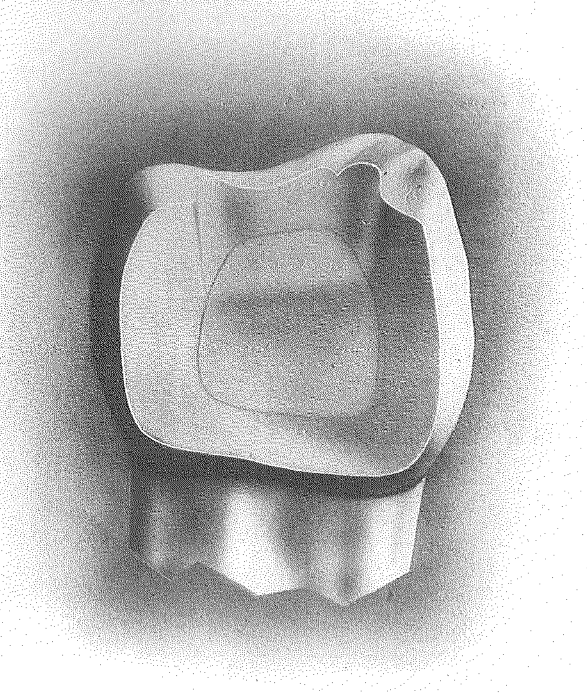


Fig. 915

thus furnishing additional anchorage. Note that there is a labial shoulder to prevent outward displacement.

CAVITIES IN BICUSPIDS AND MOLARS INVOLVING AN AXIAL AND AN OCCLUSAL SURFACE

The same general principles followed in the preparation of cavities for the reception of gold or amalgam fillings apply in inlay work with a few exceptions, which will be noted. (See Fig. 915.

First—The cavity must be formed without undercuts.

Second—The axial, buccal and lingual walls should slightly diverge, from gingival to occlusal, to allow the ready removal of the matrix in an occlusal direction.

Third—When the line of junction of the cavity wall and the periphery of the inlay comes within a contact area of a tooth in the opposite arch, fracture of one or both margins is liable to occur. Therefore cavity walls should be laid beyond such points of contact to prevent stress on the periphery of the inlay.

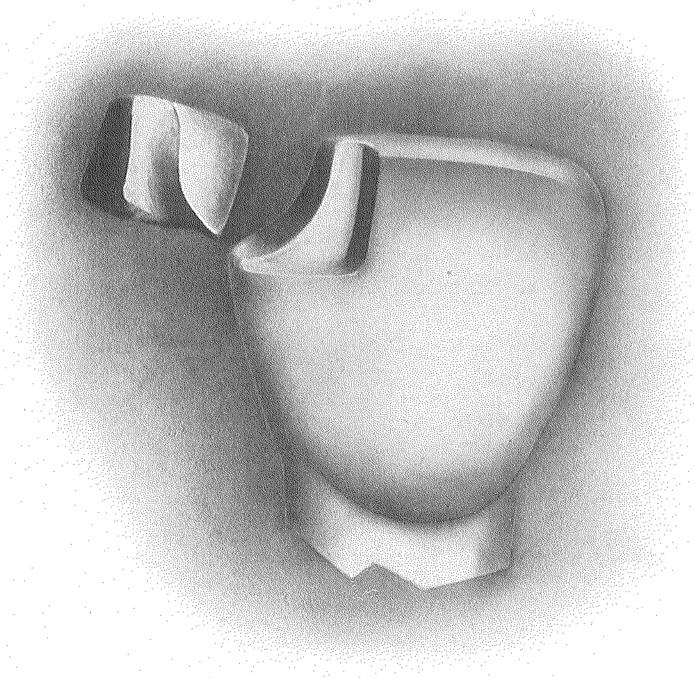


Fig. 916

Fig. 916 represents a method of restoring the angle of an incisor tooth. The cut shows a lingual view of the cavity, with the inlay rotated to the left. The labial shoulder, flat seat and slight groove in both seat and shoulder furnish needed resistance to displacement. The preparation for lower incisors should be reversed.

RESTORATION OF INCISAL EDGES

Fig. 917 illustrates a method of restoring a notched incisal edge. A lingual view of the cavity is presented. The shoulder prevents outward displacement. In lower incisors the shoulder should be prepared in the labial plate to prevent lingual displacement by the upper teeth.

The preparation of the cavities as outlined is similar in most respects to the methods recommended and taught by Dr. A. E. Peck, who deserves much credit for the interest he has

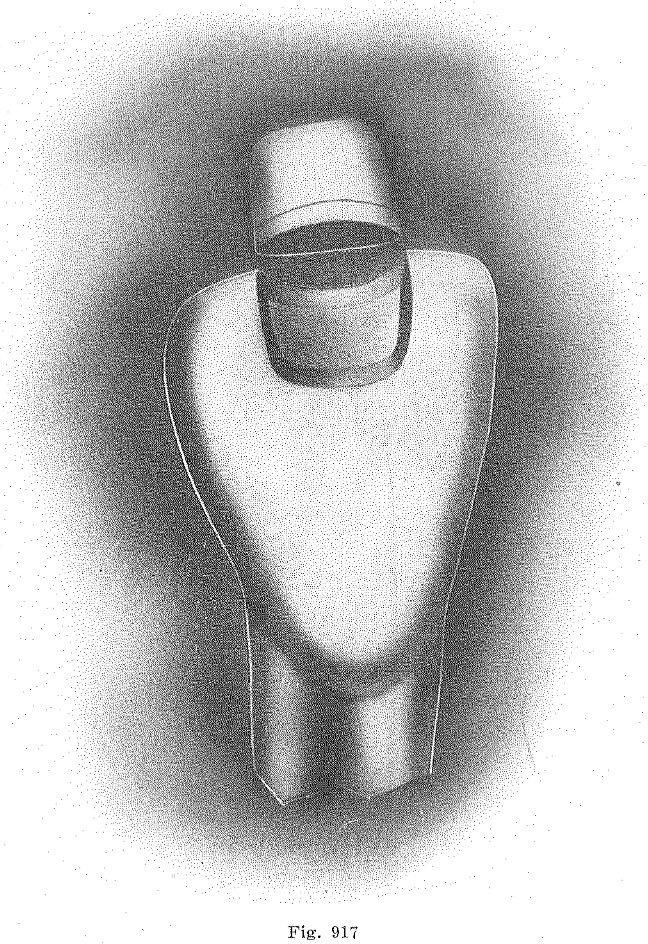


Fig. 917

displayed along this line. Those who are familiar with his system will note the points of difference as they occur.

PRODUCTION OF THE MATRIX

The conformation of the platinum foil to the cavity is a step requiring skill, patience and experience. Two methods are followed at the present time, both of which are reliable if proper care is exercised. The first consists in burnishing the foil directly into the cavity with pellets of cotton or spunk carried in the pliers and by the use of suitable burnishers of ordinary and special shapes.

The other method consists in forming the matrix against an impression of the cavity or a model derived from an impression, with a suitable swaging device.

BURNISHING THE MATRIX

The rubber dam should be applied in all cases and the cavity dusted with soapstone to prevent tearing the foil.

A piece of platinum foil, thoroughly annealed, should be cut of sufficient size to extend beyond the cavity margins when pressed into place. This is centered over the cavity and held in position with the fingers, while a small piece of spunk carried in a pair of ball-pointed pliers is pressed against the center of the foil to force it against the floor of the cavity.

Special care should be taken to obviate the wrinkling of the foil against the cavity walls, to prevent its tearing while being forced to place, or its perforation by the pliers or burnishers. Wherever a wrinkle or fold appears it represents three thicknesses of foil at that point, and while the bulk of material may be thinned down somewhat in burnishing, it cannot be reduced to any great extent. The result is that when the inlay is completed a very perceptible space exists where the fold occurred, which must be filled with cement. This is objectionable on account of the color of the cement and because of its ready dissolution under such conditions.

The foil, having been carefully forced to the floor of the cavity, is held there by a burnisher resting on a pellet of spunk. Another pellet is taken up with the pliers and forced into the cavity, carefully adapting the foil to the entire floor first, before making any attempt to adapt it to the walls.

A ligature or strip of thin tape passed through the interproximate spaces and against the matrix will oftentimes assist in holding it in place while securing adaptation of the foil to the various surfaces.

The adaptation to the walls is secured by pressing a small pellet into the cavity near the floor and drawing it outward, producing pressure toward the wall at the same time. The entire floor of the cavity should be covered with spunk, held with some suitable instrument during the operation.

Some prefer to use various shapes of rubber points for this purpose, and very good results are secured in this way, but as the spunk and cotton are always conveniently at hand and pellets of any size can be formed quickly, these materials are perhaps more commonly used than the rubber points.

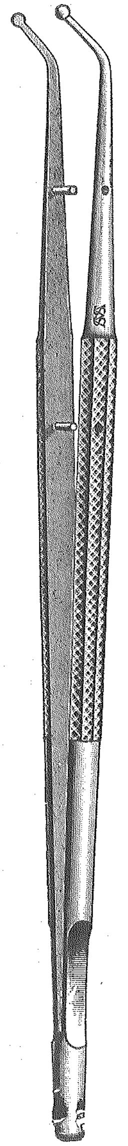


Fig. 918.—Ball-Pointed Pliers for Applying Cotton or Spunk to the Matrix

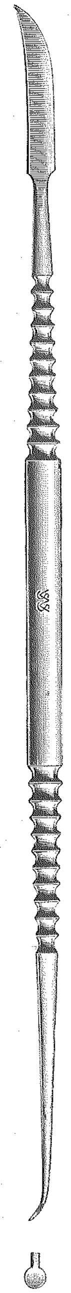


Fig. 919.—Carving Tool with Corrugated Shank, Which, by Drawing Across the Tweezers, Vibrates and Condenses the Porcelain Body

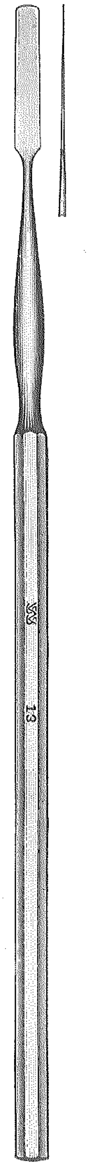


Fig. 920.—Small Spatula for Mixing and Applying the Porcelain to the Matrix

Burnishers of various forms, as the Thompson or Reeves selections, may be used to advantage in securing adaptation of the foil to the cavity walls and angles.

When fairly close general adaptation has been secured the entire matrix is filled with spunk and pressure applied with an instrument which will force the foil against the floor and walls of the cavity at the same time.

The adaptation of the foil to the outer surfaces of the tooth can be accomplished with spunk in the manner outlined, drawing the pellet from the cavo-surface angle outward in all directions until the foil lies flat upon the tooth surface.

The adaptation of the foil to the cavo-surface angle yet remains to be done. This is one of the most important steps in the whole operation. Securing perfect adaptation at this point, with sharp angle definition, without folds in the foil, insures practically perfect margins to the inlay.

The entire interior of the matrix should now be filled with spunk and a piece larger than the cavity applied over all. Pressure with a suitably shaped instrument slightly larger than the cavity or with the finger, when this is possible, is made against the spunk to force the matrix into all parts of the cavity, against the cavity margins and the tooth surfaces at the same time.

REMOVAL OF THE MATRIX

The spunk should then be removed and the matrix lifted out, the surplus, if excessive, trimmed away and the foil thoroughly annealed and returned to the cavity for adaptation.

NECESSITY FOR FINAL ANNEALING

When metal plate is swaged, hammered or burnished the relation of the molecules to each other is changed. This is especially true of platinum foil used in matrix construction. By repeatedly annealing and returning the matrix to the cavity for final adaptation the foil can be made to lie "dead flat" without change under high temperature.

Selection, Application and Fusing of the Porcelain

SELECTION OF SHADE

As porcelain powders are now supplied by the manufacturers they appear to be white, or but slightly tinted with yellow or brown. No definite idea can be formed from looking at the powder, or when made into a paste with water, as to what its tint will be when fused, as its true color is only developed by vitrifying.

To select a suitable porcelain for an inlay, to match the shade of a natural tooth, small sticks of fused porcelain, each made of a particular single shade, are supplied by the manufacturers. These sticks are made from, and numbered to correspond with, the numbers of the powders supplied. In determining the shade of porcelain to use in a given case, one of these fused pieces is placed alongside of the tooth for which the inlay is to be constructed and the similarity or difference in shade noted. This process is repeated until a satisfactory shade has been found to match the tooth, or some portion of it, against which the inlay is to rest.

It is frequently necessary to select two, sometimes three, shades of porcelain for a proximo-incisal inlay when the tooth presents marked variation in shade from gingival to incisal areas. In applying these vari-shaded porcelains to the matrix they are not blended on the slab but are applied in the matrix in the particular location where indicated. By drawing a rough instrument across the pliers with which the matrix is held the vibration so caused will blend the several colors at their margins sufficiently to obviate a sharp line of demarkation of tints. Usually after fusing the primary colors selected a neutral shade of porcelain is applied and fused to complete the contour and still further soften and blend the more pronounced underlying tints.

MIXING THE PORCELAIN

The proper colors having been selected, corresponding powders are placed separately on a clean glass slab and with a drop tube, sufficient distilled water is added to form each into a mass of medium plasticity. The powder and water should be well spatulated to thoroughly incorporate the several ingredients in each shade. To prevent the heavier from settling and forcing the lighter particles to the top of the mass, when well mixed, a linen napkin, or piece of bibulous paper, should be pressed against the paste to take up the excess moisture.

APPLICATION OF THE PORCELAIN TO THE MATRIX

The matrix is grasped with a pair of K tweezers (Fig. 921) at some point on the surplus margin in such manner as not to distort it, yet with sufficient hold to sustain not only the matrix but the porcelain to be added as well. A small amount of the paste, usually of a yellowish tinge, to serve as a foundation body, is transferred from the slab to the matrix, applied to the latter without pressure and the serrated surface of the carving tool drawn over the tweezer beaks to vibrate the porcelain in position. More is added in like manner until the matrix is from one-half to two-thirds full, leaving the labial portion deficient in order to add the proper colors later. The

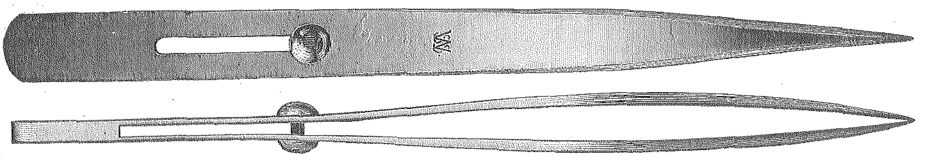


Fig. 921.— K Tweezers for Holding the Matrix. The Headed Rivet Locks the Beaks Together

partially filled matrix is now carefully passed above a Bunsen flame, or placed near the entrance of the furnace, to gradually expel the moisture, after which it is placed on a muffle tray, introduced and fused.

When removed, the various tints are applied in their respective locations, this time filling the matrix to its margins and vibrating as before so as to blend the several colors. Any excess paste which overflows is carefully brushed off with a dampened sable brush, thus avoiding thin overhanging margins in the finished inlay.

Should the colors be too pronounced when fused, a thin layer of gray or neutral tint may be overlaid and fused, as before suggested, to tone them down.

Usually in simple cavities two applications of the body and two fusings will be sufficient to produce a satisfactory inlay. In complicated cases, however, three, or possibly four, fusings may be required. It must be kept in mind, however, that each additional fusing not only produces contraction in the porcelain last added, but in the entire mass, thus increasing the danger of warpage and a misfit. The fewer times required for fusing and finishing a piece of porcelain of any class, the better the quality of the material and the less contraction and warpage will occur.

When slightly overfused, or when the vitrifying process is continued too long, both the texture of the porcelain and its color is impaired. Long continued low temperature, just sufficient to vitrify porcelain, will produce better results as to texture and color than when the process is carried on rapidly and at a higher temperature.

FURNACES FOR FUSING PORCELAIN

Various types of furnaces are used for fusing or "baking" porcelain, as this process is usually termed. The most common method of developing the required temperature is

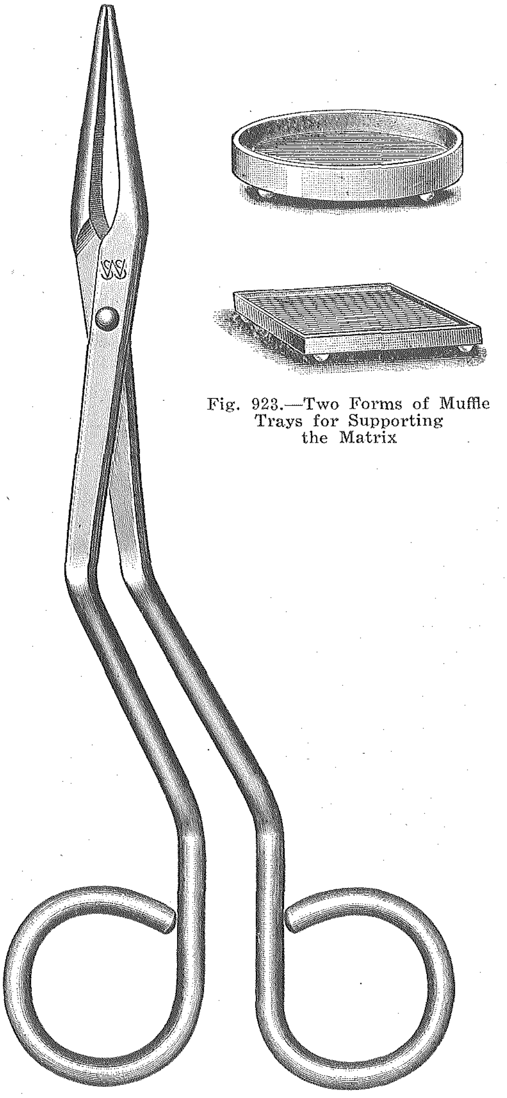


Fig. 923.—Two Forms of Muffle Trays for Supporting the Matrix

Fig. 922.— Muffle Tray Tongs, for Introduction and Removal of the Tray During the Steps of Fusion of the Porcelain

by passing an electric current through a fine platinum wire imbedded to a slight depth within the fire clay muffle walls. The resistance of the wire to the passage of the current develops an intense heat within the wire when fine, which in turn is transmitted to the fire-clay lining of the furnace.

The amount of heat capable of being developed within a muffle is dependent upon the length and sectional area of the wire, the depth it is imbedded in the fire-clay lining and the intensity of the current which flows through it. Furnaces of this type are called "electric furnaces," and as a rule are capable of developing a considerably higher temperature than that required to fuse the common porcelain bodies. In most cases a rheostat is employed to control the flow of the current and keep the temperature within working range. In some cases furnaces are fitted with pyrometers for indicating the point of fusion of the porcelain.

To Dr. L. E. Custer belongs the credit of having first constructed a practical electric furnace suitable for fusing porcelain (1894). At the present time a number of excellent electric furnaces are procurable. Gas, gasoline, oil and coke furnaces are also manufactured which, from a practical standpoint, are applicable to porcelain work. The electric furnace is preferable in dental operations because of its compactness, ease of manipulation and freedom from gases which always accompany the use of the fuels mentioned.

The temperature usually required to fuse the various inlay, crown and bridge, porcelain bodies is given under the heading of "High and Low Fusing Porcelain Bodies."

FUSING THE PORCELAIN

The moisture having been expelled from the porcelain, the matrix is placed upon the muffle slab and introduced in the furnace. Care should be taken to see that the body of the matrix rests upon the fire-clay slab, or that a sufficient number of marginal points touch to afford ample support and prevent warpage. When the form of the matrix is complicated some granular silex should be placed upon the slab and the matrix settled carefully down upon it.

When a furnace having no pyrometer is used, a pellet of pure gold is usually placed alongside of the matrix to serve as a guide in determining the point of vitrification. A little device made of soapstone or fire-clay, having a small undercut groove with slightly enlarged extremities, is cut in the concave face of the block. In the upper extremity of the groove a pellet of gold is placed and when fusion of the latter occurs it disappears by falling to the lower extremity, much as the sand in an hour glass flows from upper to lower compartment. When the temperature is reduced and the gold solidifies, by inverting the block the gold is again at the upper extremity of the groove and in position for another test.

The matrix and test block being in position, the current is turned on by moving the rheostat arm from its initial position of rest to the first contact, where is should be allowed to remain for five minutes, when it can be moved to the second contact. The arm should remain on each contact about the same length of time before moving to the next in order to reduce to the minimum the strain on both platinum wire and fire-clay lining, and also so that the porcelain may not be subjected to sudden increase of temperature. In most furnaces the rheostats are supplied with five or six contacts. When the arm is moved at five-minute intervals the porcelain will usually be near the point of fusion by the time the arm is transferred to the last contact. The gold must be closely watched and the instant it fuses the time should be noted.

By previously determined tests, the difference in time between the melting of the gold and the biscuiting, as well as glazing of the porcelain, is known, and this time should be allowed according to the degree of fusion required. This period varies usually from forty seconds to six or seven minutes, depending on the intensity of the current, the class of porcelain used and the type of furnace employed.

The first bake should be carried to the "biscuit" stage, i. e., where vitrification has occurred but the granular surface has not disappeared.

The rheostat arm is now returned to the second contact to conserve time, and heat as well, by not allowing the furnace to become cold, the muffle opened and the slab partially withdrawn, allowed to cool somewhat and, finally, the matrix is picked up with the K tweezers and the result of the first bake noted. If free from porosity, of good color and not overfused the second application of body is made as at first. When an effort is made to complete the inlay in two bakes the second application of porcelain should be very carefully executed, developing very slightly fuller contour than required to compensate for final contraction that always occurs on fusing.

When two or more colors are required to match the tooth shade they are applied at this time and blended as before described.

SECOND BAKING

The contour of the second application of body having been completed, surplus removed from the margins and the moisture expelled, the matrix is again returned to the furnace. The temperature is gradually raised as before until the surface of the inlay is glazed and perfectly free from granules, the idea being to give it such a surface as will not require the application of discs or polishing powders. Porcelain inlays baked under ordinary conditions are liable to be slightly porous under the glazed surface, and these porous spaces are frequently disclosed on grinding. Since reglazing does not always remove the pits, and if more is added to correct the defects the additional fusion will induce further dimensional changes in the inlay itself, it is best to avoid grinding and polishing if possible to do so.

DELETERIOUS EFFECT OF OVERFUSING THE PORCELAIN

Special care should be taken to not overfuse the porcelain. Some of the defects arising from this mishap are bleaching of the porcelain, friability, undue contraction and warpage and the development of porosity—sometimes to such an extent as to render the inlay useless.

THE SHADOW PROBLEM

Comparatively little difficulty is encountered in selecting porcelain of suitable translucency and color, which when fused to proper form and introduced in the cavity without cementation will harmonize with tooth structure.

The discouraging feature connected with porcelain inlay work, however, is in the variation in shade observed between the natural teeth and inlay when the latter is finished and set with cement. All varieties of cement used in the setting of inlays are opaque. Light will not readily pass through even thin, attenuated layers of this material. Therefore, unless the light which falls upon a tooth filled with a cemented inlay is directly parallel with the exposed cavity walls a shadow will be cast upon either tooth or the inlay, depending upon which is nearest the source of light.

For example, in a distal cavity in a central incisor involving the angle, when the light falls upon the tooth first—the direction of the rays slanting toward the inlay—a shadow will be observed in the latter next to the line of junction, owing to the cutting off of the light by the film of interposed cement. When the light comes from the opposite direction, striking the inlay first, the shadow will appear in the tooth, but to a less extent because of a more or less general diffusion of light in the greater bulk of tooth structure. In the upper teeth the overhang of the upper lip will often cast a shadow in the gingival portion of an inlay, though the light may be comparatively direct and well diffused.

To overcome, or at least reduce somewhat, the shadow caused by indirect rays of light on an inlay, the labial walls of cavities in the anterior teeth should be carried well to the labial. The result of such cavity formation is to increase the bulk of porcelain in the inlay and permit diffused light to enter through the porcelain, thus reducing the depth of shadow cast in inlays of limited labial exposure. The necessity for this line of procedure is evident when the form and position of an inlay, in proximal cavities, is considered. On one side the inlay is limited by an opaque layer of cement, and on the other by the proximating tooth, both of which tend to restrict the uniform diffusion of light through the porcelain except under the most favorable circumstances.

Again, the color of the cement used in setting an inlay may modify the shade of both the restoration and the tooth next to, and for a short distance away from, the cavity walls, lightening or darkening both according to the inherent tinge of the cement. The remedy for the latter defect is overcome to a great extent by using a cement which in color coincides as nearly as possible with the shade of the natural tooth.

It has been suggested that an opaque, low-fusing porcelain of the Jenkins type, in which color effects are not so much dependent upon translucency as is the case in the higher fusing porcelains, may be applied to overcome the shadow effects noted. An inlay constructed of an opaque porcelain having the essential, component colors of the tooth brought to the labial surface is but slightly affected by light striking it at various angles. The tooth in which it is placed, however, is subjected to shadow variations to the same extent as when high fusing porcelains are employed.

REMOVING THE MATRIX

When the fusing of the inlay is completed the platinum foil matrix must be removed. This may be accomplished by carefully grasping the surplus margin with the beaks of the K tweezers and with a rotary movement roll the foil away from the margins of the porcelain, using special care to avoid fracturing the latter. By wetting the inlay and matrix the danger of fracture is greatly reduced. Usually the matrix can be peeled off by grasping the surplus margin between the thumb nail and the ball of the index finger, the latter acting as a resilient cushion on which to rotate the inlay. In case the matrix tears, the adherent portion being devoid of free margins, it must be chiseled, scraped or ground away, as when allowed to remain it will interfere with the correct seating of the inlay.

ETCHING THE CAVITY SURFACES OF THE INLAY

To break up the glaze and afford better retention of the cement to the porcelain the cavity surfaces of the inlay should be etched with hydrofluoric acid. The labial, and, in fact, all the exposed surfaces of the inlay, must be protected from the action of the acid by covering them with wax, the acid having no effect on the latter material. The wax should be formed into a roll, the end heated and the inlay pressed against it, being careful to see that all surfaces on which the glaze is to be preserved are perfectly covered.

With a pencil of wax, or a toothpick, the acid is applied to the cavity surfaces, the application renewed once or twice until the glaze is removed. The acid is then washed off with water and neutralized with a solution of bicarbonate of soda, again washed and dried, when it is ready to set.

SETTING THE INLAY WITH CEMENT

The rubber dam should be applied to the tooth involved, and the proximating teeth as well, and the cavity thoroughly cleansed and dehydrated.

Cement of suitable shade mixed to medium consistency is quickly applied to both inlay surfaces and cavity walls, the inlay introduced and forced to place under gradual, heavy, maintained pressure. In proximal cavities, this pressure may be applied by forcing between the inlay and the proximating tooth a previously-prepared wedge of orange wood. Care should be taken to see that in forcing the wedge in place the inlay is not displaced or unseated at any point.

The force capable of being exerted by a thinly-tapered wedge is enormous, therefore caution must be exercised to avoid undue force in its application. The mallet should never be used in setting a porcelain inlay, as the instantaneous blow will scarcely produce flow in cement of medium consistency, while the impact is liable to fracture the porcelain.

A piece of pine stick a little larger than a lead pencil, with one end trimmed to suitable size and slightly concaved to fit snugly against the inlay, affords a most convenient means of producing and maintaining pressure upon the restoration until the excess cement has been expelled and crystallization has set in. Pressure on the inlay should usually be maintained from five to eight minutes, depending on the rapid setting qualities of the cement used.

In setting inlays in proximal cavities, a strip of rubber dam about six inches long and one-fourth inch wide can be passed between the inlay and the proximating tooth, the two ends of the strip placed together and the rubber stretched almost to its limit, in a direction at right angles to the long axis of the tooth. The resilient rubber forces the inlay into the cavity and condenses the cement in the joint line as well.

When hardened, the excess cement is removed from the joint and adjacent surfaces, the rubber dam removed, the parts syringed with warm water, and the occlusion verified to see that in setting it has not been modified by the cementing medium. If so, it should be corrected by grinding and polishing until clearance space is gained, to avoid fracture from stress of opposing teeth.

Gold Inlays

The production of gold inlays may be accomplished in various ways. With one or two exceptions, all of the many methods in vogue may be grouped into two general classes, viz., the *matrix method* and the *casting process.* A description of both methods will follow cavity preparation.

Cavity Preparation for Gold Inlays

The general principles followed in cavity formation for gold foil or amalgam fillings apply with equal force to those designed for the reception of inlays of any class. Briefly stated, these principles, as laid down in Black's Operative Dentistry, are as follows:

First—Obtain the required outline form.

Second—Obtain the required resistance form.

Third—Obtain the required retention form.

Fourth—Obtain the required convenience form.

Fifth—Remove any remaining carious dentin.

Sixth—Finish the enamel wall.

Seventh—Make the toilet of the cavity.

OUTLINE FORM

To secure the correct outline form involves the breaking down of unsound overhanging enamel walls, the removal of practically all undercuts, the opening up of fissures when required, extension for prevention of all margins to immune areas, and further extension of margins, if necessary, for convenience of introduction and removal, without distortion, of the wax model, or the foil matrix.

RESISTANCE FORM

Resistance form refers to the development of flat gingival and pulpal walls so as to withstand the stress of mastication, thus obviating the tendency of the inlay to slide from or rotate out of position under direct stress.

RETENTION FORM

In the preparation of a cavity for an inlay, the walls that lie parallel with the line of direction of introduction of the inlay should be formed at an angle of divergence of at least one degree from perpendicular to the base, to obviate distortion of the wax model in removing from the cavity. A greater amount of divergence may be permissible in some cases, but firmer and better retention follows with slight than with excessive divergence of the walls.

While cement is employed for the retention of all classes of inlays, this means alone will prove ineffectual against side stresses and strains, particularly when the inlays are to be utilized as abutments in bridgework.

Since, for obvious reasons, neither undercuts nor parallel walls are permissible in the finished cavity, and since cement is unreliable under heavy stress, some more positive means of retention must be developed in practically all cases; this may be accomplished in several ways, depending on the form and location of the cavity.

In cavities involving an axial and an occlusal surface, flat pulpal and gingival seats afford resistance to direct stress, while a dovetail on the occlusal surface will prevent the tipping stress.

When more than one axial surface is involved, and it is deemed advisable to connect the cavities and thus construct the inlay in one piece, the proper flare of the walls, to avoid undercuts, should be constantly kept in view, so as to obviate distortion of the wax model in removal from the cavity.

Frequently when two or more axial surfaces are involved, and the preparation of the cavity so as to permit the release of the matrix would require excessive sacrifice of good tooth structure, an interlocking inlay constructed in two pieces can be used to advantage. In such case one inlay having a dovetailed space to receive the interlocking spur of the adjacent piece or complement, is first cast and set, after which the wax model of the other is formed and cast in like manner. By this sectional method of construction, maximum resistance to displacement of the inlay is gained, with the sacrifice of the minimum amount of tooth structure.

Oftentimes a slightly divergent groove can be formed in the pulpal wall of the cavity in such manner as to release the wax, the resulting shoulder of which on the inlay will effectually prevent it from tipping.

In obtaining retention form in cavities in the anterior teeth, an incisal step with a notch in the lingual plate of enamel will effectually counteract the tendency to displacement from tipping stress.

Frequently, by stripping both labial and lingual plates of enamel away so as to expose the dentine, the latter may be

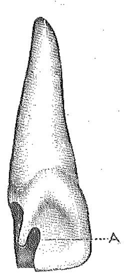


Fig. 924

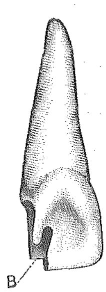


Fig. 925

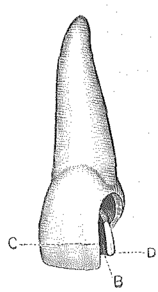


Fig. 926

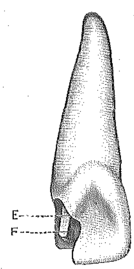


Fig. 927

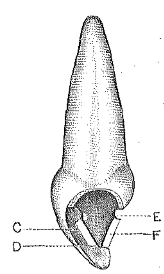


Fig. 928

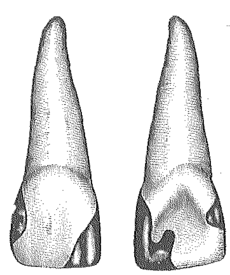


Fig. 929

Various Forms of Cavities in Which Dentin Shoulders and Lingual Grooves Are Developed for Retention Purposes (St. John)

used as a shoulder or hook, as it were, over which the inlay may be formed, and which will effectually counteract the tendency to tip. This form of cavity preparation was recommended many years ago by Dr. I. C. St. John of St. Paul, for the reception of gold foil fillings. In certain cases it has proven very serviceable for inlays.

PIN ANCHORAGE FOR INLAYS

The application of pins for the retention of inlays, and in obviating displacement under heavy stresses, has proven of great value, particularly when the inlays are utilized as abutments for bridges.

The form and location of the cavity and the condition of the tooth, whether vital or pulpless, govern the size and length of the pin.

The usual manner of developing a pin anchorage consists in drilling a hole in the gingival or pulpal wall of the cavity entirely within the dentine, in such location as not to interfere with the pulp. The direction of the hole should correspond with the line of removal, or at least not interfere with the release of the wax model from the cavity. The diameter of the hole should be but slightly larger than the pin to be employed. Before introducing the wax, the pin, cut slightly longer than the depth of the hole, is inserted and as the wax is pressed to place it surrounds the projecting end of the pin. When the wax model is removed, the pin is removed with it and caught in the investment and the gold cast around it.

CONVENIENCE FORM

Convenience form relates to such modifications in prepared cavities as will admit of the most perfect as well as convenient placing of the filling. In gold foil operations this refers to cutting away a wall or some area that interferes with proper instrumentation or the development of slight undercuts in certain locations to aid in holding the filling material until the general retention form can be made effective.

These points do not directly apply to inlay work, but indirectly the shaping of the cavity so as to permit the ready removal of the wax model and the introduction of the inlay come under this head. When the general form of a cavity has been developed, it is frequently found that some slight undercut within the dentine will seriously interfere with removal of the wax model. The removal of the undercut by reshaping the cavity may result in weakening an otherwise firm cavity wall when by carefully filling the depression with cement, the difficulty may be overcome. As a general rule, however, the best plan is to eliminate all undercuts in the development of the outline form, and not depend upon cement for such purpose.

REMOVAL OF ANY REMAINING CARIOUS DENTINE

It is just as important, in cavity preparation for inlays as for other classes of fillings, that all decayed dentine be removed to obviate recurrent caries.

Some prefer to leave a layer of leathery, decayed dentine in the pulpal or axial walls of deep cavities, under the mistaken idea that the transmission of thermal changes will be impeded and the vitality of the pulp be conserved.

This is, in nearly every instance, an incorrect procedure, for in cavities which encroach so closely on the pulp as to need a protection of this character, the varying thermal changes transmitted by a large gold inlay will very soon set up hyperemic conditions, and the pulp will die.

FINISH OF THE ENAMEL WALLS

In gold inlay as well as in gold foil operations, the cavosurface angles should be beveled for the protection of the exposed enamel rods. This is carried out as in general operative procedures by carefully planing the outer cavity margins with sharp chisels and gingival margin trimmers.

The method of using stones on the margins and in smoothing up the walls of cavities is bad practice and to be deplored. The method cannot be made effective in, nor is it universally applicable to, all classes of cavities, and where applicable the tendency is to weaken frail walls and obliterate definite retention surfaces. The only possible advantage resulting from this method is in reducing to a slight degree the discomfort to the patient, in those cases where the tooth structure is sensitive to the application of the bur.

TOILET OF THE CAVITY

The removal of all chips and debris, not only from the cavity but from the mouth as well, is important and can best be accomplished by use of the water syringe and wiping the cavity thoroughly with pellets of cotton before forming the wax model.

In forming the wax model, as will be seen later, a lubricant is used to facilitate the ready application and adaptation of the wax to all cavity surfaces. This lubricant, whatever its class, should be thoroughly removed, the cavity dried and packed with a good quality of gutta percha until the time of setting of the inlay.

SOME SPECIAL METHODS OF CAVITY PREPARATIONS

Proximal cavities in the anterior teeth, in which gold inlays are to be placed, require special attention. In case a tooth proximates the one in which the cavity occurs and the angle is involved, the cavity must be formed so as to release the wax model usually lingually or incisally.

Provision must be made to prevent the inlay when set, from becoming dislodged under tipping stress. Several methods are resorted to for accomplishing this object. These usually consist of a dovetail or some form of step in the lingual surface of the tooth involved, some of which will be illustrated.

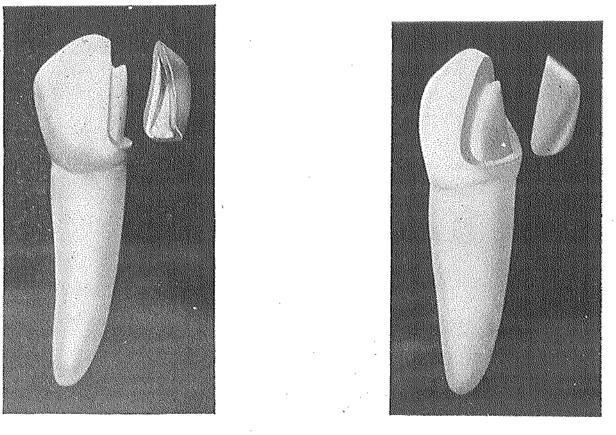


Fig. 930.— Two Views of Tooth Prepared with an Incisal Hook of Dentin (St. John)

The first of these, the St. John method of cavity preparation, previously alluded to, consists of stripping off the plates of enamel so as to expose sufficient solid dentine to form a hook for incisal anchorage. A gingival seat takes up the incisal stress. See Fig. 930.

A method of forming a dovetailed space in the lingual surface of the tooth as near the incisal edge as possible, to provide for tipping as well as outward displacement. Figs. 931 and 932.

A method of forming a step along the linguo-incisal edge, involving principally the lingual plate of enamel. The bottom of the step may be grooved slightly, and near its farthest extremity from the cavity a small hole is drilled in the dentine to receive an iridio-platinum post. The line of junction of the inlay with the labial plate of enamel, occurring on the incisal edge, invites displacement of the inlay as well as fracture of the labial plate of enamel under stress.

A method of step preparation, similar to the above, but with the labial plate reduced slightly so that the inlay will

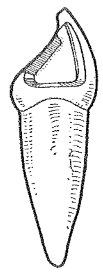


Fig. 931.— Proximal View of Distal Cavity in Cuspid Tooth, Showing Lingual Step

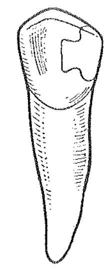


Fig. 932.— Lingual View, Showing Dovetail of Step

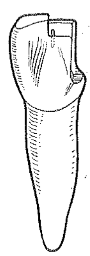


Fig. 933.— Lingual View of Both, Showing Incisal Step Cavity with Pin in Step

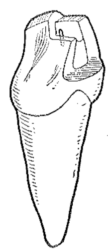


Fig. 934.— Disto-Lingual View of Preceding Tooth

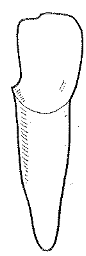


Fig. 935.— Labial View of Cavity Outline

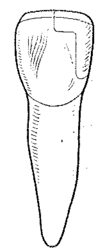


Fig. 936.— Labial View of Tooth with Inlay in Position

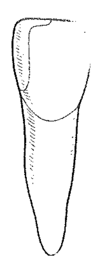


Fig. 937.— Lingual View of Incisal Step Cavity, Showing Groove Retention

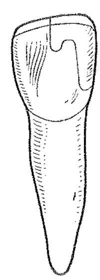


Fig. 938.— Labial View of Tooth with Inlay in Position

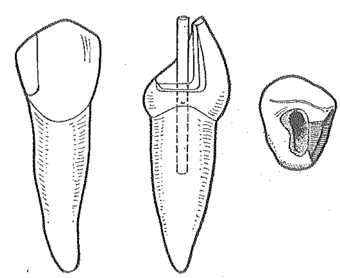


Fig. 939.— Labial, Distal and Incisal View of Cavity in Cuspid Prepared with Dovetailed Anchorage Combined with Pin

form a tip of gold over the two plates of enamel. This form of cavity preparation is preferable to the preceding. Figs. 933 to 936, inclusive.

A method of forming a step similar to the above, but instead of the pin anchorage, a drop of the step gingivally, in the lingual plate of enamel and the dentine as well, furnishes the resistance to tipping stress. Figs. 937-938.

A method of anchoring a large contour filling in a pulpless tooth by means of a pin extending into the root canal. Fig. 939.

A method of forming in the labial or buccal surface of the wax model, a cavity with undercuts, in which, after the inlay is set, a synthetic cement filling is placed to avoid the display of gold.

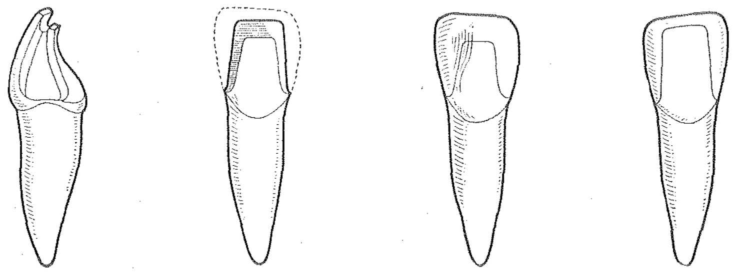


Fig. 940.— Proximal View of Tooth with Mesio - Inciso - Distal Cavity Prepared

Fig. 941.— Lingual View of the Preceding

Fig. 942.— Lingual View of Tooth with Filling in Position

Fig. 943.— Labial View of Tooth with Filling in Position

A method of preparation for a mesio-inciso-distal cavity in an anterior tooth, formed with a grooved step, cut principally at the expense of the lingual plate of enamel. The incisal edge of the tooth is reduced so that it may be tipped with gold for its protection. Figs. 940 to 945, inclusive.

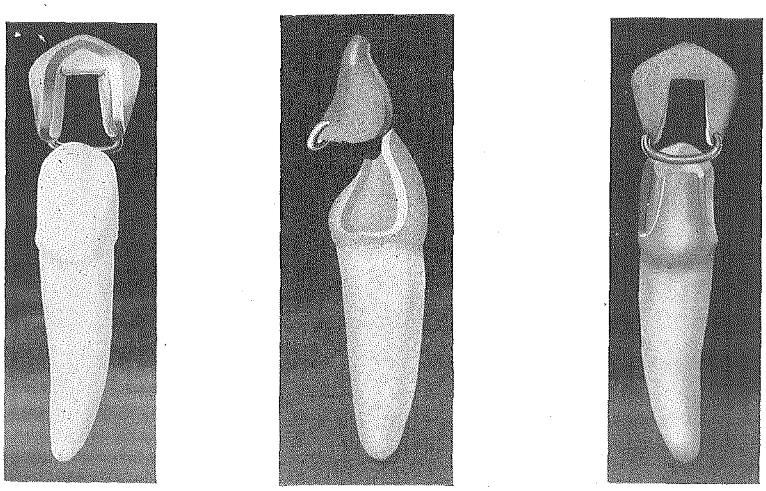


Fig. 944.— Three Views of the Wax Model for a Mesio-Inciso-Distal Inlay

In casting fillings of this type, a piece of iridio-platinum wire should be bent so that it will not interfere with the margins of the inlay. This is inserted in, and as close to the cervical terminals of the wax model as possible to prevent change of relation due to contraction.

A straight piece with square ends will serve this purpose equally as well, if inserted between the axial surfaces of the mesial and distal sections.

A mesio-occlusal, grooved cavity in an upper molar. The pulpal wall is grooved to provide against tipping stress. This

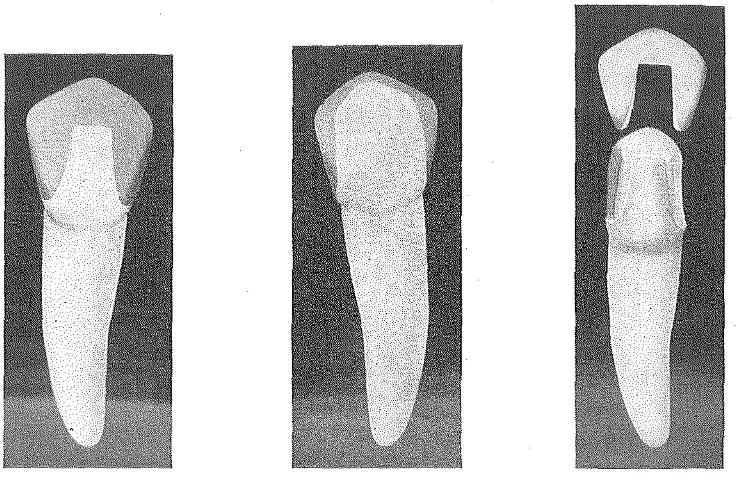


Fig. 945.— Three Views of the Completed Inlay

form of activity preparation is frequently employed when the inlay is to serve as a bridge abutment.

A loose pin anchorage for an inlay to be used as an abutment for a bridge. A square iridio-platinum bar, from 12 to

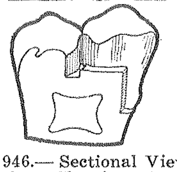


Fig. 946.— Sectional View of a Molar, Showing Grooved Step for Guarding Against Tipping Stress

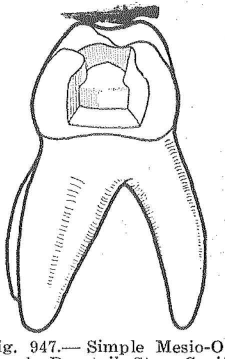
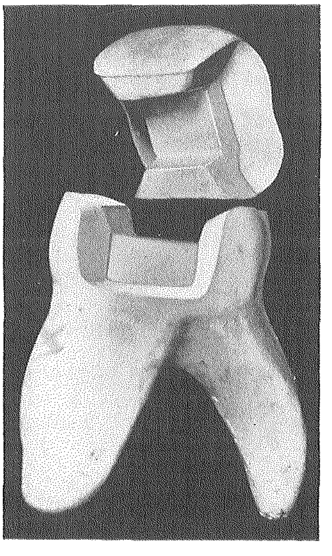


Fig. 947.— Simple Mesio-Occlusal, Dovetail Step Cavity in Molar

14 gauge, is uniformly tapered on the four sides, extending back about three-fourths of an inch from one end, and reduced sufficiently to enter the enlarged root canal the required depth for anchorage purposes. Around the tapered portion and in-

volving the area which will rest within the inlay, is wrapped a band of 1-1000 platinum foil which should lap on itself about one-half turn of the wire. The taper pin is withdrawn and the square tube of foil is tacked with a little pure gold solder to prevent it from opening. It is returned to the pin and re-adapted to correct any change that may have occurred in soldering.

The wax model is carved to proper contour, and the pin without the sleeve is warmed, passed through the wax and to position in the root canal and withdrawn. It is now heated to burn off the adherent wax and oiled to prevent the sleeve be-



Fig, 948.— Mesio-Occluso-Distal Cavity and Wax Model for Same

coming fast. The sleeve is again returned to position, pin warmed and the two are passed through the opening in the inlay and into the canal to proper position. A small heated instrument is passed around the sides of the tube so as to cause the wax to adhere to it, but not to the pin. The latter is now withdrawn, while the tube remains in the wax. The tube should be long enough to project beyond the upper and lower surfaces of the wax, so as to become inclosed in the investment. On removal of the wax model, the tube is first filled with investment, after which the model is invested in the usual manner. When cast, the projecting ends of the tube are reduced to the level of the inlay surfaces, the opening cleared for the reception of the pin, the inlay finished and set and while the cement is still soft the pin is forced to place. Care should be taken to avoid the excessive use of cement which might be forced into the canal from which it would be difficult to expel it.

This attachment is intended to be used in conjunction with bridge work, and as the setting of the bridge is of itself a particular operation, the following plan could be adopted:

Fill the root canal, or the outer portion of it, with temporary stopping, being careful not to encroach on the base of the cavity. Set the bridge in the usual manner, and when the cement has hardened, with a small, rough, heated instrument remove the temporary stopping, and free the canal from all debris, after which the pin may be set independently and the projecting end reduced with stones to the level of the inlay. This method was suggested and has been successfully used by Dr. A. L. Le Gro of Detroit, Mich., who has demonstrated it at various times within the past few years.

A method of utilizing short pins for anchorage purposes, placed in various locations in cavities prepared in vital teeth, has been extensively applied by Dr. M. L. Ward of Ann Arbor, Mich. In this system he makes use of one or more pins or a two-point staple, the bent portion of which is enclosed in the inlay.

The main points to keep in mind in applying this system of anchorage to inlays are to arrange the pins parallel with the line of direction in which the wax model is withdrawn from the cavity, and in drilling the holes to avoid encroaching on the pulp.

A method of shoulder anchorage, applicable to axio-occlusal cavities in vital bicuspid and molar teeth. In this system a groove is cut at the extremity of the step farthest from the axial wall involved and of sufficient depth to prevent radial movement of the inlay outward. Usually from one to one and one-half millimeters in width and depth will be ample dimensions for the groove. Fig. 946.

A simple method of dovetailed anchorage, applicable to axio-occlusal cavities in vital teeth. This cavity preparation differs but little from that followed in gold foil operations except that all axial walls must flare slightly from gingival and pulpal surfaces, from one to two degrees. Fig. 947.

The Matrix Method of Inlay Production

The preparation of cavities intended for the reception of inlays formed in a matrix is essentially the same as for inlays of any class, viz., the development of flat seats, and slightly flaring walls, to permit release of the matrix without distortion. The subject of cavity preparation will be found on page 931.

The matrix of gold or platinum may be formed in two ways, by the *direct,* or by the *indirect* method.

DIRECT METHOD OF PRODUCING A MATRIX

The direct method consists in adapting a piece of 24-carat gold, or platinum foil, to and against the cavity surfaces of the natural tooth. The steps are as follows:

Cut a piece of foil somewhat larger than the cavity and from 1-1000 to 1-500 of an inch thick, the thicker foils, while being more difficult to adapt, are less liable to distort in subsequent steps.

Anneal the piece, center it over the cavity, and with spunk or pellets of cotton, in the ball-pointed pliers, press it against the cavity floor and gradually adapt it to the cavity walls and margins.

Since the steps are practically the same as in forming a platinum matrix for a porcelain inlay further details may be found on page 920.

When general adaptation of the foil to the cavity surfaces has been secured, the peripheral excess is trimmed away, a narrow margin, however, being left to outline the cavity margins and prevent the gold, in fusing, from being drawn outside to the cavity surfaces of the matrix.

Finally, the matrix should be annealed and readapted to the cavity with spunk or cotton, applied under heavy pressure, to correct warpage.

In simple cases the matrix is carefully removed, laid on the solder block, some small squares of plate or pellets of pure gold, previously spheroided and fluxed, placed in the interior, and high-grade solder fused into the matrix and around them.

During the fusing of the solder the pure gold pellets or pieces are not fused, consequently there will be less contraction and less danger of warpage of the matrix than when solder alone is used.

Sufficient gold is added and fused to develop desired contour, the inlay pickled in acid, washed and returned to the cavity for final reduction with stones and discs.

It is then cemented in position and the final polish applied as with a gold foil filling.

VARIATION IN METHOD

In compound cavities, it is frequently advisable to force slightly softened wax in the matrix while in the cavity, being particularly careful to adapt it to the margins.

The matrix is then removed and its cavity surfaces imbedded in some good investment material. When hardened, the wax is removed, the matrix fluxed, case heated, and solder applied as above described.

FORMING THE MATRIX BY THE INDIRECT METHOD

An impression of the tooth is secured in modeling compound. One of the cup pattern trays, suggested by Dr. Roach, may be used or one can be improvised from thin aluminum plate by the method described by Dr. Van Woert. (Items of Interest, 1913.)

The impression is dusted with talcum powder and the surplus carefully brushed from the deeper portions. This is to serve as a separating medium.

Modelite or a good quality of cement is mixed to medium thick consistency, applied and forced into every portion of the impression, building it up in sufficient bulk to withstand the stress of matrix adaptation, without fracturing.

When the cement has hardened, the modeling compound is removed, and the cement tooth partially imbedded in modeling compound for support, or it may be set in a ring of the swaging device.

In either case, the cement reproduction of the tooth should be so placed that its axial walls will be supported to resist side stress. Most of the force of matrix adaptation should be applied vertically, downward.

The matrix may be adapted, either by burnishing or swaging, or by both methods combined.

When possible to do so it is advisable to test the adaptation of matrix to tooth cavity before contouring with gold.

When the matrix method is carried out accurately, comparatively perfect adaptation of an inlay to tooth and cavity surfaces can be secured.

Cast Gold Inlays

GENERAL REMARKS

To be reasonably successful in the casting of inlays and of prosthetic restorations in general, it is necessary to know something of the physical properties of the materials employed.

Casting operations involve the use of waxes, investments, and the metal of which the restorations are to be made, usually gold. These materials, within certain limits, are subject to the same law as are nearly all solid substances, viz., that *heat expands* and *cold contracts,* the amount of dimensional change being generally dependent on temperature variations.

In the various steps, from the formation of the wax model to its reproduction in metal by casting, the materials under consideration are subjected to widely varying temperature changes. These changes, as the work is carried forward, tend to produce errors, by increasing or decreasing the size of the model, the form of the investment, and, finally, reduction in size, or in warpage of the metal casting itself, which changes are oftentimes sufficient to render it worthless.

While no absolute line of procedure, for avoiding error in the casting process has been determined, certain facts of importance are known, which, if observed, will minimize the tendency to error.

PHYSICAL PROPERTIES OF THE MATERIALS EMPLOYED IN CASTING

With few exceptions, the physical law, as previously stated, that *heat expands and cold contracts,* applies to solids, liquids, and gases alike. The standard of measurement of the linear, superficial, or cubical change, occasioned by raising the temperature of a given substance, is based on the increase noted in elevating the temperature of that substance from 0 to 1° C. The amount of such increase is termed the *co-efficient* of *expansion.*

Between 0 and 100° C., the co-efficient of expansion in a metal, an alloy, or any substance of standard character, is comparatively constant for that or any like class of substances. When metals are alloyed, or when the composition of substances is modified, their co-efficients of expansion change, sometimes to a remarkable degree. The following four alloys of nickel and iron, although instances of the extreme type, serve to illustrate this fact.

	Nickel.	Iron.	Mean co-efficient of expansion between O and 100 deg. C.
No. 1	28	72	.000015
No. 2	36	64	.0000015 (Known as "invar")
No. 3	45	55	.0000088
No. 4	60	40	.000012

Varying the proportion of nickel and iron only 8 per cent reduces the co-efficient of expansion of the invar to one-tenth that of the first alloy. Combining the same two metals in the proportions as shown in the fourth alloy, results in increasing the expansive index to within .000003 that of the first.

EXPANSIVE AND CONTRACTILE FORCES

When metal is expanded by heat, a certain amount of energy is developed which becomes apparent on restricting its free movement. According to Joule's data, when a pound of iron is raised in temperature from 0 to 100° C., it expands one-two-hundred-and-eightieth of its bulk. The energy or force of this expansion is sufficient to raise seven tons one foot in height.

A bar of iron 10 inches long will expand 1/200 of an inch with a raise in temperature of 45° C. The force of this expansion is equivalent to 50 tons.

A bar of malleable iron, of one inch sectional area, is stretched 1/10000 of its length by a weight of one ton. Raising its temperature about 9° C. will elongate it to the same extent.

When bodies have been heated to a high temperature, the force produced by their contraction in cooling is equivalent to the force which is needed to compress them to the same extent by mechanical means. (Ganot's Physics.)

The relation of these examples of expansive and contractile forces to inlay work, particularly to investments, will be brought out later.

PRINCIPAL SOURCES OF ERROR IN INLAY CONSTRUCTION

The three principal classes of materials used in inlay construction, as previously stated, are waxes, refractory investments and gold of varying carets. In manipulative procedures these materials are subjected to dimensional changes which vary according to the composition of the substance used, and the technical methods employed. The many varieties of wax exhibit a wide range of difference in their hardness, adhesiveness, cohesiveness, expansive tendency, liability to warp, and general susceptibility to thermal changes.

Investment materials vary greatly in composition, density and porosity. Some maintain their integrity at high temperatures without crumbling, crushing, or flaking, while others are more or less disintegrated.

Gold of varying carats and compositions shows different expansive indices, and more or less variation in fluidity, as a general rule, when fused. The higher the carat of gold used, the sharper will be the casting, while less contraction will occur in cooling. There are, however, exceptions to this in some of the more recent alloys of gold.

Two or more men using identically the same materials, following the same technic, and working under as nearly the same conditions as possible, will not produce identical results. Duplicate pieces produced by the same individual, even when extreme care is taken to follow the same methods, vary more or less.

This fact, together with variations in the physical properties of materials employed, renders impossible the production of *perfect inlays.* A near approach to good adaptation and general requirements, however, may be secured by using carefully selected materials, and by exercising care in technical details.

WAXES

The basis of most of the inlay waxes is beeswax. In its natural condition beeswax is not suitable for inlay models. It is too soft and bends too easily to retain its form in handling. Beeswax consists of three principal substances, first, Myricyl palmitate, $C_{30}H_{61}\ C_{16}H_{31}O_2$; second, Cerotic acid, $C_{27}H_{54}O_2$, and Cerolein, a waxy organic compound.

Beeswax melts at 63° C. (145° F.), Sp. Gr. .960. When melted on a plaster slab it is gradually absorbed, and if pure leaves no residue. On applying increased heat it is volatilized. It is quite adhesive when pressed firmly against an object. This is a detrimental quality, as it tends to stick to cavity walls. Beeswax lacks cohesiveness and consequently its molecules do not cling together firmly. For this reason it is brittle, and in carving, thin margins tear away easily.

PARAFFIN

Paraffin is a natural, wax-like substance, usually composed of two or more members of the paraffin series of hydrocarbons. Its formula varies somewhat, depending on its derivation, but corresponds generally with the following: $C_{28}H_{58}C_{29}H_{60}C_{30}H_{62}$. It melts between 113° to 149° F., depending on the source from which procured, and on cooling forms a white, rather hard, compact crystalline mass. It is quite cohesive, but not very adhesive in a cold state.

EFFECT OF COMBINING WAX AND PARAFFIN

By combining beeswax with paraffin, frequently having a very considerable excess of the latter, the product is less adhesive, more cohesive, and somewhat harder than when uncombined. Some of the resins are frequently added to the foregoing combination, to give increased hardness. Such products sometimes fail to volatilize, leave a residue in the matrix, and are usually detrimental.

ESSENTIAL REQUISITES OF A WAX

Briefly stated, the necessary qualities of an inlay wax are as follows:

First, it must have a low coefficient of expansion.

Second, it should be strongly cohesive, but not perceptibly adhesive.

Third, when cold, it should break before bending.

Fourth, it should be hard enough at body temperature to carve well.

Fifth, it should become plastic at a reasonably low point above body temperature.

Sixth, it should be dark in color and translucent, so that in carving, tooth surfaces may be seen through thin layers of it.

In practice, a wax should be selected, as previously stated, which, on testing, leaves no residue. If a residue remains, it should be discarded, as its use would result in rough and imperfect surfaces to the inlay. The next most important quality in a wax is a low range of expansion. It must be borne in mind that the wax is forced into the cavity in its most expanded condition. The higher the temperature required to render it plastic, the greater its expansion, and, consequently, the more contraction will occur in cooling to room temperature. While in this contracted state, the investment of the model is usually accomplished. It is therefore smaller than when first adapted to the cavity walls. While, in the subsequent steps of casting, the investment and ring expand under heat, and possibly the matrix itself may become slightly enlarged, such changes are beyond control. They may correct, partially or wholly, the error of contraction in the wax, or they may lead to still greater error, through unequal expansion, since the crucible portion of the investment is much hotter than the bottom, at the moment of casting.

ELASTIC PROPERTIES OF WAX

When a roll of wax is rendered plastic by heat, bent in the form of a ring, and chilled, the ends being unattached, it will remain in that form so long as the temperature is not raised. In bending, the molecules on the outer periphery of the ring are elongated, while those along the inner periphery are compressed.

In most materials, and in wax as well, the tendency of molecules, when stretched or distorted, is to return to normal

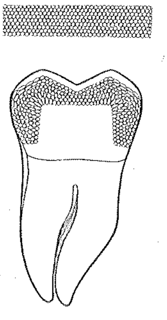


Fig. 949.—Diagrammatic Drawing, Showing Molecular Arrangement of Wax When Melted and Run in Bar Form. Diagram of Tooth with Bar Bent Into a Mesio-Occluso-Distal Cavity. Notice the Elongation of Theoretical Molecules on the Outer Periphery and the Compressed Condition of Those in the Inner Periphery

form and relation to each other, when the stress which distorted them, or the force which holds them in abnormal form and position, is removed. Chilling the wax hardens it, and renders inert the tendency of the molecules to return to normal form. By subsequently raising the temperature of the wax, the force which locks the molecules in their strained relation is partially overcome, and, to a limited extent, they return to their original form, causing the ends of the wax ring to separate. The temperature at which the inherent tendency of the molecules of wax to recover their form becomes perceptible varies according to the composition of the material. It is evident that some waxes, hard enough to carve at body temperature, change form on removal from the mouth, while others apparently do not exhibit such tendency. Time, and fluctuating temperature, without doubt, encourage warpage, therefore, to avoid excessive dimensional change and warpage, the wax model should be invested as soon as possible.

INVESTMENT MATERIALS

The refractory basis of most investment materials, used for casting purposes, is pulverized silex, of varying degrees of fineness, and in some cases graphite. Plaster of paris serves as a binder, or cementing medium, and fills the voids between the granules of silex. Various other substances are added to control the time of setting, prevent contraction, and impart smoothness and density to the mass when mixed.

EXPANSION OF INVESTMENT RING AND INVESTMENT MATERIAL

The coefficient of expansion of brass of which most casting rings are made is .000018, between 0 and 100° C., that of quartz between 0 and 1000° C., 00000055. (Ganot's Physics.) The expansion of the brass is therefore thirty-three times greater at only one-tenth the temperature, than that of quartz. The coefficient of expansion of graphite is .0000078 (Ganot's Physics), or about 14 times greater than that of quartz, but perceptibly less than brass. Its effect, when combined with quartz in an investment, is to increase the coefficient of expansion. Some of the best investments procurable contain a considerable percentage of graphite incorporated for this purpose. The coefficient of expansion of the materials mentioned is variable, according to composition, variety, etc.

Since the investment ring expands on heating, the investment itself should also expand and follow the walls as closely as possible, first, to counteract the internal force brought upon the matrix walls in casting the gold under pressure, thus preventing the investment from cracking or bulging outward in thin places, and second, to prevent the investment dropping from the ring in handling; third, to enlarge the mold slightly, thus compensating to a slight extent for contraction of the gold. Expansion of the investment, therefore, is a necessary quality.

Some investment materials show a tendency to contract toward several common centers when overheated. When this occurs, cracking of the investment follows and the general surfaces of the matrix are warped.

Some investment materials are subject to varying dimensional changes on the application of heat, depending on the quantity of water used in mixing. Thin mixes, as a rule, show a greater tendency to contract and warp than thick mixes of the same material. Taggart's investment is an exception to this rule, as it has a high coefficient of expansion when mixed thin enough to be poured.

ESSENTIAL PROPERTIES OF AN INVESTMENT MATERIAL

The essential properties of an inlay investment material, briefly stated, are as follows:

First, it should not contract in setting, even when mixed thin.

Second, it should be dense and free from perceptible porosity when set.

Third, it should be hard, resistant to stress, and show no tendency to crack when heated to casting temperature.

Fourth, it should possess a high expansive index, and a low coefficient of conductivity under heat.

Fifth, it should not be fused, by the molten gold, in casting the latter.

Since there is no cohesion whatever between the granules of refractory materials themselves, a binder must be incorporated, which in practically all cases is plaster of Paris. As has previously been shown, this material is a crystallized, di-hydrate of calcium sulphate, which decomposes to a greater or less extent at 190° C. The crystals do not immediately crumble on being heated, but are greatly weakened, so that the application of slight force is sufficient to disintegrate them. That the matrix walls of overheated cases do not flake away more readily than would at first appear from the disintegration of plaster is due to the mechanical interlocking of the granules of the various materials of which the investment is composed, and which lie in more or less close contact. Decomposition of the binder from overheating is largely responsible for the roughening and bulging outward of the matrix walls under the pressure of casting.

As an example, casts and investments composed of plaster alone, although at first expanded with slight rise in temperature, when heated to high temperatures, contract, crack and distort very quickly. Plaster, therefore, should not be used to excess in inlay investments or the quality of the latter will be impaired in proportion to the excess of this material present. By using but little more than an amount sufficient to fill the voids between the granules of refractory materials, contraction is, to a great extent, obviated and the tendency to crack and warp is greatly reduced. Roughly estimated, the proportion of plaster to refractory materials ranges from 25 to 40 per cent.

Further valuable discussion of this subject will be found under the heading, "Refractory Materials," by Dr. Weinstein, page 1040.

DIMENSIONAL CHANGES IN GOLD, DUE TO TEMPERATURE CHANGES

When gold changes from a fused to solid state and normal temperature, its cubical contraction, according to Dr. W. A. Price's findings, is about 6.75 per cent of volume.

Linear, being one-third that of cubical contraction, is, therefore, about 2.25 per cent. In an inlay one-fourth inch wide, or long, the linear contraction of that surface would show a deficiency of about .005 of an inch.

While heavy pressure, applied during and after injection of the molten gold into the mold, might, by the compressive force exerted, reduce to a slight extent the percentage of contraction noted, such method is impracticable, because of the comparative non-resistance of the investment materials to heavy pressure.

Contraction of the gold, therefore, is a constant source of error in the production of castings of exact dimensions.

COMPENSATING FOR ERRORS DUE TO CONTRACTION OF GOLD

Various means have been suggested for minimizing the errors arising from the contraction of gold in cooling, a few of which will now be mentioned.

First, the use of an investment which will expand on heating, thus enlarging the matrix to a slight extent. This method, however, is subject to error, for unless the investment is uniformly heated it will not be equally expanded, and as a result the mold walls will be distorted.

Second, heating the wax model somewhat above body temperature by investing in warm, instead of cold, investment, thus expanding it slightly before the investing medium hardens. Error may or may not occur when this method is followed; if the wax is under molecular strain, yet rigid at room or body temperature, investing it in a warm medium may release the tension and result in warpage of the model before the investment hardens. When not subjected to molecular tension, expansion without distortion will occur, thus favorably increasing the dimensions of the matrix.

Third, the use of sufficient gold to insure a considerably larger residual button in the crucible after injection into mold than the bulk of gold in the casting. Naturally, the casting, being smaller, and the matrix walls in a less heated state than the crucible, the contents of the mold will solidify first. When the sprue is of sufficient size and its length not excessive, as contraction of the gold within the matrix sets in, the pressure on the more highly heated residual gold in the crucible forces it in and feeds the contracting mass within the mold until it solidifies.

The necessity for the unequal balancing of the gold as suggested is apparent for the following reasons:

To produce sharp castings it is necessary that the gold be in a superheated condition, considerably above its actual fusing point. The contraction of superheated gold may be divided into two stages, first, that which occurs in passing from its highest heated and most expanded condition to the freezing state, and second, from the point of congealing to normal temperature.

Now, if gold, in a superheated condition, be cast into either a hot or cold matrix, and no provision is made for replenishing the contracting, fluid mass, the casting will be defective, and in case of inlays the margins will be rounded.

RESULT OF CONTRACTION OF GOLD IN INLAY ADAPTATION

The result of contraction of gold in inlay construction is that, in a simple cavity, the inlay will fail to fill the cavity perfectly, a more or less open space showing around the margins, while the axial surface usually sinks slightly below that of the tooth.

Since, as has been previously shown, the contractile force exerted by a casting, in cooling, is equivalent to the mechanical force required to compress gold, of similar bulk, an equal amount by mechanical means, it therefore follows that in mesio-occluso-distal inlays the investment interposed between the mesial and distal flanges of the inlay will be compressed and distorted to a greater or less extent.

As a result of such contraction, the inlay frequently fails to go to place. To seat it, the tooth may be reduced, the inner walls of the matrix enlarged or the occlusal portion of the inlay stretched sufficiently to permit its being driven to place.

Dr. Price suggests two means for overcoming the difficulty; first to cast the inlay against a reproduction of the tooth, developed in a special artificial stone, or to cast the inlay around a threaded iridio-platinum bar, extended through and beyond the occlusal body of the inlay, sufficiently to gain a firm hold in the investment.

Still another method, suggested by a member of the profession in Wisconsin, whose name the writer cannot recall, consists in drilling a hole through the occlusal portion of the inlay, inserting a fine saw and cutting buccally and lingually almost, but not quite, to the walls to weaken the gold, introducing the inlay and driving it to place. As a result the gold is stretched and the inlay lengthened. Care should be taken to see that the gingival ends are not bent outward, or, if so, to readjust them, after which wax is filled in the hole and saw cut, the inlay invested and the opening filled with solder.

Since ordinary investments, used in casting, are unable to resist the force of contraction of the gold, practically the only means left is to select a material that expands perceptibly during the heating and casting process.

Technic of Cast Gold Inlay Construction

FORMING THE WAX MODEL

Inlay waxes are prepared in stick form and are also supplied in the form of cones and various irregular shapes suit-

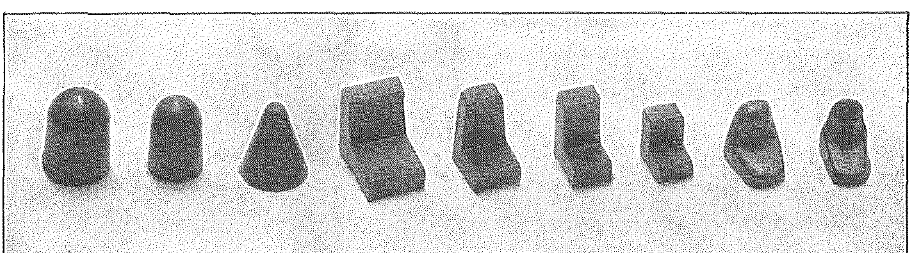


Fig. 950.— Various Forms of Inlay, Wax Blocks

able for introduction into different classes of cavities, without bending.

These blocks and sticks are formed by melting the wax and casting into molds. They are, therefore, free from molecular tension.

Select a wax form of approximately the shape, but larger than is required to fill the cavity.

If the cavity is irregular as one of the mesio-occluso-distal class, a form should be carved, of the desired shape, from a large block, or two forms may be joined by melting their contact surfaces, and the required form carved from the united pieces.

Soften by placing in hot water, the temperature of which should range from 115° to 139° F., according to the variety of wax used.

Price's wax becomes workable at 115° F., Peck's at 120° F., Cleveland Dental at 127° F., S. S. White at 128° F., Consolidated at 130° F., Goslee's at 135° F. and Taggart's and Klewe's at 139° F.

The wax should be entirely immersed in the water, remaining there a sufficient time to become uniformly heated throughout. Dry the cavity and apply a thin film of oil to prevent wax adhesion. Introduce wax in the cavity, and with ball of the thumb or finger apply steady, positive pressure in such direction as will force the wax *into* and *against* cavity walls and margins.

Avoid changing direction of pressure, or rolling the ball of the finger over the wax. When change of direction of pressure, from any cause, occurs, the wax is liable to become unseated, or moved away from the cavity walls. Then, when contraction of the wax occurs, as is invariably the case, errors in adaptation are still further increased.

Continue pressure until wax has cooled to body temperature. Heat a spatula and soften the occlusal surfaces. Instruct patient to subject the wax to the action of opposing teeth, not only in full occlusion, but to lateral movements as well.

Remove peripheral surplus of wax and carve to desired form. The carving tool should be applied so as to cut parallel with the line of junction of wax with cavity margin or be drawn diagonally across the junction from wax to tooth. When drawn from tooth to wax, the latter is liable to be torn or drawn away from the cavity margin and thus result in a defective margin of the wax model.

A smooth finish may be given axial surfaces by means of silk strips, moistened with oil of cajeput. Flat surfaces may be smoothed with pellets of cotton, slightly moistened with the oil.

Remove the wax model carefully with small instrument, and attach sprue former.

In all cases the attachment of the sprue to the wax should be at the highest point of the matrix, when the ring is set in proper position for casting.

When any portion of the mold is higher than the point of entrance of the gold into the latter, air frequently becomes

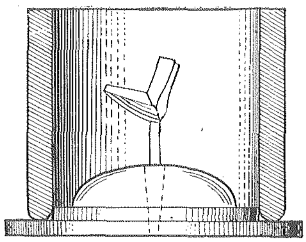


Fig. 951.— Wax Model of Inlay Attached to Sprue Former, Ready for Investment

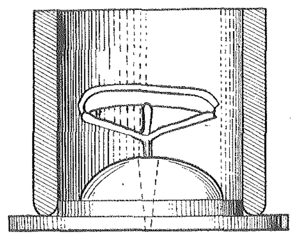


Fig. 952.— Wax Model of Small Saddle, Ready for Investment. Three Wax Sprue Formers Lead from Metal Sprue Former to Extremities and Center of Model

confined or the gold becomes chilled and fails to perfectly fill such high areas.

A small strip of gold plate may be heated sufficiently to melt its way into the wax, and when cold this will serve as a plier grasp in removing the model. It may be allowed to remain in the wax when invested, and when the inlay is cast, the projecting end will facilitate handling the inlay while fitting. After serving its purpose it may be removed by cutting and the surfaces polished smoothly. Suggested by Dr. T. L. Pepperling.

The sprue former is now heated and applied at the point of proximate contact. It must be imbedded sufficiently to obtain a firm hold upon the model so that displacement will not occur during investment.

The wax around the sprue former should be smoothed properly and a slight amount added, if necessary, to insure strong proximate contact.

INVESTMENT OF THE WAX MODEL

The sprue former with wax model attached, is now set in the opening of the crucible former and the wax washed with a soapy water solution and afterward clear water, applied with fine brush, to remove the oil.

A mix of investment of medium consistency is now made and with a fine brush the surfaces of the wax are carefully coated with a film of it. The investment ring is now set in position, the rounded margin down, and the space around the model entirely filled with investment.

Care should be taken, both in coating the wax and in filling the ring with investment, to avoid the formation of air spaces.

When the investment has hardened, the surplus projecting from the open end of the ring is squared off, the crucible former removed, the sprue former heated sufficiently to melt the wax at its inclosed end, after which it is carefully removed.

Remove from the crucible and the sprue any particles of investment that may be present, so that when ready to cast the mold may be clear.

DRYING OUT THE INVESTMENT AND ELIMINATING THE WAX

Place the investment ring about three inches above a low Bunsen flame for five minutes, that it may become gradually heated.

Lower the ring and raise the flame until the latter touches the investment, and continue the heating process for five or ten minutes longer.

Increase the flame until it passes up, surrounding the sides of the ring. Continue the heat at this higher temperature until the investment is freed from all moisture and the gas has been driven off. At no time should the heat be applied so rapidly as to *boil* the wax and force it through the sprue.

Test by holding a piece of cool glass close to upper end of ring.

When all gas and moisture has been expelled, the ring is set aside and allowed to cool before casting.

VARIATION IN THE METHOD OF PREPARING THE MOLD FOR CASTING

When investment has hardened, the ring is placed about six inches above a medium-sized Bunsen flame and allowed to remain in the current of heated air until all moisture is expelled.

This may require thirty minutes or more, and during the process the temperature will be raised somewhat above 212° F. It should not at any time be raised much above that point.

Now, since wax melts at about 150° F., it will be absorbed by the investment as the moisture is expelled from the latter. A film of wax, however, will remain on the matrix walls.

The ring may be set aside to cool, before casting the gold, or the button of gold may be placed in the crucible, fused and cast immediately, if desired.

The film of wax in no way interferes with the production of a sharp casting. In fact, when the gold is sufficiently superheated and injected into the mold, under proper conditions, a sharper and cleaner casting can be produced by this than by the former method.

The instant the gold is forced into the matrix its temperature is considerably above 2000° F. All gas and air in the matrix is forced outward through the walls into the investment, the film of wax is instantly carbonized and prevents the oxygen in the air, forced out, from coming in contact with the gold, the result being a clean, bright casting.

The greatest advantage, however, is that the binder in the investment has not been disintegrated by previous heating, and as a result the matrix walls are firm and comparatively unyielding. The roughness, therefore, so frequently seen on cast gold surfaces, when the investment is previously highly heated, is not noticeable in a casting produced by the method just described.

Credit for this method of treatment of the invested case belongs to Dr. Chas. B. Meade of Rockford, Ill., who first demonstrated it at a clinic of the Chicago Dental Society.

THE CASTING OF GOLD

Under the most favorable circumstances a certain amount of time unavoidably elapses between the discontinuance of the heat applied in fusing the gold and its injection into the mold.

The instant the flame is discontinued the temperature of the gold begins, and continues to drop, resulting in change from a fluid to a pasty and finally a solid state.

When gold is brought to a fused condition only, and the flame is discontinued, these changes occur very quickly, so rapidly, in fact, that in introducing it in the mold, even under heavy pressure, the latter will seldom be filled perfectly, because of the changes mentioned.

Therefore, to insure sharp castings, gold must be *superheated* considerably above its actual fusing point in order that it may not only enter the mold, but be sufficiently fluid, after injection, to conform to all irregular surfaces of the matrix under the compressive force applied.

The most important contribution of Dr. Taggart to the casting process was the discovery that in order to cast sharply, gold must be superheated considerably above its fusing point.

This he accomplished readily by means of a slight modification of the Knapp nitrous oxide and gas blowpipe.

When all moisture has been eliminated, the ring is placed in the casting device, a button of gold considerably larger than required is placed in the crucible, brought to a superheated condition and as quickly as possible forced into the matrix under pressure.

With the Taggart appliances the gold may be quickly brought to a superheated condition by means of the nitrous

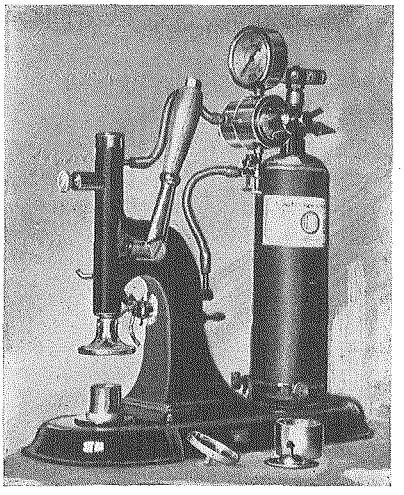


Fig. 953.— The Taggart Compressed Gas Casting Machine

oxide and gas blowpipe and the casting quickly accomplished by forcing the sealing cap down tightly upon the ring margins.

With the R. & R. vacuum machine, the chamber should be emptied of air before fusing the gold, when, after this has been accomplished, by opening the valve, the gold is drawn into the matrix by suction.

Further details of gold, reducing fluxes, investments, etc., of practical value will be found in the section on metallurgy, under the general topic, "Alloys of Gold," etc., by Dr. Weinstein.

ROUGH FINISHING THE CASTING

On removal of the casting from the investment, it should be washed, boiled in acid, and again washed, to remove the acid.

The button is now removed from the casting, the rough points removed with discs, being careful while doing so not to mar the margins, and in proximo-occlusal inlays to preserve a strong contact point.

Should nodules be present in any of the inlay surfaces which proximate cavity walls, they should be smoothed down

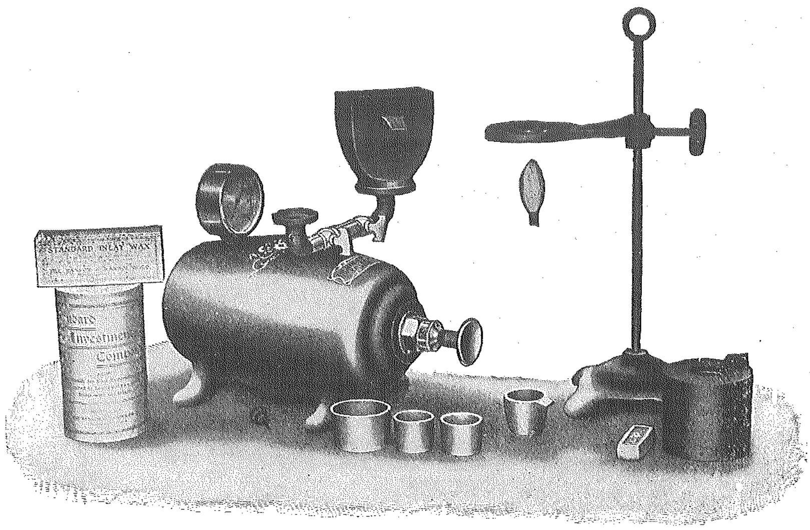


Fig. 954.— The Ransom & Randolph Vacuum Casting Machine

with chisels, discs or stones or reduced in any manner most convenient. When present, they prevent proper seating of the inlay.

SETTING THE INLAY

When, by test, the inlay can be perfectly seated, it is removed, the cavity rendered thoroughly dry, cement mixed and applied in the usual manner, and the filling set under continued, heavy pressure.

FINISHING

When the cement has thoroughly hardened, the margins of the inlay are now given their final finish with discs, strips, and polishing powders.

Previous to the final setting, however, the contact and adjacent areas of the filling are polished, thereby reducing danger of loss of proximate contact, which frequently occurs in final finishing, unless separation of the teeth is previously made.

CHAPTER XXXII

AN OUTLINE OF METALLURGY

The science of metallurgy deals with the extraction of metals from their ores, with their physical properties when free and uncombined, and with the changed conditions brought about by alloying the individual metals, or by the presence of some other substances, either in the form of impurities or that may have been added for some definite purpose.

Metallography deals more particularly with the structural form of metals and their alloys, the study in this comparatively new field in physics being carried on chiefly with the microscope. It is closely related to the chemistry of metals, and yet it covers a field not occupied, and yields information not obtainable, by ordinary chemical analysis.

In the practice of prosthetic dentistry, about fifteen of the metals are used to a greater or less extent, either in their pure state, or in the form of alloys. To handle these various metals intelligently and economically, so as to secure the best results, the prosthetic dentist should have an intimate knowledge of general and metallurgical chemistry, as well as of the collateral sciences. In the description of the metals now about to be considered an effort will be made to point out those essential physical and chemical properties and peculiarities which, if overlooked or misunderstood by the prosthetist, may result in mishaps of a more or less serious character.

All of the material substances of the universe with which we are acquainted consist of elements alone or in combination with each other.

An element is a substance which cannot be split up or decomposed into dissimilar substances by any means now known, and differs from a compound, which may be split up or separated into dissimilar substances.

At this time there are about eighty elements known, fifty-two of which are metals. It is possible that some of these substances which are now considered elements may prove to be compounds.

Facts, Hypotheses, Theories and Speculations

ELEMENTS

An element is a substance which cannot be decomposed into simpler substances by any method now known. Stated differently, "an element is a distinct species of matter which has not been shown to be composite."

As before stated, at the present time, so far as is known, there are about eighty elements in the universe. The physical properties of most of these are well understood, but a few, because of their scarceness and the difficulties attending their examination, have but sparse accumulated data. It is not only possible, but quite probable that other elements now unknown may be discovered, and that some of those now classed as elements may prove to be compounds.

DISCOVERY OF ELEMENTS BY MEANS OF THE SPECTROSCOPE

The spectroscope has aided materially in the detection of some of the elements, and by means of it their presence in the universe was recognized before they themselves were isolated. As an illustration, in 1868 a bright line was noticed in the spectrum of the sun's atmosphere which differed from that of any element then known. Lockyer and Frankland, believing it to be a new element in the sun, called it *helium*, from the Greek, meaning *the sun*. Twenty-seven years later Sir William Ramsay discovered in the spectrum of *cleveite,* a line corresponding with that of helium, which was still unknown except by its spectrum. On further examination this new element proved to be a gas, a constant component of the earth's atmosphere, and, as will be shown later, an end product of radio active substances under certain conditions. Because of its spectroscopic position it received the name of helium. For many years the spectrum of the Aurora Borealis was a subject of puzzling investigation. This light shows in it a peculiar, greenish yellow line, unlike that of any other element known. The discovery of krypton solved the problem, its spectrum showing the identical line found in that of the "Northern Lights."

THE MUTABILITY OF MATTER

There is a growing belief among physicists that some, possibly all substances now known as elements, may be transmutable or capable of being changed from one to the other. The change, however, appears to be one of degradation.

No laws have been discovered by which this mutability of matter can be brought about at will or among the elements indiscriminately. Certain facts, however, have been observed and verified time and again, beyond the question of doubt, that under definite conditions degradation of elements occurs. The character of the element before such change occurs can be recognized, the intense energy exhibited while decomposition is going on can be noted and even measured to a certain degree, and the character of the substance into which the original element is finally resolved can be determined.

BRIEF OUTLINE OF RECENT DISCOVERIES

To make these facts more plainly apparent, a statement of some of the discoveries in physical and chemical fields in the last twenty years, together with their bearing on the subject under discussion, will be in order.

ELEMENTAL GASES

In 1894 Lord Rayleigh discovered in the atmosphere a new and hitherto unsuspected gaseous element. Because it would not combine chemically with any other substance except at intensely high temperatures, and in other ways seemed generally inert, it was named "argon," which means "lazy." It closely resembles nitrogen in its physical properties, is slightly heavier and extremely difficult to separate from the latter gas with which it is associated in the atmosphere.

In 1895, Sir Wm. Ramsay discovered four other elemental gases in the air, viz., helium, neon, krypton, and xenon, all of which have similarly inert properties to argon. These five gases have all been "won out of the hidden places in the air," and as will be seen later, the presence of most of them in this medium can be accounted for.

DISCOVERY OF THE X-RAYS

In the same year Prof. William Konrad Roentgen discovered the peculiar penetrating power of the rays from an induced electric current when passed through a vacuum. These rays are now known as Roentgen, or X-rays, and their power of penetrating opaque substances and affecting light proof photographic plates is well understood and made use of in innumerable ways, particularly in the medical and dental fields, for diagnostic purposes.

DISCOVERY OF RADIO-ACTIVE SUBSTANCES

In 1896, Becquerel discovered that all compounds of uranium emitted a radiation capable of penetrating opaque objects similar to but not with the same energy or rapidity displayed by the X-ray. Uranium compounds are derived from pitchblende, a complex mineral containing many other elements. The residue left after extracting practically all of the uranium is the source from which radium is derived. The Curies noticed that this residue possessed considerable radio-activity. In an effort to locate the true source of the emanations, they found that after separating the residue into its constituent parts, so far as could be done at that time, that most of the radio-activity was concentrated in the chloride of barium. On subjecting the barium chloride to further reduction, the barium was finally eliminated and a substance which proved to be radium chloride was secured. Radium, the element, has not yet been isolated. Its salts $RaCl_2$ and $RaBr_2$ are commonly prepared and employed for experimental and other purposes. The spectrum of radium and its chemical relations to other elements indicate that it should be classed among the metals of the alkaline earths.

There are about twenty-five substances which possess, in varying degrees, distinct radio-active properties. The salts of radium mentioned exhibit this property more strongly than any of the others.

DECOMPOSITION OF RADIUM COMPOUNDS

The peculiar feature of the radium compounds is that they decompose, rapidly at first, then more slowly, until finally practically nothing remains of the original salt. The intense energy displayed in their decomposition is half spent in the first four days after the preparation of the salt, but in that time there has been emitted, proportionately, three million times more heat than will result from any other chemical action known.

There are three principal types of rays emitted by radio-active substances, designated as alpha, beta, and gamma rays. The alpha rays are electro-positive particles or electrons of atomic size which fly through space at the amazing velocity of twenty thousand miles per second. A little radium brought near a screen of zinc sulphide produces brilliant, scintillating stars of light. Each star is the result of impact of an alpha particle or atom against the screen. The beta rays act most readily on photographic plates. The gamma rays possess the greatest penetrating power, readily passing through a lead plate seven centimeters thick. The principal difference aside from the effect of the several rays seems to be one of velocity, the alpha rays having the greatest and the gamma rays the least speed.

CHARACTER OF THE EMANATION FROM RADIO-ACTIVE SUBSTANCES

Dorn has proven that the emanation from radio-active substances is a gas, which, under dry atmospheric conditions, eventually breaks down or decays into helium.

Later Ramsay, in an effort to utilize or conserve some of the enormous energy which is manifested during and is apparently the result of its debasement, placed the radium compound in water. Instead of decaying into helium as it does in dry atmosphere, it is finally resolved into neon, the second of the elemental gases mentioned.

When copper sulphate is dissolved in the water in which the radio-active substance is placed, neither helium nor neon are found, but argon is the final product.

Prof. Duncan sums up these facts as follows: "It appears then, that this gas, this radium emanation, which, it must be said, has a good claim to the name of element, decays or becomes transmuted, not into one other element, but into three, according to its surrounding circumstances."

THE DEGRADATION OF COPPER

Ramsay's researches further led him to believe that the action of the radium emanations on the copper sulphate broke down or changed some of the copper into lithium. He bases his deduction on the following: At the beginning of his experiments lithium was not present in the water, in the copper, in the emanations, in the air, nor in the glass apparatus with which the experiments were conducted, but the final results showed loss of copper and the presence of lithium. Everything else could be accounted for but the loss and additions noted, and those only on the basis of the degradation of copper into lithium through the influence of radio-activity.

DEBASEMENT OF VARIOUS SUBSTANCES INTO HYDROGEN

Still another fact of extreme interest was observed, viz.: that water in the presence of radium emanations breaks up into oxygen and hydrogen, not in the usual proportions of two volumes of hydrogen to one of oxygen, but the resulting uncombined gases show from 10 to 20 per cent too much hydrogen.

Prof. J. J. Thompson has shown that in the energetic electrical field generated in a Crookes tube, various substances give off particles charged with positive electricity, that these particles are independent of or differ in character from the gas from which they originate, that they are of two kinds, one to all appearances identical with the hydrogen atom, the others resembling in every respect the alpha particles which emanate from radio-active substances. All of the substances with which he experimented were decomposed, in part, into the element of hydrogen.

These experiments of Thompson's, conducted in a different field with unlike apparatus without employing any of the so-called radio-active substances, serve to confirm most forcibly the work of Ramsay and others, and establish the fact that hydrogen results from the debasement of other elements when conditions are favorable.

SUMMARY OF THE STATEMENTS PRESENTED

From present knowledge it appears evident that uranium is transmuted into radium; that radium may be transmuted into helium, neon, or argon, depending on surrounding conditions; that copper, under the influence of the alpha rays, may be debased into lithium; that the energizing influence of the alpha as well as the X-rays, acting on inert substances, causes them to break down into hydrogen, and finally, that the radium emanations are themselves the product and evidence of elemental change and decay.

The atomic weight of copper is 63.6 and that of lithium is 7.03. In every case the substance resulting from the degradation of an element stands lower in the atomic scale than that from which it was derived, copper and lithium being examples of what is seen in all of the other elements in which such changes have been noted.

In reference to "The decay of an element," Prof. Alexander Smith, Director of General and Physical Chemistry, University of Chicago, says: "The phenomena of radio-active substances lead undeniably to the startling conclusion that *some, if not all, of the element are capable of spontaneous decomposition.*"

The following table from "Scientific Ideas of Today," by Charles R. Gibson, shows the progress of chemical discovery of the elements in the last 464 years.

THE ELEMENTS IN ORDER OF THEIR DISCOVERY

A. D.	Elements	Discovered by
1450	Antimony	Valentine (German alchemist)
1450	Bismuth	Valentine (German alchemist)
1520	Zinc	Paracelsus (Swiss chemist)
1694	Arsenic	Schroder (German)
1733	Cobalt	Brandt (German)
1738	Phosphorus	Brandt (German)
1751	Nickel	Cronstadt (Russian)
1766	Hydrogen	Cavendish (English)
1772	Nitrogen	Rutherford (English)
1774	Manganese	Gahn (Swedish)
1774	Oxygen	Priestley (English)
1780	Uranium	Klaproth (German)
1781	Tungsten	d'Elihujar (Spanish)
1782	Molyodenum	Hjelm (Swedish)
1782	Tellurium	Reichenstein (German)
1785	Titanium	Klaproth (German)
1798	Chromium	Vauquelin (French)
1801	Tantalum	Hatchett (English)
1801	Cerium	Berzelius and Hisinger (Swedish)
1801	Vanadium	Del Rio (Spanish)
1803	Osmium	Tennant (English)
1803	Palladium	Wollaston (English)
1804	Iridium	Tennant (English)
1804	Rhodium	Wollaston (English)
1807	Potassium	Davy (English)
1807	Sodium	Davy (English)
1808	Barium	Davy (English) and Berzelius (Swedish)
1808	Strontium	Davy (English)
1808	Boron	Davy (English) and Gay-Lusac (French)
1808	Magnesium	Davy (English)
1808	Calcium	Davy (English) and Berzelius (Swedish)
1810	Chlorine	Davy (English)
1810	Fluorine	Ampere (French)

A. D.	Elements	Discovered by
1811	Iodine	Courtois (French)
1817	Selenium	Berzelius (Swedish)
1817	Lithium	Arfvedson (Swedish)
1817	Cadmium	Herman and Stromyer (German)
1823	Silicon	Berzelius (Swedish)
1824	Zirconium	Berzelius (Swedish)
1826	Bromine	Balard (French)
1827	Berylium	Wohler (German)
1828	Aluminum	Wohler (German)
1828	Thorium	Berzelius (Swedish)
1828	Yttrium	Wohler (German)
1841	Lanthanum	Mosander (Swedish)
1843	Terbium	Mosander (Swedish)
1843	Erbium	Mosander (Swedish)
1844	Ruthenium	Claus (German)
1846	Columbium	Rose (English)
1860	Cæsium	Bunsen and Kirchloff (German)
1862	Thallium	Crookes (English)
1863	Indium	Reich and Richter (German)
1868	Helium (in the Sun)	Lockler (English)
1868	Rubidium	Bunsen (German)
1875	Gallium	Boisbaudran (French)
1878	Ytterbium	Marignac (French)
1879	Thulium	Cleve (Swedish)
1879	Scandium	Nilson (Swedish)
1879	Samarium	Boisbaudran (French)
1885	Praseodymium	Welsbach (German)
1885	Neodymium	Welsbach (German)
1886	Gadolinium	Marignac (French)
1886	Germanium	Winkler (German)
1894	Argon	Rayleigh and Ramsay (English)
1895	Helium (On Earth)	Ramsay (English)
1897	Krypton	Ramsay and Travers (English)
1898	Xenon	Ramsay (English)
1898	Neon	Ramsay and Travers (English)
1898	Radium	Curie (French)

THE ELEMENTS IN THE ORDER OF THEIR ATOMIC WEIGHTS

1.	Hydrogen	1.008	4.	Glucinum	9.1
2.	Helium	4.00	5.	Boron	11.0
3.	Lithium	7.03	6.	Carbon	12.0

7.	Nitrogen	14.04	43.	Ruthenium	101.7
8.	Oxygen	16.0	44.	Rhodium	103.0
9.	Fluorine	19.0	45.	Palladium	106.5
10.	Neon	20.0	46.	Silver	107.93
11.	Sodium	23.05	47.	Cadmium	112.4
12.	Magnesium	24.36	48.	Indium	114.0
13.	Aluminum	27.1	49.	Tin	119.0
14.	Silicon	28.4	50.	Antimony	120.2
15.	Phosphorus	31.0	51.	Iodine	126.85
16.	Sulphur	32.06	52.	Tellurium	127.6
17.	Chlorine	35.45	53.	Xenon	128.0
18.	Potassium	39.15	54.	Cæsium	132.9
19.	Argon	39.90	55.	Barium	137.4
20.	Calcium	40.1	56.	Lanthanum	138.9
21.	Scandium	44.1	57.	Praseodymium	140.5
22.	Titanium	48.1	58.	Cerium	140.25
23.	Vanadium	51.2	59.	Neodymium	143.6
24.	Chromium	52.1	60.	Samarium	150.0
25.	Manganese	55.0	61.	Gadolinium	156.0
26.	Iron	55.9	62.	Terbium	160.0
27.	Nickel	58.7	63.	Erbium	166.0
28.	Cobalt	59.0	64.	Thulium	171.0
29.	Copper	63.6	65.	Yitterbium	173.0
30.	Zinc	65.4	66.	Tantalum	183.0
31.	Gallium	70.0	67.	Tungsten	184.0
32.	Germanium	72.5	68.	Osmium	191.0
33.	Arsenic	75.0	69.	Iridium	193.0
34.	Selenium	79.2	70.	Platinum	194.8
35.	Bromine	79.96	71.	Gold	197.2
36.	Krypton	81.8	72.	Mercury	200.0
37.	Rubidium	85.4	73.	Thallium	204.1
38.	Strontium	87.6	74.	Lead	206.9
39.	Yttrium	89.0	75.	Bismuth	208.5
40.	Zirconium	90.6	76.	Radium	225.0
41.	Columbium	94.0	77.	Thorium	232.5
42.	Molybdenum	96.0	78.	Uranium	238.0

The Kinetic Constitution of Matter

Matter is composed of or at least presents itself to our senses in three distinct forms, viz., solids, liquids and gases. The molecular theory of matter, as believed in and taught by the physicists of today, may be briefly stated as follows:

Matter consists of units called *molecules;* these in turn are composed of still smaller units of elements called *atoms;* atoms are made up of still smaller units consisting of elementary charges of negative electricity, called *electrons,* each of which probably has a nucleus or center of positive electricity.

THE VIBRATION OF MATTER

It is believed that the electrons move about or vibrate within the atom; that the atoms vibrate within the molecule, to a lesser degree; and that the molecules move about within the mass of matter, freely when the matter is gaseous, restricted in movement when solid or liquid, but still possessing movement.

The infinitesimal particles of gold in a colloidal state, although much larger than the estimated size of electrons, when viewed through that wonderfully simple but simply wonderful instrument, the ultra-microscope of Zsigmondy, enables one to form some slight conception of the vibration of matter. Here is his own description of what may be seen:

" * * * The small gold particles no longer float, they move—and that with astonishing rapidity. A swarm of dancing gnats in a sunbeam will give one an idea of the motion of the gold particles in the hydrosol of gold. They hop, dance, jump, dash together and fly away from each other, so that it is difficult in the whirl to get one's bearings.

"This motion gives an indication of the continuous mixing up of the fluid, and it lasts for hours, weeks, months, and, if the fluid is stable, even years.

"Sluggish and slow in comparison is the analogous Brownian movement of the larger gold particles in the fluid, which are the transition forms of ordinary gold that settles.

"The smallest particles which can be seen in the hydrosol of gold show a combined motion, consisting of a motion by which the particle moves from 100 to 1,000 times its own diameter in one-sixth to one-eighth of a second, and a motion of oscillation of a considerably shorter period, because of which the possibility of the presence of a motion of oscillation of a higher frequency and smaller amplitude could not be determined, but is probable." (Colloids and the Ultra-Microscope, Zsigmondy).

The following comparison will give an idea of the size of the smaller gold particles:

The limit of visibility of an ordinary high power microscope is about one-fourth micron, or one-four-thousandth of a millimeter, a micron being one-one-thousandth of a millimeter, or about one-twenty-five-thousandth of an inch.

Under favorable conditions, particles of one one-millionth millimeters in diameter can readily be seen with the ultramicroscope. Some of the smaller particles of gold are barely visible with this instrument, and it is believed that still smaller particles exist.

When planed surfaces of gold and lead are brought in contact and held together firmly for several weeks, on examination it will be found that particles of gold have made their way into the lead, likewise particles of lead can be found within the gold, thus showing that molecules of solid substances vibrate or move about not only in the mass of like material, but wander away into unlike substances.

Prof. A. Wilmer Duff, of the Worcester Polytechnic Institute, after citing this and similar instances of diffiusion, states: "There are many other reasons for believing that the particles of matter are in all cases in motion. This hypothesis is called the hypothesis of the *kinetic constitution of matter.*"

In reference to electrons, Sir William Ramsay has expressed himself as follows: "Electrons are atoms of the chemical element electricity; they possess mass; they form compounds with other elements; they are known in the free state, that is, as molecules." (Trans. Chemical Society, Great Britain, 1908.)

THE UNEQUAL DISTRIBUTION OF ELEMENTS

"More than 99 per cent of terrestrial material is made up of eighteen or twenty elements, of which the quantities of the first eleven, as estimated by F. W. Clarke, are given in the following table:

Oxygen	49.98	Sodium	2.28
Silicon	25.30	Potassium	2.23
Aluminum	7.26	Hydrogen	0.94
Iron	5.08	Titanium	0.30
Calcium	3.51	Carbon	0.21
Magnesium	2.50		
			99.59

"The evidence of the spectroscope shows that the sun and stars contain many of the very same elements as does the earth."—Alexander Smith.

"Recent researches have thrown a flood of light upon these questions (the unequal distribution of elements). It is now believed that the elements are not the changelesss systems that they were once thought to be, but rather systems in slow but incessant mutation.

"According to Prof. J. J. Thompson, all of the elements represent successive condensations of one primary stuff, whose atoms, called *electrons* or *corpuscles*, weigh less than the 1/1,000 part of an atom of the lightest known terrestrial element, namely hydrogen. This primary stuff is negative electricity, which is therefore a true chemical element."—Geoffrey Martin, in Triumphs and Wonders of Modern Chemistry.

Elements and Their Atomic Relation to Each Other

The elements when studied collectively, although differing in many respects from each other, as, for instance, in their atomic weight, specific gravity, valence and physical appearance, have many peculiar properties in common.

Observation has shown that certain definite relations exist between the elements, particularly when arranged in series or groups. The gradual and almost uniform increase in the atomic scale, beginning with hydrogen, the lowest, and progressing up to uranium, the highest, in the atomic series, has long attracted attention and given rise to the idea that such orderly progression is not the result of chance, but of some so far undiscovered law.

Hydrogen, discovered by Cavendish in 1776, is the lightest known terrestrial element. Until recently its atom has been rated as 1 of the atomic scale, but for reasons subsequently to be stated, it is now accorded the value of 1.008. When the atomic weights of the other elements are computed on the basis of 1 for hydrogen, it is found that several are whole numbers and many more approximate whole numbers.

PROUT'S HYPOTHESIS

Just one hundred years ago William Prout, an English physician, observing that the atomic weights of many of the elements were either exactly or approximately whole numbers, advanced the idea that all of the other elements were composed of hydrogen atoms in various stages of condensation, and that therefore their atomic weights must be even multiples of that of hydrogen. The fact that some of the atomic weights as then determined terminated in decimals, he regarded as the result of errors in calculation.

Chemists lined up in support of, or in an effort to disprove, Prout's theory, and for a time great diversity of opinion prevailed, due largely to the fact that the atomic weights of some of the various elements had not been determined accurately.

The brilliant work of Stas, a Belgian chemist, in the period between 1855 and 1865, in accurately computing the atomic weights of many of the elements, cleared up much of the existing confusion. As a result of his efforts, the even multiple theory of Prout was proven incorrect. Later it was shown that the atomic weight of oxygen was not 16, as Prout's hypothesis called for, but 15.879, which, however, was within ⅛ of 1 per cent of a whole number.

Further, it was found that by allotting to oxygen the atomic weight of 16, and computing the atomic weights of all of the other elements on this basis, a much larger percentage of them was resolved into whole numbers than when calculated on the basis of 1 for hydrogen. By this system of computation, which is the accepted one at present, the atomic weight of hydrogen is 1.008, as before stated. Considering the atomic weight of oxygen as 16, the atomic weights of fifty-five elements are found to be either whole, or within 1/10 of 1 per cent of whole numbers.

Now since it is clearly shown that the atomic weights of more than five-eighths of all known elements are approximately whole numbers, much interest in chemical and physical fields has been aroused, and efforts have been made to determine, if possible, the laws governing the atomic, as well as other interesting relations discernible in the elements. This interest, which is greater at present than ever before, first found tangible expression in the hypothesis of Prout, although the theory of the *unity of matter* is one of very ancient origin.

THE TRIADS OF DOBEREINER

In 1827 Dobereiner called attention to the fact that among the elements then known, there occurred here and there groups of three having remarkably similar chemical properties. These groups have since been termed the "Triads of Dobereiner."

The following will serve to illustrate some of the various triads observed.

Atomic Weight		Atomic Weight		Atomic Weight	
Calcium	40.1	Sulphur	32.1	Chlorine	35.4
Strontium	87.7	Selenium	79.2	Bromine	80.0
Barium	137.4	Tellurium	127.5	Iodine	126.8

The first group is composed of alkaline earth metals.

They are white in color, about as soft as lead, and decompose water at ordinary temperatures, resulting in the formation of hydroxides with the liberation of hydrogen. In most compounds these metals are divalent.

The second group, consisting of Sulphur, which is very abundant, and Selenium and Tellurium, which are comparatively rare, forms a series of similar compounds.

The third group are sometimes called *the halogens* (producers of sea salt), because they are found in sea water. The first is a greenish-yellow gas, the second is a red liquid and the third is a purplish-black solid. They are monovalent in their compounds with hydrogen, and when combined with the latter, form acid gases soluble in water.

The most remarkable characteristic noted, however, was in the ratio existing between their atomic weights. Dobereiner noticed that when the atomic weights of the first and third element of any triad were added and the sum divided by two, the resulting mean coincided very closely with the atomic weight of the intermediate element of the triad, as is shown below:

Calcium ....Atomic Weight..	40.1	
Barium ....Atomic Weight..	137.4	
	2/177.5	
	88.7	mean
Strontium ..Atomic Weight..	87.7	
Sulphur ....Atomic Weight..	32.1	
Tellurium ..Atomic Weight..	127.5	
	2/159.6	
	79.8	mean
Selenium ...Atomic Weight..	79.2	

Chlorine ...Atomic Weight..	35.4	
Iodine .....Atomic Weight..	126.8	
	2/162.2	
	81.1	mean
Bromine ...Atomic Weight..	80.0	

While in no case is the resulting mean exactly equal to the atomic weight of the second member of the triad, it is so close in each instance as to suggest the possibility of an undiscovered law which, if known, might clear up the discrepancies. The work of Dobereiner and others since his time has resulted in the discovery of many other interesting and peculiar correlated properties of the elements.

THE OCTAVES OF NEWLANDS

In 1863 Newlands called attention to the fact that when the elements were arranged in the order of their atomic weights, beginning with the lowest, hydrogen 1, running through the entire list of the elements then known and ending with uranium 240, at regular intervals, every eighth element, in most instances, bore a striking resemblance in certain properties to the preceding eighth below, or the succeeding eighth element above. This method of classification is known as the *Octaves of Newlands.* While the discovery of Newlands was remarkable, he failed to realize its great importance, or work out the full details of it, being unable to classify all of the elements satisfactorily.

THE PERIODIC SYSTEM OF MENDELEEFF

In 1869 two chemists, Dimitri Mendeleeff, a Russian, and Lothar Meyer, a German, working independently, presented almost simultaneously what is known as the *Periodic System of the Elements.* Priority in this manner of classifying the elements has been accorded Mendeleeff, although Meyer's work, which was almost identical, was performed without knowledge of Mendeleeff's efforts. The periodic system, as presented by Mendeleeff and Meyer, was based on the Octaves of Newlands, but differed from the work of the latter by including all of the then known elements. Previous to his death in 1907, Mendeleeff revised the periodic table,, modifying it to include all of the more recently discovered elements (1903).

TABLE OF THE PERIODIC LAW. (Mendeleeff, 1904.)

Series	Zero Group	Group I	Group II	Group III	Group IV	Group VI	Group VI	Group VII			
0	*x*										
1	*y*	Hydrogen H=1.008									
2	Helium He=4.0	Lithium Li=7.03	Beryllium Be=9.1	Boron B=11.0	Carbon C=12.0	Nitrogen N=14.04	Oxygen O=16.00	Fluorine F=19.0		Group VIII	
3	Neon Ne=19.9	Sodium Na=23.05	Magnesium Mg=24.1	Aluminum Al=27.0	Silicon Si=28.4	Phosphorus P=31.0	Sulphur S=32.06	Chlorine Cl=35.45			
4	Argon Ar=38	Potassium K=39.1	Calcium Ca=40.1	Scandium Sc=44.1	Titanium Ti=48.1	Vanadium V=51.4	Chromium Cr=52.1	Manganese Ma=55.0	Iron Fe=55.9	Cobalt Co=59	Nickel Ni=59 (Cu)
5		Copper Cu=63.6	Zinc Zn=65.4	Gallium Ga=70.0	Germanium Ge=72.3	Arsenic As=75.0	Selenium Se=79	Bromine Br=79.95			
6	Krypton Kr=81.8	Rubidium Rb=85.4	Strontium Sr=87.6	Yttrium Y=89.0	Zirconium Zr=90.6	Niobium Nb=94.0	Molybdenum Mo=96.0	—	Ruthenium Ru=101.7	Rhodium Rh=103.0	Palladium Pd=106.5 (Ag)
7		Silver Ag=107.9	Cadmium Cd=122.4	Indium In=114.0	Tin Sn=119.0	Antimony Sb=120.0	Tellurium Te=127	Iodine I=127			
8	Xenon Xe=128	Cæsium Cs=132.9	Barium Ba=137.4	Lanthanum La=139	Cerium Ce=140	—	—		—	—	— (—)
9		—	—		—	—	—	—			
10	—	—	—	Ytterbium Yb=173	—	Tantalum Ta=183	Tungsten W=184	—	Osmium Os=191	Iridium Ir=193	Platinum Pt=194.9 (Au)
11		Gold Au=197.2	Mercury Hg=200.00	Thallium Tl=204.1	Lead Pb=206.9	Bismuth Bi=208	—	—			
12	—	—	Radium Rd=224	—	Thorium Th=232	—	Uranium U=239				
13		R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	RO_3 RH_2	R_2O_7 RH		RO_4	

A chart of the periodic system of the elements consists of 13 horizontal columns called series, numbered from zero to 12, inclusive, subdivided into 9 perpendicular columns called groups, numbered from zero to 8, inclusive. The elements are arranged in the series from left to right in the order of their atomic weights, and in the perpendicular group columns according to their chemical properties.

It will be noticed that certain spaces are unoccupied by elements because of breaks in the regular progression of the atomic weights, and which, if closed up, would throw the remaining elements out of their natural groups. From this the inference is drawn that elements may yet be discovered to fill these vacant spaces.

When Mendeleeff first devised the table there was a space in series 4, group III, another in series 5, group III, and still another in series 5, group IV. Two years later, in 1871, he declared his belief that elements would be found to occupy these spaces. He described their properties and atomic weights, and named them eka-aluminum, eka-boron and eka-silicon. In 1878 Boisbaudrau, a French chemist, discovered gallium, eka-boron; in 1879 Nilson, a Swedish chemist, discovered scandium, eka-aluminum, and in 1886 Winkler, a German chemist, discovered germanium, eka-silicon, all of which corresponded to Mendeleeff's predictions as to properties, and fit exactly in the vacant spaces.

NEW ELEMENTS

In Mendeleeff's latest table he includes two new elements, neither of which, so far as is known, have a place among the terrestrial elements. These two head the list and are designated as x and y, both supposed to be gases and lighter than hydrogen.

Coronium, found in the spectrum of the sun's highest atmosphere, beyond the tips of the sun's flames and highest protuberances, is believed to coincide with y, whose atomic weight is estimated by Mendeleeff at 0.4, or possibly less.

X is called Newtonium, after the famed English physicist. This gas element, according to Mendeleeff's calculations, has an atomic weight of probably 0.000001. Arrhenius states that "its atoms ought, therefore, to be about 500 times lighter than electrons." Now since electrons are 1,000 times smaller than the hydrogen atom, it naturally follows that it would require 500,000 Newtonium atoms to equal one of hydrogen.

Mendeleeff further believed that the element x, or Newtonium, is the substance from which the luminiferous ether, which pervades all space, is formed.

THE ELEMENTS CONSIDERED IN GROUPS

The zero group of elements is composed of the gases of the helium family. These are all monoatomic and generally inert, forming no compounds with other elements. On account of their scarcity, obscure nature and lack of combining power, their presence among the terrestrial elements was for a long time unknown. It is only within recent years that they have been isolated. The original periodic table, therefore, contained no zero group, because all but one of the elements now embraced in it had at that time not yet been discovered. Helium was known by its spectrum only as a sun element. Because of their atomic weights, they naturally precede Group 1, but their presence in nowise invalidates the periodicity of the other elements. In fact, their discovery and position only confirms the previous findings.

Take, for instance, the first triad of Series 4, argon, at. wt. 38, calcium, at. wt. 40.1 = 78.1 divided by 2 = 39.5 The atomic weight of potassium, the middle factor of the triad, is 39.1. Observe, again, the first triad of Series 8, xenon, at. wt. 128, barium, at. wt. 137.4 = 265.4 divided by 2 = 132.7. The atomic weight of caesium, the middle factor, is 132.9.

When the elements in any group are considered closely it will be seen that while their atomic weights increase rapidly from above downward, and they differ in other respects, yet there is in most cases a marked resemblance as to chemical properties.

Prof. Duncan calls attention to the fact that each group may be arranged in two sub-groups, the elements embraced in each of which are very closely related. Group 2 is taken as an example.

The elements in the order of their atomic weights are: Beryllium, magnesium, calcium, zinc, strontium, cadmium, barium, mercury and radium. By the sub-group arrangement the elements having the greatest number of common properties are brought together as follows:

Sub-group A.	*Sub-group B.*
Calcium.	Beryllium.
Strontium.	Magnesium.
Barium.	Zinc.
Radium.	Cadmium.
	Mercury.

THE ELEMENTS CONSIDERED IN SERIES

As before stated, the elements arranged in horizontal rows are termed series.

Hydrogen is unlike any other element, because it is an essential component of all acids, and it, therefore, forms a series by itself.

While there is a general similarity between the elements in one series to those in another, there is a marked and progressive variation between the elements in the same series. First, the atomic weights rise from left to right, or from 1 to 7, in comparatively regular gradations. Second, in each horizontal row the first element of the series is a well-marked metal or base-forming element, while the succeeding ones gradually merge from metallic into the non-metallic class, or acid-forming elements, with the exception of manganese, the seventh element of the fourth series.

Third, in every series the valence toward oxygen ascends from 1 to 7, while the valence toward hydrogen or chlorine ascends from 1 to 4, and then uniformly descends to 1.

The elements in Group 8 belong to the metallic class, have similar properties to each other, but do not fit in the scheme of the octaves, as their presence in the beginning of the succeeding series would disarrange the grouping of the remaining elements, according to their chemical group similarities. They are, therefore, placed in Group 7, outside of the octave system, although their valences are continuous with those of the regular table.

From the many correlated facts observed, the *periodic law* has been formulated as follows: *The properties of elements are periodic functions of their atomic weights.*

Many other interesting relations have been disclosed, the details of which can be found in various works on advanced chemistry, particularly Dr. Gordin's Inorganic Chemistry, in which will be found a clear and concise statement of the periodic correlations of the elements and of the imperfections of the system as well. These few crudely-stated facts have been introduced with the idea of creating a desire for further knowledge in this most interesting field.

The following works have been consulted and largely utilized in the presentation of the foregoing facts:

Gordin's Inorganic Chemistry.
Smith's General Chemistry for Colleges.
Levy and Willis, Radium.
Arrhenius' Theories of Chemistry.

Gibson's Scientific Ideas of To-day.

Martin's Triumphs and Wonders of Modern Chemistry.

Kennedy Duncan's Some Chemical Problems of To-day and the New Knowledge.

Duff's Physics.

Ganot's Physics.

Metals

Of the fifty-two metals, about fifteen are used in the arts and sciences in their true metallic condition, as well as in combination with each other and with the non-metallic elements.

A metal is an opaque elementary substance which, with the single exception of mercury, is solid at ordinary temperature; is a good conductor of heat and electricity; has a metallic luster; has the property of replacing hydrogen in acids forming salts, and is electropositive as compared with the non-metallic elements.

METALLOIDS

Certain of the non-metallic elements, iodine, arsenic, phosphorus, silicon, sulphur and carbon, possess to a greater or less degree the properties attributed to metals, especially the power of reflecting light, and which is known as *metallic lustre.*

They are all more or less opaque, while carbon is a conductor of both heat and electricity, which properties, with the exception just noted, are confined exclusively to the metals. This group of elements, therefore, while not metals, are called *metalloids,* from the resemblance in some respect to the metals.

FORMS OF MATTER

Matter, as previously stated, presents itself to our senses in three distinct forms, as solids, liquids, or gases. These forms, in most instances and under proper conditions, are susceptible of change.

For example, a metal liquifies when subjected to heat.

Water vaporizes under heat and solidifies at low temperatures.

Hydrogen at extremely low temperature and under high pressure liquefies and can be solidified on further reduction of temperature and increase of pressure.

OCCURRENCE OF METALS IN NATURE — MINERALS

Most of the metals are found in combination with some of the non-metallic elements, as oxides, sulphides, or carbonates, etc.

Usually the combinations are of such nature as to entirely mask their metallic character and render them unrecognizable as metals, and, when so occurring, are called *minerals.*

NATIVE METALS

Gold, silver, copper, platinum, mercury, bismuth, antimony and iron frequently occur in nature in their true metallic condition, and are known as *native* metals. Those just mentioned are about the only ones so occurring.

ORES

When a mineral is found which contains a particular metal in sufficient quantity to pay for its extraction on a commercial basis, it is called an *ore* of that metal.

NOBLE METALS

Metals included under this head are those whose compounds with oxygen are decomposable by heat alone at a temperature not exceeding redness. The following comprise the list of noble metals.

Gold, silver, platinum, palladium, rhodium, ruthenium, osmium, iridium, mercury.

BASE METALS

Under this classification are included the metals whose compounds with oxygen are not decomposable by heat alone, but retain oxygen at high temperatures.

PHYSICAL PROPERTIES OF METALS

Since there are properties common to all metals, these properties will be briefly explained before taking up the study of the individual metals.

Some of these properties, common to all, but which, of course, vary, according to the individual metal, are atomic weight, specific gravity, melting point, malleability, ductility, tenacity, conductivity of heat, and electricity, specific heat, color, etc.

ATOMIC WEIGHT

The atomic weight of an element is the weight of one of its atoms compared with the weight of an atom of hydrogen.

Hydrogen is the lightest of all known substances, and is taken as the unit or 1 of the atomic scale. Atomic weight, ırefore, may be considered as the proportion by weight in ich elements unite chemically.

SPECIFIC GRAVITY

The specific gravity of any substance, whether solid, liquid gas, is the measure of its density. The standard or unit of asurement of solids and liquids is water, and that of gases hydrogen.

The specific gravity of a solid or a liquid of a given bulk its relative weight to a like bulk of water under like conditions of temperature and pressure.

In order to find the specific gravity of any solid, it is first ighed in air, then in water, and its weight in water deducted om its weight in air. The weight in air is then divided the difference thus obtained, and the result represents e specific gravity of the substance. A convenient formula r determining the specific gravity of solids and liquids is follows:

Let W=weight of substance in air.

Let W_1=weight of substance in water.

Let sp. gr.=specific gravity.

Then $\frac{W}{W-W_1}$ = sp. gr.

The specific gravity of most metals can be somewhat ineased by hammering, rolling, wire drawing or cold pressure.

The specific gravity of aluminum, it being the lightest etal of commercial importance, is 2.5, while osmium, which the heaviest, is 22.47.

Comparing two cubes of equal size of aluminum and osium, the first would weigh 2.5 and the latter 22.47 times more ıan an equal bulk of water.

MELTING POINT

When an element or substance is changed from a solid to liquid state as the result of thermal increase, the point at hich such change occurs is called its "melting" or "fusing" oint.

When a liquid is reduced to a solid state by lowering its mperature, the point where such change occurs is called s "freezing" point.

The melting point and the freezing point of a metal usually approach each other very closely, but are never quite the same. They are so close at times as to be incapable of registration by the thermometer.

Some substances expand on being melted, while others contract. When a substance expands on being melted, and it is subjected to increase of pressure above normal during the fusion process, the effect is to raise its melting point. On the other hand, a substance which contracts on melting, when subjected to increase of pressure, has its fusing point decreased. By reversing the pressures, opposite results are obtained.

The range of fusibility or the melting points of the various metals differs greatly. Mercury melts at—38.9 deg. C., and, consequently, is liquid at ordinary temperatures. Bismuth, tin, lead, zinc and antimony melt below a red heat; aluminum requires a red heat; gold, silver and copper a bright red heat; iron and nickel, an intense white heat, while platinum and palladium are still more refractory, fusing only in the electric arc or the oxyhydrogen flame.

Some metals, when heated beyond their melting points, readily vaporize, zinc, antimony and mercury being the most common examples of this class. As a matter of fact, all of the metals can be volatilized if subjected to a sufficiently high temperature.

Most of the metals pass from the solid to the liquid state under the influence of heat and under increased temperature volatilize. Osmium, however, is an exception to this rule, as is passes from the solid to the volatile condition without assuming the liquid state.

The following table, by Pouillet, will give an idea of temperature as displayed by color:

	°C.	°F.
Incipient red corresponds to	525	977
Dull red corresponds to	700	1292
Incipient cherry red corresponds to	800	1472
Cherry red corresponds to	900	1652
Clear cherry red corresponds to	1000	1832
Deep orange corresponds to	1100	2012
Clear orange corresponds to	1200	2192
White corresponds to	1300	2372
Bright white corresponds to	1400	2552
Dazzling white corresponds to	1500	2732

Most metals expand when heated, and contract on cooling. Within certain limits the expansion is proportional to the degree of heat to which they are subjected. There are, however, certain exceptions to this rule. Antimony expands at the moment of becoming solid, and bismuth occupies more space in the solid than in the liquid state. This property renders these metals particularly useful in alloys of type and fusible metals, where sharp, well-defined castings are desirable.

MALLEABILITY

Malleability is that property of metals by which they may be beaten out or otherwise extended into thin sheets without a break in the continuity of their surfaces. This property varies in different metals, some possessing it to a marked degree, while in others it is almost entirely absent.

Gold is the most malleable of all the metals. It can be beaten out into extremely thin attenuated sheets, 1/300000 of an inch thick. In other words, it would require 300,000 sheets laid one upon the other to measure an inch in thickness. Gold, therefore, is taken as the standard or unit of measurement of the degree of malleability of metals, and is rated "first rank."

This property is seriously impaired by the presence of impurities, and also by heat, although the latter tends to increase the malleability in zinc. This metal, when cast, is crystalline and brittle, but when heated to about 150°C., it is capable of being rolled into thin sheets, and these retain their malleability to a considerable degree when cold.

Metals of a crystalline structure are almost totally devoid of this property, while those of a soft and tenacious character are the most malleable.

DUCTILITY

Ductility is that property possessed by metals by means of which they may be drawn out into wire or rods, by lateral compression, without breaking.

Gold possesses this in the highest degree, since it can be drawn out into the most delicate wire; a piece one mile in length having been drawn from less than one gram weight.

The softness and tenacity of a metal control the degree of ductility.

Ductility is affected by heat, which increases this property in some metals and decreases it in others.

Lead is the least ductile because of the slight tenacity by which the molecules are held together. Bismuth and antimony are examples of metals in which this property is almost wholly absent because of their crystalline structure.

Steel is extremely ductile, and is now being drawn into wire 1/1000 of an inch in diameter for commercial purposes.

Ductility is modified by mechanical working, the latter affecting metals to such an extent at times as to render them unworkable until this property is again restored by annealing.

ANNEALING

This process consists in heating metals and cooling, slowly in some cases, and rapidly in others.

Annealing changes metals from the hardened condition produced by hammering, rolling, wire-drawing, burnishing and polishing, to a soft, pliable condition.

It is supposed that the molecules in a metal, changed by the processes mentioned, are under a greater or less degree of tension which, while not of sufficient force to do so, tends to return them to their former relation. Under the influence of heat, and, as before stated, in the case of some metals, followed by sudden chilling, as when plunged into cold water while hot, the tension referred to is destroyed and the molecules are brought to a normal relation to each other under the changed conditions.

The degree of hardness developed in metals by mechanical working is dependent upon the character and amount of force applied within and up to certain limits. In other words, a moderate amount of manipulation will produce a moderate degree of hardness, while an excessive amount of working will produce the extreme degree of hardness capable of being produced in a particular metal.

If a metal be worked to its extreme limit of hardness, and is then annealed, a greater or less amount of warpage is noticeable. This is apparent in swaging metal plates. The base, when swaged, may lie in absolute contact with the die, yet, when annealed, the adaptation will be found to have changed. A slight amount of swaging will again restore the adaptation, and, if annealed again, very little, if any, change will be noticeable.

This fact renders it imperative that matrices of platinum or gold foil, when adapted to cavities for inlay work, should be annealed thoroughly, and a final adaptation secured before introducing the porcelain for baking. By observing this suggestion, misfits traceable to this cause are obviated.

Intentional or accidental alloying of the metals also modifies their degrees of ductility, sometimes increasing, and again diminishing, this property. The slightest trace of lead, zinc, bismuth or antimony in gold impairs its ductilty to a marked degree, hence the necessity in dental laboratory procedures of keeping gold perfectly free from these baser metals.

TENACITY

Tenacity is that property of metals which enables them to resist stress or dead weight when applied to rods or wires in the direction of their length.

This property, as well as those of malleability and ductility, is greatly affected and readily influenced by the presence of other metals or impurities, and by heat, which in some cases increase and in others decrease these various properties.

The tenacity of iron, for instance, is greatly increased by the addition of a small per cent of carbon, while the presence of silicon diminishes it.

In addition to the ordinary or comparative tests of tenacity of a metal, several other kinds should be considered, and these are classified according to the externally acting force.

Ordinary tenacity, as before stated, relates to resistance to traction or direct pull; relative tenacity, resistance to fracture; reactive tenacity, resistance to crushing; shearing tenacity, resistance to lateral displacement; torsional tenacity, resistance to twisting.

When metal bars are subjected to a certain amount of tension, permanent elongation occurs. If the tension is not sufficient to produce this result, the bar will return to its original length. This line of division is called the *elastic limit.*

In machine construction, when wires or rods are used, it is essential that such parts be composed of metals of suitable kind, and be of sufficient size, to withstand stress without passing beyond the elastic limit.

TENSILE STRENGTH

The tenacity of *tensile strength* of metals and alloys is tested by placing a bar of the metal of one inch sectional area in a suitable testing machine and applying stress sufficient to fracture it. The following table will convey an idea of the wide range of difference in tenacity of various metals and alloys. (From Carnegie's handbook.)

	Average, Pounds.
Brass	18,000
Brass, wire	49,000
Bronze or gunmetal	36,000
Copper, cast	19,000
Copper, bolts	36,000
Copper, wire	16,500
Iron, cast	16,500
Iron, wrought	53,000
Iron, wire	70,000 to 100,000
Lead, sheet	3,300
Steel	50,000 to 80,000
Tin, cast	4,600
Zinc	7,000 to 8,000

ELASTICITY

This property refers to the amount of force which can be resisted by metals under stress without permanent deformation or "set" being produced.

The "modulus of elasticity" is the force that would be required to double the length of a bar if its elasticity remained perfect. The "modulus" is an index of the stretching capacity of a metal.

FLOW

Metals which in a solid state can be shaped into any required form by pressure are said to possess the property of flowing.

Stampings, lead pipe, rods, coins, medals, etc., are examples of what can be accomplished through this property. The flowing property depends upon a combination of other qualities, such as malleability, ductility and toughness, together with a sufficient amount of tenacity to permit the molecules of metals to roll over each other without adhesion being destroyed.

CONDUCTIVITY OF HEAT

Conductivity of heat refers to the property of different substances for transmitting heat. The degree of rapidity of heat transmission varies greatly in different substances, metals being the best conductors. This property also varies in the different metals, silver being the best, and it is, therefore, taken as the standard of measurement, and is rated 100.

CONDUCTIVITY OF ELECTRICITY

Conductivity of electricity refers to the capacity of metals for receiving and transmitting a current of electricity. Silver in this case also is the best conductor, and is taken as the standard of comparison, being rated 100. As a general thing, the best conductors of heat are also the best conductors of electricity. There are, however, exceptions to this.

Those metals ranking low in the scale of conductivity of electricity offer resistance to the passage of a current. This resistance is very apparent in platinum, iron and nickel, and as resistance to the passage of a current is marked by a rise in temperature, these metals, as well as the alloy known as German silver, are used for rheostat and electric furnace construction.

The electric furnace, commonly used in porcelain work, consists of a metal case lined with fireclay, so shaped as to give a muffle form to the interior, in which the piece to be baked is placed. In the inner walls of the fireclay is imbedded fine platinum wire, and as the current passes through this, it becomes heated, and the temperature in the interior of the furnace is gradually raised to the point of fusion of the porcelain, usually about 1200° C.

The following table gives the comparative conductivity of heat and electricity of fourteen metals, and, as before stated, silver heads the list in both tables:

Heat.		Electricity.	
Silver	100	Silver	100
Copper	85	Copper	97.8
Gold	53.2	Gold	76.7
Aluminum	31.3	Aluminum	65.5
Zinc	28.1	Zinc	29.6
Cadmium	20.1	Cadmium	24.4
Tin	15.5	Iron	14.6
Mercury	13.5	Platinum	14.5
Iron	11.9	Tin	14.4
Nickel	....	Nickel	12.9
Lead	8.5	Lead	8.4
Platinum	8.4	Antimony	3.6
Antimony	4.0	Mercury	1.8
Bismuth	1.8	Bismuth	1.4

The conductivity of a substance, as a rule, diminishes with a rise in temperature.

EXCEPTION TO THE GENERAL RULE OF CONDUCTIVITY OF ELECTRICITY

One important exception to this might be mentioned here. The oxides of some of the metals, especially when combined, exhibit the opposite quality, viz., being non-conductors when cold and conductors when heated. This principle is made use of in the construction of pyrometers or instruments for measuring heat units and applied to porcelain furnaces.

Two methods are employed. In one case a thermopile, an apparatus consisting of two or more plates of dissimilar metals, which upon being heated generate a mild current of electricity, are built in the back of the furnace. As the furnace gradually rises in temperature, the current in the thermopile increases, which is indicated by a mila-voltmeter modified to correctly register the fusing point of the various porcelains.

In the other case, a Nernst glower, a small rod composed of the oxides of zirconium and yttrium, which when cold is a non-conductor, but which when heated readily transmits a current, is placed in the muffle and connected with an independent dry cell current.

As the furnace temperature rises the dry cell current finds its way through the glower and is registered by an apparatus similar to the one before described.

Profs. Dewar and Jenkins, in determining the conductivity of metals and alloys at very low temperatures, found that the resistances of pure metals decrease in such ratio as to convey the idea that, if absolute zero could be obtained, all resistance would vanish. The resistance of alloys, however, does not diminish in the same ratio. For example, at—200° C. the alloys—platinoid, German silver, platinum silver and phosphor bronze—show nearly the same resistance as at 0° C.

An illustration of the wide range of conductivity of the metals can be presented by making a chain composed of alternative links of platinum and silver wire of the same size and passing a current of electricity through it. The platinum links will become heated, while the silver links will remain normal except at their junction with the platinum, where the heat from the latter is transmitted by contact.

SPECIFIC HEAT

It has been found that different metals are capable of absorbing different amounts of heat when subjected to the same degree of temperature.

The amount of heat necessary to raise one kilogram of water through one degree of temperature, from 4° to 5° C., is taken as the unit or standard of specific heat, and this is called the *thermal unit*.

The quantity of heat necessary to raise a kilogram of mercury through one degree C. is only 0.033 of the heat unit, and this fraction expresses the specific heat of mercury relatively to water. It, therefore, follows that the same quantity of heat required to raise one kilogram of water through one degree of temperature would produce an equal increase in temperature in about 30 kilograms of mercury.

The greater the specific heat of a substance, the greater the heat necessary to raise the temperature through any given degree, and conversely, the less the specific heat, the smaller quantity of heat required.

TABLE OF SPECIFIC HEAT

Mercury	0.03332	Silver	0.0570
Gold	0.03244	Cadmium	0.0567
Iron	0.1138	Tin	0.0562
Nickel	0.1086	Antimony	0.0508
Cobalt	0.1070	Lead	0.0314
Zinc	0.0956	Palladium	0.0308
Copper	0.0952	Platinum	0.0311
Palladium	0.0593		

EXPANSION

It is a well-known law of physics that substances expand when heated.

This movement is particularly marked in metals, since they are good conductors of heat.

THE CO-EFFICIENT OF EXPANSION OF SUBSTANCES

The *co-efficient* of expansion of any substance is the *amount* which the unit of length (surface of volume) expands in passing from 0° to 1° C.

The co-efficient of expansion is constant in metals crystallizing in the *regular system*. In the others, the expansion varies according to crystallization, this movement occurring in the direction of the various axes. Such metals are usually tested by compressing their powders.

In the industrial field a thorough knowledge of the expansion of different material is essential so that provision may be made for compensating for it in the construction of buildings, bridges, and large pieces of machinery.

In assembling bridges in the dental laboratory it is essential that an investing material be used whose co-efficient of expansion is about equal to that of gold.

If one is employed whose co-efficient of expansion is much greater, the assembled pieces will be moved apart as the investment expands under heat, and while in that changed relation become fixed by the solder, the result being that the bridge is lengthened.

The following table gives the linear expansion occurring in metals when raised from a temperature of 0° to 100° C. The fraction represents the ratio of linear expansion per length of rod:

Cadmium	.003067	or	1/326
Lead	.002932	"	1/342
Zinc	.002915	"	1/343
Aluminum	.002307	"	1/432
Tin	.002232	"	1/448
Silver	.001930	"	1/518
Copper	.001672	"	1/598
Bismuth	.001620	"	1/617
Gold	.001451	"	1/689
Nickel	.001270	"	1/787
Iron	.001070	"	1/934
Antimony	.001050	"	1/952
Platinum	.000900	"	1/1123

COLOR

Most metals are gray or white in color, these colors merging into bluish tinges in some cases. Gold is a rich yellow color in masses, but transmits a greenish tinge in thin attenuated sheets. Copper is of a decidedly red color. The color of most metals is changed by alloying with other metals.

Gold alloyed with silver is changed to a greenish tinge, and when alloyed with copper a decidedly red color is imparted to it. By combining silver and copper in proper proportions, gold may be reduced in fineness without material change in color.

WELDING

This process consists in uniting two pieces of metal together by pressure so as to form one compact piece. The requisites of a metal necessary to successful welding are that it must be clean, soft, and that it should possess considerable malleability and toughness.

In the case of iron, some of these properties are developed only at a high temperature, in which condition it is in a pasty state. The surfaces to be united are cleaned and covered with borax to remove any oxide that may be present and prevent further oxidation, or sand can be used also, which by combining with the iron forms a fusible silicate, and which, under the blows of the hammer, is forced out from the contact surfaces.

When subjected to hammering or pressure, the molecules of metal are capable of interpenetrating or diffusing into and among each other so as to form a continuous piece.

Steel must be welded at a considerably lower temperature than iron because of its lower fusing point. The carbon also is liable to burn out when overheated, and its quality thus become impaired. Because of the difference in the melting points, and for the reason just stated, it is difficult to weld iron and steel together.

Gold is an example of a metal which can be welded cold. In the form of foil, pure gold is rolled into pellets or folded into small pieces and packed into tooth cavities by mallet force or hand pressure. Under favorable conditions it can be worked into a mass seemingly as solid as though it had been cast.

In electric welding, the pieces to be united are placed in a suitable device for holding them in proper contact and relation to each other, and a powerful current of low tension is passed from one piece to the other. The high resistance at the junction, caused by imperfect contact, develops an intense heat at this point, and when heated sufficiently the surfaces are jammed together and union occurs.

The metals which weld most readily are gold, silver, tin, lead, iron and nickel.

As a matter of fact, a number of the metals, when powdered and subjected to intense pressure, can be welded cold.

The following table, by Professor Spring, shows the amount of compression required to unite those listed into a solid mass:

	Tons per sq. inch.
Lead	13
Tin	19
Zinc	38

Antimony	38
Aluminum	38
Bismuth	38
Copper	33
Lead flows at	33
Tin flows at	47

WELDING COPPER TO IRON

A remarkable yet simple method of *welding* copper to iron is being employed for many purposes in the industrial fields. The copper and iron objects it is desired to unite are bound in contact, placed in a crucible, and finely ground retort carbon, moistened slightly with sugar water to make it adhesive, is packed closely around them. The crucible is then heated in a furnace for half an hour at a temperature about midway between the melting point of copper and iron, when perfect fusion of the two metals will occur, the welded joint being tougher than either of the two metals.

A peculiar fact concerning this process is that the surfaces of the metals to be united need not be prepared, cleansed or fluxed in any manner, the graphite and sugar taking the place of the ordinary fluxes, clearing away any oxide that may be present, and preventing the atmospheric oxygen from getting to the joint. The molecular cohesion is as strong and perfect between copper and iron as between the molecules of the individual metals; such a weld is not to be compared to the ordinary brazed joint, which is merely an imperfect superficial surface union.

The process is utilized in welding steel teeth to cast iron wheels, in joining pieces of wrought iron where ordinary welding operations are not practicable, in the construction of large gun projectiles, in ship construction, in the electrical and many other fields where an absolute union between pieces of similar as well as dissimilar metals is desirable. Professor Simpson, of London, is given credit for this remarkable method of welding copper to dissimilar metals.

ALUMINOTHERMY

From 1760, when Moreau, a French chemist, named the white substances he obtained by calcining alum, "alumina," because he believed it to be the oxide of a metal, until Wohler isolated it in 1827, repeated but futile efforts were made by many to discover some means of reduction of aluminum from its ores.

The strong affinity of aluminum for certain non-metallic elements, particularly oxygen, is very marked. It is only through the action of a powerful electric current together with suitable fluxes that the oxide of aluminum is decomposed. When freed from oxygen, however, aluminum under ordinary conditions is not readily oxidized, but under favorable conditions the two elements most energetically unite, with the evolution of intense heat.

This places aluminum among the most powerful of the reducing agents, since many metallic oxides which cannot be broken up with carbon are readily reduced by it. Professor Goldschmidt, of Essen, Germany, in 1904, discovered this fact and applied it to industrial purposes. So effective has it proven that "alumino-thermics," as the process is called, occupies a unique and previously unfilled place in high temperature chemical, metallurgical, and industrial fields.

The process is comparatively simple and easy of application. Finely granular, metallic aluminum together with the oxide of iron and some substance to act as a flux, as fluor spar, are placed in a suitable receptacle. Some magnesium filings mixed with barium or sodium peroxide — a mixture highly combustible—are thrown on top to "kindle the fire," or start chemical action.

Almost instantly there is a flash, the development of a temperature of more than 3000 C., and in the bottom of the crucible lies a little button of iron with a film of slag, the oxide of aluminum, covering its surface.

A mixture of granular aluminum and oxide of iron is sold for industrial purposes under the name of "thermit." This mixture when placed in a very simple hopper-like apparatus from which it is fed to the point desired, constitutes a most powerful, portable blacksmith shop. It is used for uniting the ends of street car rails, welding them together to form a "continuous rail." Large castings of iron or steel when broken can be perfectly welded by this means, and, as before intimated, the oxides of many of the metals can be easily and quickly reduced without the annoying combinations of metal with carbon that so frequently follow ordinary fuel reduction processes.

TEMPERATURES, COMMON AND EXTRAORDINARY

Although most of the metals can be welded cold, under heavy pressure, it is found more convenient as well as economical to render the surface to be united plastic by heat, so that the molecules may more readily interpenetrate and molecular union be established.

The degree of heat necessary to apply in successful welding operations coincides closely with the fusing points of the metals to be united, and in soldering operations with the fusing point of the solder employed.

The following list indicates some of the temperatures ordinarily employed in soldering and welding operations, as well as some developed for special purposes. Comparative heat of the sun and hottest stars as indicated by the spectroscope is also given.

180 to 200 C soft soldering operations.

1000 to 1200 C hard soldering, as silver and the various alloys of gold.

1800 C is about the highest temperature attainable in a fuel furnace on account of the fire clay lining fusing at this point.

2000 C represents about the temperature of the oxy-hydrogen flame.

3000 to 3300 C. Thermit.

3400 C oxy-acetylene blow-pipe.

3500 to 4000 C. electric arc.

5000 C. cordite, confined and exploded exerts a pressure of 50 tons per square inch.

6000 C. estimated temperature of the sun.

30000 C. estimated temperature of some of the hottest stars (Lockyer).

The last of these records can, of course, be only approximate, since time, space, refraction of light, and other possible sources of error, detract from the accuracy of the spectroscopic scale, by means of which temperature readings of celestial spheres are determined.

Even Lockyer's temperature estimates, astonishing though they seem, pale into insignificance when compared with those of Arrhenius, who suggests a possible temperature of 7,000,000 C. in some of the larger stellar bodies, which, of course, consist of elements in a highly rarefied gaseous state, and in an intensely heated and active condition.

SOLDERING

Soldering consists in uniting the surfaces of metals together by heat without pressure. This is usually accomplished by the interposition of another metal or alloy, called a *solder*, that fuses at a lower temperature than the metals to be united.

Soft soldering is accomplished by using a solder that fuses *below* a red heat, and *hard soldering* by means of one that fuses *above* a red heat.

Autogenous soldering is a process of uniting metals by direct fusion of their contact surfaces, and is used principally in plumbing operations. In crown and bridge work this method is sometimes employed for uniting the two ends of a gold band together without the interposition of solder, and is commonly termed *sweating*.

In all three methods of soldering it is essential that a *flux* be used. This prevents oxidation of the solder and surfaces to be united, and also dissolves any oxide that may be present. In hard soldering and sweating operations, borax or a solution of boracic acid is used most frequently. For soft solder, chloride of zinc, to which a little sal ammoniac is sometimes added, is most frequently used.

Rosin is also used for this purpose, and in plumbing operations where lead joints are to be united, stearin, or tallow, is often employed.

CONDITION ESSENTIAL TO SUCCESSFUL SOLDERING

The conditions necessary to successful soldering are as follows:

1. Close contact of the surfaces to be united.

2. Exposure of clean, bright surfaces over which the solder is to flow.

3. Use and proper distribution of a suitable flux.

4. A solder which will fuse at a slightly lower temperature than the metals on which it is to be used, and which will flow freely. It should also conform, as closely as possible, in color and fineness to the metals to be united. This is a necessary consideration in gold dental substitutes.

5. There should be a gradual and uniform application and distribution of heat, and in dental operations involving the use of porcelain facings, the flame should be directed around the base and sides of the investment to drive off the moisture, heat the porcelain and allow it to expand before the platinum pins are heated, otherwise fracture of the porcelain is likely to occur.

6. The reducing flame should be used to prevent oxidation of the solder and the surfaces to be united.

THE STRUCTURE OF FLAME

To solder successfully, it is necessary to understand the structure of flame. A common candle flame will serve as an illustration. A flame of this character consists of four parts: (1) a dark central zone or supply of unburned gas surrounding the wick; (2) the luminous zone or area of incomplete

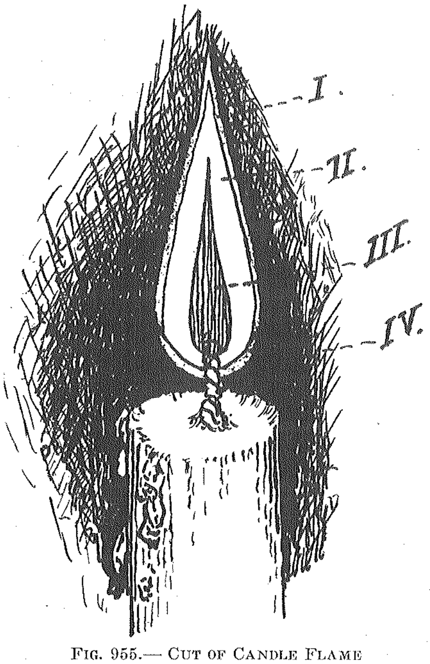


FIG. 955.— CUT OF CANDLE FLAME

I Semi-Luminous Flame
II Luminous Flame
III Unburned Gas Zone
IV Carbon Monoxid Flame

combustion immediately outside the inner zone; (3) the outer or non-luminous zone, or area of complete combustion; (4) a deep blue flame at the base which extends only a slight distance upward, consisting of carbon monoxide gas. The central zone of unburned gas is generated by the heat of the flame acting on and decomposing the fat, and is highly charged with carbon. In the luminous flame the particles of carbon in the inner zone float outward and become heated and incandescent, imperfect combustion occurring, since the supply of oxygen is insufficient to form CO_2.

In the outer zone the supply of oxygen from the surrounding air is sufficient to produce complete combustion.

The small, deep blue part at the base of the flame consists of carbon monoxide gas.

THE BUNSEN FLAME

In the Bunsen flame the gas is admitted into the base of the burner, and passes up through a tube to the point of ignition. Near the bottom of the tube are openings for admitting air. As the gas passes upward, the air is drawn in also, and mixes with the gas; and when ignited the flame burns without luminosity, but with intense heat, because the admitted air furnishes the necessary amount of oxygen for complete combustion.

THE BLOWPIPE FLAME

The blowpipe usually consists of two tubes—a large outer one for conducting the gas, and a small inner one for admitting the air—and so shaped as to be convenient to handle. (See page 998.)

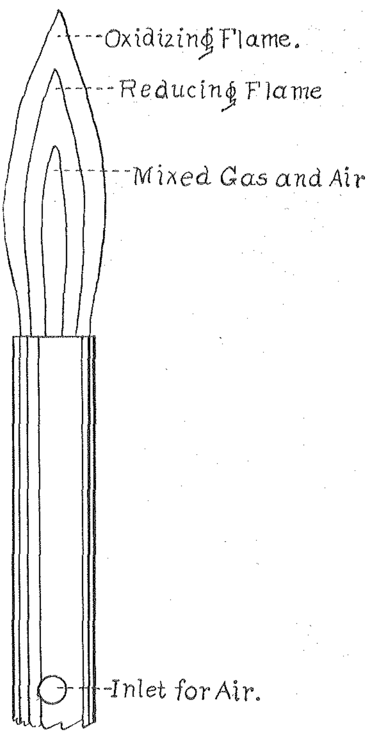


Fig. 956.— Bunsen Flame

When in operation the air is forced in the center of the flame through the inner tube by compression, and the requisite amount of oxygen for complete combustion thus supplied.

The blowpipe flame consists of three zones, an inner one of mixed unburned gas and air; a middle zone of bluish tinge, and an outer zone, slightly yellowish in color. Just beyond the tip of the inner blue flame is a point termed the reducing flame. If this flame be directed upon the oxidized surface of a metal, for example, a copper coin, the surface is immediately brightened, and the oxide removed. This is due to the presence of particles of carbon in excess in this part of the flame uniting with the oxygen in combination with the copper, and under the influence of heat CO_2 is formed, and passes off as a gas, leaving the metal clean and untarnished.

When the flame is removed, however, the oxygen from the air immediately re-combines with the copper again, unless some means, such as a flux, like borax, is used to prevent it.

Near the extremity of the outer cone is a point known as the oxidizing flame, so-called because, when applied to

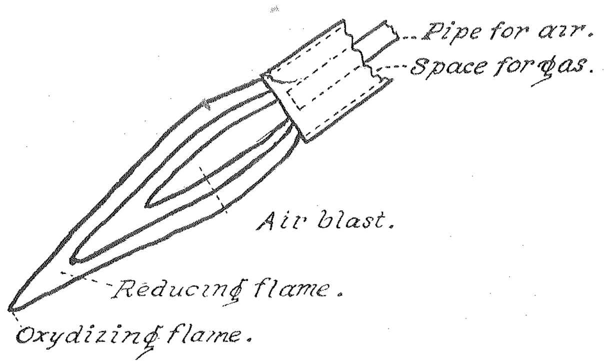


Fig. 957.— Blowpipe Flame

metallic surfaces, regardless of how bright and clean, they immediately become oxidized by the action of the external air.

In all soldering operations, therefore, care should be taken to cover the solder and the surfaces over which it is to flow with flux, and apply the reducing flame.

When solder is applied in considerable bulk, as in backing crowns and dummies, in bridge work, the flame of the blowpipe should be continued some little time upon the fused solder, to permit the flux in the deeper parts to find its way to the surface. If this precaution is not observed, the retention of the flux in the solder causes pits to form throughout the mass, and in grinding down and finishing the piece these are frequently exposed. When this condition occurs, the case requires resoldering, or the exposed pits must be filled by plugging with material of essentially the same character as that of which the piece is constructed.

MICRO STRUCTURE OF METALS

The study of the structure of metals under the microscope is a field apart from that of general metallurgy, and may more properly be included in the science of metallography.

It is impossible to obtain sections of metals transparent enough for examination in the ordinary manner under the microscope, therefore they must be studied by *reflected light.*

The surfaces of specimens to be examined are first ground, and then highly polished.

This is accomplished by the use of stones and emery paper of gradually increasing fineness, and afterwards finishing with fine polishing powder.

The polished surface is then etched with very dilute nitric acid. A mixture of equal parts sulphuric acid and bichromate of potassium, with ten times its bulk of water, is frequently used for this purpose.

The etching process brings out the structure of the metal or alloy being examined, so that under the microscope it is readily determined whether the structure is crystalline, granular, or amorphous.

In the examination of some steels by this method it has been observed that they are not homogeneous throughout, but composed of imperfectly crystallized grains called *ferrite,* crystals of iron and carbon called *cementite,* and a combination of ferrite and cementite, called *pearlite.* This method of examining metals and alloys has proven of great practical value in the industrial world, for by it the means of producing the best qualities of crude and finished material have been determined, and data established by means of which stock material already manufactured may be selected for a given purpose.

ALLOYS

Most of the metals can be united with one another in various proportions by the aid of heat. The product of such a combination is termed an alloy.

Alloys cannot be regarded as chemical combinations, although it is probable in some instances that chemical combinations may occur.

MATTHIESSEN'S THEORIES AS TO THE NATURE OF ALLOYS

Matthiessen expressed the belief that an alloy of two metals may be:

First, a solution of one metal in another.

Second, a chemical combination.

Third, a mechanical mixture.

Fourth, a solution or mixture of two, or all of those mentioned, or a perfectly homogeneous diffusion of one body in another.

AFFINITY OF METALS FOR EACH OTHER

The affinity of metals for each other is variable, and consequently they will not alloy uniformly. A good example of this is seen by melting lead and zinc together. When melted and agitated they may be diffused through each other, but if allowed to cool slowly, they separate, the zinc, being lighter, rising to the top, while the lead will settle to the bottom of the crucible.

LIQUATION

This tendency of metals to separate on cooling is known as *liquation.* In some cases it can be overcome, and in others partially so, by breaking up the ingot and remelting it.

OBJECT IN ALLOYING METALS

The prime object in alloying metals is to fit them for some special application for which in their pure state they are unfitted.

Some of the results of alloying may be tabulated as follows:

1. To increase strength, elasticity and tenacity.
2. To harden.
3. To reduce the melting point.
4. To modify the color or structure.
5. To facilitate the production of sound and workable castings.
6. To resist corrosion or oxidation.

Examples: Gold is alloyed with copper and silver to harden it; its fusing point reduced and its color modified according to the proportions of the metals used.

Silver is rendered harder and its color modified by the addition of copper.

Copper is hardened by the addition of zinc, its toughness reduced, and its reddish color changed to yellow, as is apparent in the many-colored brasses produced. Its strength, tenacity, and elasticity are enhanced by the addition of nickel.

By the addition of tin to copper an alloy known as bell metal is produced, in which is developed a quality of *sonorousness* not present in either of the uncombined metals.

As a general rule, the alloying of one metal with another reduces the melting point of the most difficultly fusible, and sometimes reduces the fusing point of the alloy below that of the least fusible.

In making alloys, if the fusing points of the metals being combined are widely separated, it is best to melt the most refractory first, and then add the lower fusing constituents. This will prevent to a great extent, at least, the tendency of the latter to volatilize. The union of the low with the high fusing metal should be effected at as low a temperature as possible.

EUTECTICS

When two or more metals are fused, and combined by heat, on cooling down, or *freezing,* certain portions of the molten alloy frequently exhibit a tendency to crystallize before the entire mass solidifies. Such behavior indicates that the union by fusion of the component metals has resulted in not one, but a series of alloys, differing in fusibility and usually in physical properties.

The most liquid portion of the alloy, or that which solidifies last, is called a *eutectic* alloy, from *eu* well, and *teko* fuse, meaning *well fused.* (Gr.)

The formation of eutectics may be partially obviated by stirring the molten alloy until it begins to congeal.

When metals are alloyed in certain proportions for some definite purpose, as in the compounding of solders and dental amalgam alloys, the formation of eutectics is a disadvantage because the component metals will not be uniformly diffused throughout the mass.

AMALGAMS

An amalgam is an alloy of two or more metals, one of which is mercury.

A *dental amalgam alloy* usually consists of tin and silver, to which is sometimes added a small percentage of other metals, such as platinum, gold, zinc, copper, etc., for the supposed improvement of *color, edge strength, hardness* and *resistance to stress.*

As a matter of fact, *any* amalgam alloy will in time discolor in the mouth, while as to resistance to stress, edge strength, etc., it has been demonstrated that an alloy of silver and tin in the proportion of 72.5 to 27.5, when properly *tem-*

pered and amalgamated, fulfills the requirements as well as most of the alloys containing additional metals.

Dental amalgam alloys are finely comminuted, being either in the form of filings or of shavings, in order to facilitate their amalgamation with mercury.

Copper amalgam consists of pure copper and mercury usually brought into combination with the galvanic current. It softens when heated and hardens again on cooling. It is used very often in the filling of temporary teeth. On account of its tendency to discolor, oftentimes becoming black, it is not extensively used for permanent operations.

SPECIFIC GRAVITY OF ALLOYS

The specific gravity of an alloy, as a rule, differs from the mean of the specific gravities of its constituents. In case of contraction occurring, the density of the mass has increased, and when expansion occurs, the reverse condition prevails. It is thought probable that, when the density of an alloy is greater than the mean of the specific gravities of the metals involved, chemical combination has occurred.

The following table, by Thenard, illustrates the variations of density in a number of alloys:

Alloys of greater specific gravity than the mean of their constituents.	Alloys of lower specific gravity than the mean of their constituents.
Gold and zinc.	Palladium and bismuth.
Gold and tin.	Gold and silver.
Gold and bismuth.	Gold and iron.
Gold and antimony.	Gold and lead.
Gold and cobalt.	Gold and copper.
Silver and zinc.	Gold and iridium.
Silver and lead.	Gold and nickel.
Silver and tin.	Silver and copper.
Silver and bismuth.	Copper and lead.
Silver and antimony.	Iron and bismuth.
Copper and zinc.	Iron and antimony.
Copper and tin.	Iron and lead.
Copper and palladium.	Tin and lead.
Copper and bismuth.	Tin and palladium.
Copper and antimony.	Tin and antimony.
Lead and bismuth.	Nickel and arsenic.
Lead and antimony.	Zinc and antimony.
Platinum and molybdenum.	

TABLE OF THE PHYSICAL PROPERTIES OF SOME OF THE METALS

	Symbol	Atomic weight	Specific gravity	Melting point	Mallea-bility	Ductility	Tenacity	Conduc-tivity heat	Conduc-tivity electricity	Specific heat
Gold..........	Au.	197.2	19.4	1063°C	1″ rank	1″ rank	7″ rank	53.3	76.7	0.0324
Iron..........	Fe.	55.84	7.84	1530	9 "	4 "	3 "	11.9	14.8	0.1138
Platinum......	Pt.	195.2	21.4	1755	6 "	3 "	5 "	8.4	14.5	0.0311
Iridium.......	Ir.	193.1	22.4	2350	Red Heat	Brittle	Brittle			
Silver.........	Ag.	107.88	10.5	960.5	2″ rank	2″ rank	6″ rank	100	100	0.057
Copper........	Cu.	63.57	8.9	1083	3 "	5 "	4 "	85	97.8	0.0952
Aluminum.....	Al.	27.1	2.6	658.7	2 "	7 "	8 "	31.3	65.5	0.0956
Zinc..........	Zn.	65.37	.7	419.4	8 "	6 "	9 "	28.1	29.6	
Cadmium.....	Cd.	112.4	8.54	320.9	5 "	11 "	10 "	20.1	24.4	0.0567
Lead..........	Pb.	207.10	11.4	327.4	7 "	8 "	12 "	8.5	8.4	0.0314
Tin...........	Sn.	119.0	7.3	231.9	4 "	7 "	11 "	15.5	14.4	0.0562
Mercury.......	Hg.	200.6	13.6	38.9	....	....	....	13.5	1.8	0.0333
Nickel........	Ni.	58.68	9	1452	11″ rank	5″ rank	2″ rank	....	12.9	0.1108
Bismuth.......	Bi.	208.0	9.75	271	Brittle	Brittle	Brittle	1.8	1.4	0.0308
Antimony.....	Sb.	120.2	6.7	630	"	"	"	4	3.6	0.0508

Melting points according to U. S. Bureau of Standards. (Revision of 1915.)

Gold

Gold has been known and used from the remotest antiquity, and its value as a medium of exchange recognized by civilized and uncivilized peoples in all ages.

Alchemy was defined as the art of transmuting the base metals into gold and silver, and the ancient alchemists experimented with this end in view. Their labors, however, while not accomplishing the discovery of this much desired process, did result in the discovery of many curious scientific truths on which the foundation of modern chemistry stands, and thus gold has played a very important part in the advancement of science and civilization.

There is, perhaps, no other metal whose intrinsic value has remained so permanent as has that of gold. Its comparative scarceness, its beautiful, rich, yellow color, the ease with which it can be worked into different forms, together with the fact that it does not readily tarnish or oxidize under ordinary conditions, may account for the high regard in which gold is held. As before stated, it has been used from time immemorial as a medium of exchange, and in most countries to-day is the basis or standard of the monetary systems.

OCCURRENCE AND DISTRIBUTION

Although comparatively scarce, gold is found quite widely distributed over the earth. It occurs *native* or in metallic condition, and also combined with silver, lead, tellurium, or with sulphides. It is obtained from two very different sources; first, from placer or alluvial deposits of rivers and streams, both ancient and modern, and, second, from veins in rocks.

PLACER DEPOSITS

The placer deposits are the result of the weathering and disintegration of the rocks carrying the vein gold, and as these fall to pieces they are washed down stream with the sand, gravel and soil and settle in the beds of rivers. In time the channels of the streams change, and the beds of gravel or placer, bearing the gold, are left high and dry sometimes miles from any water. The vast placer deposits on the western slopes of the Sierra Nevada mountains are supposed to be the beds of ancient rivers long since obliterated.

Placer gold is usually in the form of small pellets, flakes, or rounded grains, the larger pieces, those weighing ½ ounce or more, being called nuggets. The largest mass of gold ever found in one piece was taken from the placer deposits of Victoria, Australia, and weighed 183 pounds, its value being over $40,000. Another one, the "Blanch Barkley" nugget, also found in Australia, weighed 146 pounds. A nugget was found in Prussia in 1842 which weighed 96 pounds, and in California a number of pieces have been found which weighed 20 pounds or more. These, however, are rare instances of gold occurring in large masses, the usual form being, as before

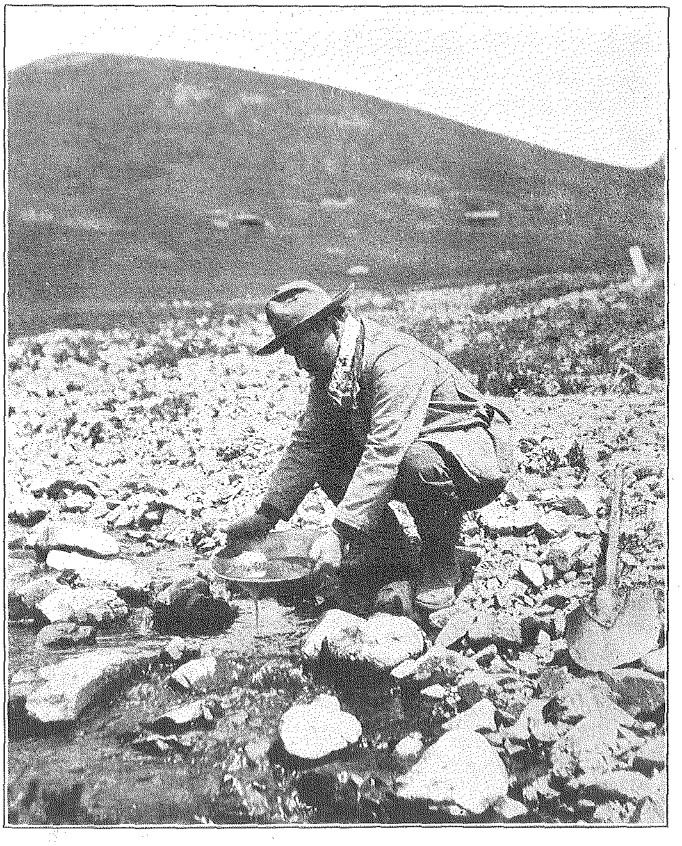


Fig. 958.— Panning Placer Gold

stated, in small flakes and grains, and frequently as fine dust, the particles being so small as to be indistinguishable without the aid of a lens.

PLACER MINING

Gold is obtained from placer deposits in several ways, the most simple of which is by means of the "pan." This consists of a shallow vessel, usually of sheet iron, about 14 or 16 inches in diameter and two or three inches deep, in which the soil bearing the gold is placed. This is then held in water and the pan given a rotary and side-to-side motion, which washes out the soil and sand and leaves the gold in the bottom of the pan.

Fig. 959.— Washing Placer Gold in a Cradle

The Cradle is a similar device, constructed on a somewhat larger scale, for washing larger quantities of soil.

The Sluice is a convenient means of washing still larger quantities of soil where running water is convenient. It consists of a long flat-bottomed trough set on a slight incline so that the water may readily run through it from end to end.

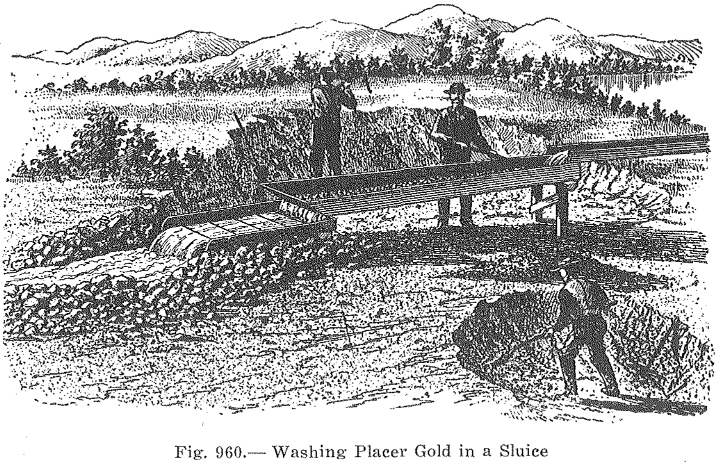


Fig. 960.— Washing Placer Gold in a Sluice

Across the bottom, strips are placed parallel with the water current, and others are placed at right angles to these, thus forming a series of small compartments which contain mercury. Since mercury has a strong affinity for gold, the smallest particles are saved in this manner. The soil is thrown into the upper end of the sluice and the current washes it down over the ridges, the lighter particles being thus carried off, leaving the gold amalgam in the bottom.

At regular intervals the mercury charged with the gold is removed, placed in retorts and subjected to heat. This distills off the mercury and leaves the gold. The mercury is recovered by conducting its vapor into suitable condensers, when it is again ready for use.

These sluices vary from a few feet to several hundred in length, those used in hydraulic mining often being a mile long.

In the small sluices the soil is thrown in with shovels, while in hydraulic mining it is loosened by a large forcible stream of water directed against the bank or hill of gravel by means of a hose with nozzle. The water used for tearing down the soil is directed into the sluices and is utilized for washing the gravel.

VEIN GOLD

When gold is found in veins in rocks, the rock or mineral with which it is associated is first mined, then crushed to reduce it all practically to a powder. This is accomplished by first crushing the rock into small pieces, and then stamping the broken pieces by special machinery called a stamp mill.

EXTRACTION OF GOLD FROM ORES

More or less variation exists in the construction and operation of stamp mills, depending principally on the character of the ore to be reduced. Stamp mills are usually built on a side hill or inclination having a fall of at least 30 feet in the length of the mill. For economical reasons they should be situated convenient to both fuel and water.

The inclination of the ground enables the various pieces of machinery to be placed so that gravity carries the crushed ore from one to the other without difficulty. In the highest part of the mill is placed the platform, which receives the ore, and from which it is shoveled into the *crusher*. This breaks the mineral into pieces 3 inches or less in diameter, in which condition it is carried down to the *stamp mill*.

The stamp mill consists of large, flat-bottomed iron mortars, into which are fitted heavy iron pestles, each weighing from 500 to 1,000 pounds. These are lifted by cam devices, keyed on a revolving horizontal shaft, and fall by their own weight. Stamps are usually ranged in line, in groups of five stamps each, operating in a common mortar box. A stream of water carries the pulverized material against amalgamated copper plates, placed in the sides of the mortar, the mercury on which retains the gold, while the earthy constituents are washed away.

At intervals, before the mercury has become saturated with the gold, the plates are removed and scraped, and the amalgam thus collected subjected to powerful pressure in leather bags. This squeezes out the excess of mercury through the pores of the leather. The thick amalgam remaining is then placed in retorts, subjected to heat, and the mercury distilled off.

The gold remains in the retort in a spongy state, and is usually quite free from other metals, with the exception of silver. It is then melted with suitable fluxes, cast into bars and shipped as bullion.

CHLORINATION PROCESS

Gold ores can be reduced and the gold freed by means of chlorine gas. The process is as follows:

The ore is first crushed, then roasted to expel sulphur, arsenic, antimony or other volatile substances that may be present. The roasted ore, slightly dampened, is then placed in wooden vats having false bottoms.

When the vats are charged, close-fitting covers are placed over them and chlorine gas is introduced under the false bottom. This in time rises through the false bottom and into the moistened ore, converting the gold into a soluble chloride, which is afterward removed by washing. From this solution the gold can be precipitated by the sulphate of iron.

CYANIDE PROCESS

This process is much in favor in many parts of the world because of its cheapness and from the fact that low-grade ores which cannot be worked economically by other processes can be reduced profitably by this method.

The advantage of the cyanide over the chlorination process lies in the fact that in the method under consideration it is unnecessary to roast the ore.

The process is as follows: The ore is first crushed, and in this condition is placed in vats with false bottoms similar to those used in the chlorination process, but deeper. Water containing a small percentage of cyanide of potassium is then added to the contents and allowed to slowly percolate through the mass. This process is known as *lixiviation.* The gold is dissolved by the cyanide and carried out in solution, when it is afterward precipitated by zinc shavings.

PHYSICAL PROPERTIES

The fusing point of pure gold is 1063 deg. C., its specific gravity 19.4, malleability and ductility first rank, tenacity seventh rank, conductivity of heat 53.3, electricity 76.7, and specific heat .0324.

PREPARATION OF PURE GOLD

In the dental laboratory gold scraps and filings accumulate, and these can be refined, the base metals eliminated and the pure gold reduced to the desired carat by alloying with pure metals in proper proportions.

Filings should be spread on a paper and a horseshoe magnet passed back and forth through them to remove any particles of iron that may be present. They should then be treated with acids, to remove such of the baser metals as are not actually alloyed with the gold.

The gold is now placed in a flat-bottomed flask that may be subjected to heat without breaking and covered with *aqua regia*. This is composed of two parts of concentrated hydrochloric to one part of nitric acid. Heat is then applied and additions made to the acid from time to time until the gold is all in solution.

The solution is then weakened with water and filtered. If any silver is present, it will be retained on the filter paper. The solution should be further diluted until only very slightly acid. A clear solution of ferrous sulphate is now slowly added and time allowed the gold in solution to precipitate. This usually requires several hours. The clear liquid is then drawn off and the brown precipitate of metallic gold is heated several times with dilute hydrochloric acid to remove iron. The precipitate is then thoroughly washed to remove every trace of acid, dried out, the filter paper carrying the gold folded and placed on charcoal block or in furnace, borax and saltpeter added and the metal fused.

TREATMENT OF SCRAP PLATE

When the clippings from plate of the same carat are allowed to accumulate and kept separate, these may be simply remelted, cast into the ingot mold and rolled out into plate of the required thickness without the necessity of refining.

Alloying Gold

For most dental purposes, with the exception of foil for filling and plate for backing porcelain facings, gold is reduced in fineness. That in most common use for crowns and bridges is 22 C. and 21.6 C. (coin gold); 20 and 18 C. gold is used for dentures.

The term *carat,* used in this connection, indicates the number of parts of pure gold there is in an alloy. Pure gold is called 24 carat, and may be regarded as 24-24th pure; 22 carat is 22-24th pure, or 22 parts pure gold and 2-24 alloy; 20 carat is 20-24ths pure and 4-24 alloy, etc.

REDUCTION OF GOLD

The dentist can make his own gold plate and solder of any desired carat, if ordinary skill is exercised.

Gold plate of a known carat can be increased or decreased in fineness by the addition of pure gold, or of gold plate of a higher or lower carat. This process, whether raising or lowering, is called *reduction.*

BOSER'S RULE

A general rule that answers for both methods is that known as Boser's rule. *"The difference between the carat of gold used to reduce with and the required carat, is to the difference between the required carat and the carat of gold to be reduced, as the weight of the gold to be reduced is to the weight of reduction metal required. The weight of the entire mass, when alloyed, may be found by adding the weight of gold reduced to the weight of reduction metal required."*

U. S. gold coin is 90 per cent pure gold and 10 per cent alloy (silver and copper), or 21.6 carat fine. This is frequently employed in crown and bridge work. It is a little darker in color than 22 carat gold because of the percentage of copper contained, and is more difficult to work, since it is harder and stiffer; 22 carat gold is, perhaps, most generally used in crown and bridge work, and 20 carat and 18 carat in denture construction.

Pure gold is frequently used for backing teeth because of its softness and ease of adaptation to the porcelain.

An alloy of 75 parts pure gold and 25 parts pure silver (18 carat) is sometimes used for backing teeth when it is necessary to impart a greenish tinge to the porcelain. This alloy is known as *green gold.*

GOLD SOLDERS

Most solders contain a trace of zinc or cadmium to reduce the fusing point of the gold so that solder of a given carat may be fused upon plate of the same carat without danger of melting the latter.

Dr. Dorrance gives the following alloy as a practical one for making good colored gold solders:

Pure silver	1 part
Pure zinc	2 parts
Pure copper	3 parts

These are melted together to form an alloy, the copper and silver being melted first, after which the zinc is added quickly in small pieces and the mass stirred to insure thorough mixing of the metals, then poured into water to granulate it.

If 20 carat solder is desired, it can be made by taking 4 parts of this alloy and 20 parts pure gold; 18 carat gold solder may be made by taking 6 parts of the alloy and 18 parts pure gold, etc.

The proportion of the zinc in most solders is 1 to 24 parts of the entire alloyed mass.

Dr. W. H. Trueman recommends the following solders as being of good color, easy flowing, and as tough as gold plate. An excess of zinc is added to compensate for some slight loss from volatilization:

22 Carat Solder

Pure gold	22
Copper	1
Zinc	1¼

18 Carat Solder.

Gold	18
Copper	2
Silver	3
Zinc	1½

TABLE OF MIXED CARATATION

The following table gives the proportions of the various metals used in jewelers' gold plate:

	Parts		
Carats.	Copper.	Silver.	Gold.
23	½	½	23
22	1	1	22
20	2	2	20
18	3	3	18
16	5	3	16
15	6	3	15
14	7	3	14
12	8½	3½	12
10	10	4	10
8	10½	5½	8

Gold plate may be made by using all copper, or all silver, as the alloying agent, but its color is materially changed in either case, becoming darker when alloyed with the former, and lighter or of a green tinge when alloyed with the latter.

As before stated, pure gold may be reduced in fineness without material change of color by the use of silver and copper in proper proportions.

CLASP GOLD

Platinum is added to gold to impart elasticity to it, and when gold is so alloyed it is called *clasp metal.* The following formula is one recommended by Harris:

20 carat *clasp gold:*

Pure gold	20 dwt.
Copper	2 dwt.
Silver	1 dwt.
Platinum	1 dwt.

Clasp gold is usually made of 26, 24 and 22 gauge, the thickness of plate required for a given case depending on the length of teeth to be clasped, long teeth requiring thin, and short teeth thick, plate. (See Clasp Metals, page 1033.)

PLATINUM SOLDER

Formerly platinum base plates, dentures and the metal parts of porcelain crowns and bridges were soldered with pure gold, but this method was not satisfactory, because the gold diffused itself into the platinum and formed a brittle, crystalline alloy, incapable of resisting much stress. For this reason the use of pure gold as a solder for platinum has been abandoned and an alloy of gold and platinum substituted by which the difficulty mentioned is obviated:

No. 1.

Pure gold	75 parts
Pure platinum	25 parts

No. 2.

Pure gold	80 parts
Pure platinum	20 parts

No. 3.

Pure gold	85 parts
Pure platinum	15 parts

Some Recent Work Concerning Gold Alloys

The following section, from page 1013 to 1063, is the result of a series of recent researches in gold alloys and kindred subjects, by Dr. L. J. Weinstein of New York, the copyright of which he holds.

This section was written specially for and will appear in Dr. F. A. Peeso's work on "Removable Crown and Bridge Work," now in press.

The author of this valuable contribution has kindly granted the writer the privilege of its presentation in this book.

Author's Preface

"In the preparation of this contribution, it has been the aim of the author to present a brief and practical rather than an academic discussion of the subject.

"In addition to a consideration of the gold alloys, it was found advisable to include a section on the closely allied and important subjects of refractory materials and fluxes used in connection with gold, during soldering or casting operations.

"The series of investigations, upon which this contribution is based, was started during the year 1908, when the author experienced considerable difficulty in attempting the execution of removable bridge work along the lines laid down by Dr. Peeso.

"In attempting to use the coin gold and modifications of same in the form of solders, he was seriously handicapped by the comparatively low melting point of the coin gold and the inadequacy of the other gold alloys usually obtainable, which, to the man of exceptional skill, is not so apparent as to one of average, or even less than average, skill.

"In view of the well-known fact that platinum is a metal that could be alloyed with gold to increase the melting point of the latter, a number of experiments were made to produce a formula for a gold alloy sufficiently high in melting point so that it could be used as a substitute for coin gold and thereby eliminate the process of "sweating," which, in the hands of the author and many other novices, was a more or less hazardous procedure, and instead, soldering the resultant high fusing gold with other gold of a melting point equal to that of 24 or 22k., and thus obtaining a strong union that would withstand the subsequent, and often numerous, soldering operations required for the completion of the case.

"The alloys finally developed were found so satisfactory that it is not too much to say that even in the hands of the most skilled operator these alloys will prove of considerable value, if for no other reason than the very great difference in the melting point between the highest and lowest fusing alloys in the series and the consequent increased facility and safety during the necessary subsequent soldering operations.

"In the author's efforts to obtain information from which to formulate alloys he was greatly handicapped, inasmuch as there were no dental publications bearing to any extent on the subject. After a thorough study of the then recently revised books on dental matallurgy, a number of experiments were made, the results of which did not appear to correspond with the data in the text books. A number of works on general metallurgy were consulted and found to differ materially with the dental text books in a great many instances, particularly on data concerning the properties of the binary alloys of gold and silver, gold and platinum, etc. In order to establish a definite foundation upon which to base further researches, the author proceeded to make a series of binary alloys and from the resultant data was enabled to proceed with the development of more complex alloys.

"The resultant formulæ given herein have been in practical use for a period ranging from two to five years, and while the author does not claim that his is by any means the last word on the subject, he trusts that the results of his research will prove of some immediate benefit to both advanced students and practitioners. ——— ——— ———."

Introduction

The elements following gold have been divided into four groups. This division is an arbitrary one, and made solely for the purpose of facilitating future references. (See table 1, page 1015.)

Binary Alloys

It is a well-known fact that pure gold has but a limited use in the construction of various dental appliances and that it is necessary to alloy it with various other metals in order to increase its durability, hardness, tenacity and to vary the melting point above or below that of pure gold, as may be required. The metals in common use for this purpose have been copper, silver and platinum, the latter to a limited extent; also zinc, cadmium, etc., for solders, which, of course, require a considerably lower melting point than the gold upon which they are to be used.

NECESSITY OF A KNOWLEDGE OF BINARY ALLOYS

A thorough knowledge of the properties of the simple binary alloys is of paramount importance, because these properties almost invariably give an indication of what may be expected from more complex alloys.

It is generally accepted by metallurgists that binary alloys of gold and silver, copper, platinum or palladium form solid

TABLE No. 1.
THE MELTING POINTS* AND DENSITIES OF METALS.

	Name of Metal	Symbol	M.P.°F	M.P.°C	Density
	GOLD	Au	1945	1063	19.3
GROUP I	Silver	Ag	1761	960	10.5
	Copper	Cu	1981	1083	8.9
	Platinum	Pt	3190	1755	21.5
	Palladium	Pd	2820	1550	11.4
GROUP II	Iridium	Ir	4170	2300	22.5
	Osmium	Os	4900	2700	22.5
	Rhodium	Rh	3525	1940	12.1
GROUP III	Zinc	Zn	787	420	7.1
	Cadmium	Cd	610	321	8.6
	Tin	Sn	450	232	7.3
	Aluminum	Al	1218	658	2.7
GROUP IV	Nickel	Ni	2646	1452	8.9
	Cobalt	Co	2714	1490	8.7
	Manganese	Mn	2237	1225	7.4
	Chromium	Cr	2750	1510	6.9
	Tantalum	Ta	5160	2850	14.5
	Tungsten	W	5430	3000	18.7
	Molybdenum	Mo	4500	2500	8.6
	Vanadium	V	3150	1730	6.1
	Titanium	Ti	3450	1900	4.5

*From Circular No. 35, U. S. Bureau of Standards.

solutions. That is, solutions of one metal in another, if in proportions within certain limits. Such binary alloys as will be discussed, form solid homogeneous solutions except when otherwise noted.

It is therefore unnecessary to enter into an academic discussion of the possible molecular affinity existing among various elements or of eutectics formed between the metals in the binary alloys that will be considered, because such compounds or mixtures do not occur in such alloys as may be considered fit for use in the mouth. For example, alloys of gold and copper in the proportion of 82 per cent gold to 18 per cent copper (by weight) form a eutectic, which is the lowest fusing of the gold copper series, and when more than 18 per cent copper is present the copper is not in uniform solution and segregates. As the alloys containing over 15 per cent copper are extremely brittle and lack uniformity, no binary alloys containing more than 10 to 12 per cent copper will be considered. In other words, alloys of gold and copper, where copper does not exceed 12 or 13 per cent, do not form any compounds with special characteristics.

To simplify the references to ternary, quaternary or more complex combinations of metals, alloys of only two metals will be termed, as is customary, "binary," but the alloys composed of three or more metals will be termed "complex" alloys.

Section I

Gold and Silver

Silver is commonly utilized as an alloying element with gold. It is used, to a considerable extent, as part of the alloy in dental golds, and, as will be shown later, principally as a cheapening agent.

EFFECT OF SILVER UPON GOLD

There seems to prevail generally an erroneous conception regarding the properties of silver-gold alloys. It has been stated* that silver is used to harden and to lower the melting point of gold. This deduction is distinctly contrary to the results obtained by the author. After making a number of binary alloys, it was proven that even the maximum percentage that may be used in dental work, say 25 per cent of silver to 75 per cent gold, does not confer any perceptible hardness upon the gold, neither does it lower the melting point to such an extent that the difference could be measured with a pyrometer.

Practically the only effect silver (even if present to the extent of 25 per cent) has upon gold is to discolor the gold, making it greenish, and lower the specific gravity, thus increasing the volume. It will thus be seen that silver confers no special benefit upon gold, except cheapening it and acting as a color modifying agent. On the other hand, it may prove detrimental, as a considerable proportion of silver may *interfere with the action of other alloying elements* when attempt-

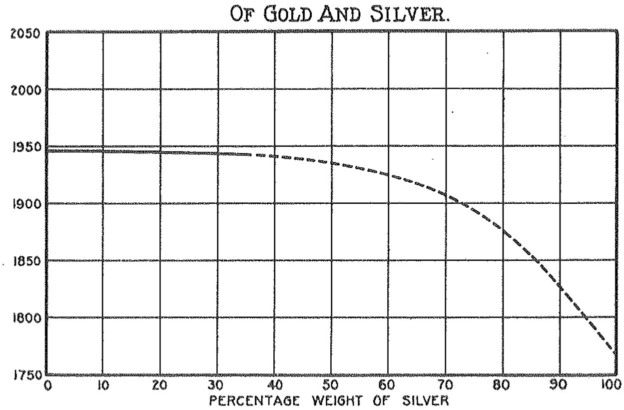
* Essig's Metallurgy (Koenig's revision), p. 163.
* Hodgen's Metallurgy (Milberry's revision), p. 278.

ing to produce a complex gold alloy, and also on account of the strong affinity that oxygen and other gases possess for silver. It will thus be readily seen that small percentages may sometimes be used to advantage as a color modifying agent, but a large percentage of silver is distinctly contraindicated.

Silver, in such proportions as may be needed for dental golds, alloys uniformly and without difficulty and may be depended upon to remain in uniform distribution.

The author has found that gold alloys, with a high percentage of silver, when remelted and cast, show in the casting a considerable variation of the silver content which indicates that a partial separation takes place. This has not been in-

MELTING POINTS OF ALLOYS OF GOLD AND SILVER.



5%	Ag.	M.P	1945°F.	1063°C.
10%	"	"	"	"
15%	"	"	1943°F.	1062°C.
30%	"	"	1942°F.	1061°C.

Fig. 961

vestigated further for the reason that castings of gold with a high percentage of silver have no practical application. As stated before, small percentages of silver have practically no effect upon the gold and this fact has been taken advantage of for a considerable period of time by at least one manufacturer who alloys pure gold with from one to two per cent of silver and sells it as 24k. This alloy appears so similar to pure gold that the ordinary eye is deceived and the unprincipled manufacturer is the gainer.

Fig. 961 illustrates the melting point curve of gold-silver alloys.

Practically the same determination appears in very recent works on metallurgy.*

* Fenchel's Metallurgy.

Silver-platinum alloys have been used to a considerable extent for crown posts, dowels, backings, etc. As a rule, alloys of this character (20 to 30 per cent) are extremely unsatisfactory, both during their manipulation and in ultimate service, and their use should be avoided. They are somewhat improved with higher percentages of platinum, but the alloys are extremely non-uniform and still quite soluble in acids and apt to discolor and corrode. The cost with more platinum is considerably higher, and even then the alloys are not equal to a fair grade of alloyed gold, either in usefulness or economy.

GOLD AND COPPER

Copper is one of the most commonly used and most useful alloying elements. It confers hardness and elasticity upon gold, but is detrimental when used in large proportions on account of its great tendency to lower the melting point of the alloy and the strong oxidation and brittleness of the alloys when the copper is in high proportion. It is, however, a most useful, and, in fact, an indispensable alloying element if employed judiciously. Alloys of gold and copper, such as U. S. coin gold (Au. 90 Cu. 10), have been used with most satisfactory results, both from the standpoint of durability and resistance, against action of the oral fluids, and an alloy of this character is ideal for crown work, except for the disadvantage of its low melting point, which is caused by the copper content, and its range of usefulness is therefore limited even in the hands of the skilled operator. This inadequacy, as will be shown later, can be corrected by substituting platinum, etc., for some of the copper, thus raising the melting point and reducing oxidation without changing the valuable properties the coin gold possesses, namely, strength and durability.

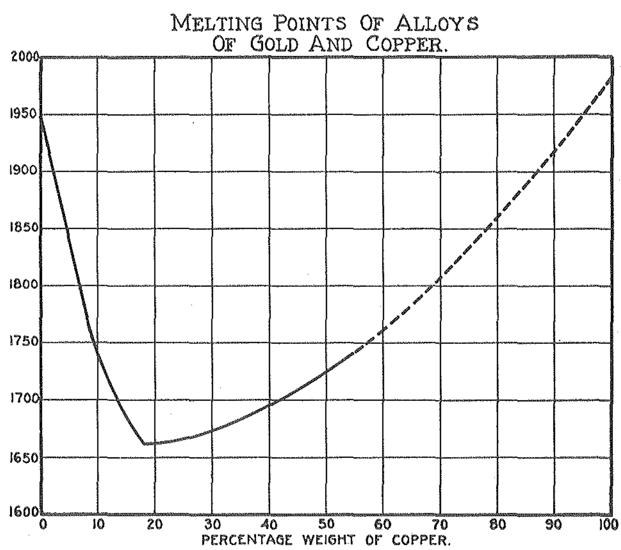
Fig. 962 illustrates the melting point curve of gold-copper alloys.

As will be seen from the chart, the melting point of pure gold drops rapidly upon the addition of copper; 5 per cent copper lowers the melting point about 100 degs. F., 10 per cent copper lowers the melting point of gold about 200 degs. F., 15 per cent copper lowers the melting point about 250 degs. F., and 18 per cent causes a drop in melting point of about 300 degs. F. As will be seen from the illustration, the lowest melting point between gold and copper is when 18 per cent cu. is present. The addition of more than 18 per cent cu.

causes a rise in melting point until the melting point of copper, 1980 degs. F., is reached.

As mentioned previously, it is advisable to limit the total copper content to 10 or 12 per cent. Consequently, if the melting point of an alloy of gold and copper of requisite strength and hardness is too low, it is necessary to use platinum or palladium to bring it to the point desired.

The valuable properties of copper as a hardening agent have apparently been underestimated by writers, but taken



5%	Cu.	M.P	1840°F.	1004°C.
10%	"	"	1735°F.	946°C.
15%	"	"	1690°F.	921°C.
18%	"	"	1661°F.	905°C.

Fig. 962

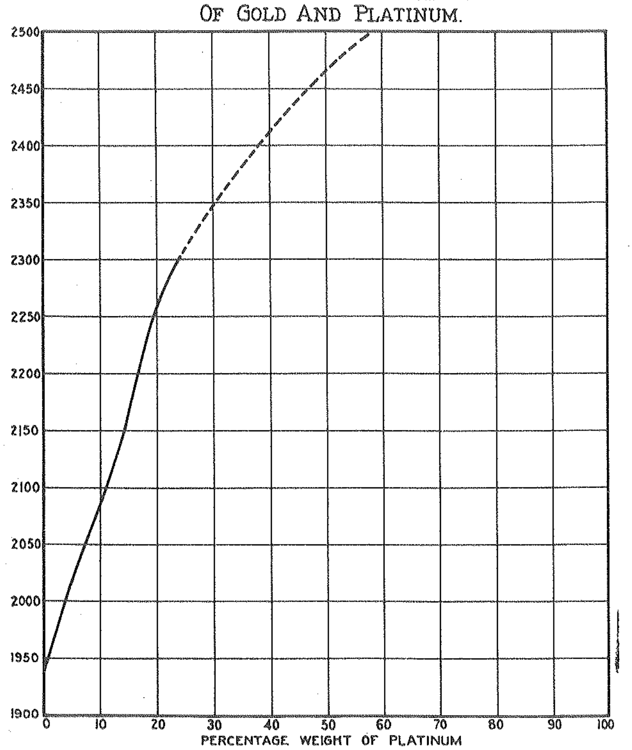
advantage of by manufacturers, as will be noted in the composition of commercial clasp metals.

GOLD AND PLATINUM

Platinum is being used to some extent as an alloying element with gold principally for clasp metal, etc. It has been stated that platinum confers great elasticity and hardness upon gold, which appears correct, only to a limited extent. The author's experiments have indicated that platinum has comparatively little effect as a hardening agent upon gold. It does, however, raise the melting point considerably, as will be shown later.

Platinum is much inferior to copper as a hardening agent. This is readily proven upon an examination of a binary alloy of gold and copper containing 10 per cent copper and a binary alloy of gold and platinum containing 25 per cent platinum (so called platinum solder). A comparison of two pieces of equal dimensions will show that the gold-copper alloy, with 10 per cent copper, is quite as hard and elastic as the gold alloy

MELTING POINTS OF ALLOYS
OF GOLD AND PLATINUM.



5% Pt.	M.P.	2015°F.	1102°C.
10% "	"	2085°F.	1141°C.
15% "	"	2165°F.	1165°C.
20% "	"	2260°F.	1228°C.

Fig. 963

with 25 per cent platinum, and more uniform. It is therefore evident that platinum is not the most suitable hardening agent and its range of usefulness as an alloying element is therefore limited.

Platinum, however, is an excellent adjunct to copper, as it tends to raise the melting point, which is lowered sensibly by any considerable percentage of copper.

Fig. 963 illustrates the melting point curve of gold-platinum alloys.

Large percentages of platinum cannot be alloyed uniformly with gold, and in order to insure a uniform alloy it is not advisable to use more than 5-10 per cent in a binary alloy and 10-15 per cent in a complex alloy. In the latter the *other alloying elements help to hold the platinum in uniform distribution.* If it is desired to raise the melting point of an au.-cu. alloy higher than 5-10 per cent platinum makes possible, it is advisable to use palladium, which *combines perfectly* in both the binary and complex alloys that will be considered.

GOLD AND PALLADIUM

Palladium is as yet a comparatively rare metal. It has been used to some extent in the industries and arts, but practically to no extent in dental golds. Palladium is a metal very similar to platinum except for its specific gravity, 11.4, which is considerably lower than platinum and its melting point, which is also considerably lower than that of platinum.

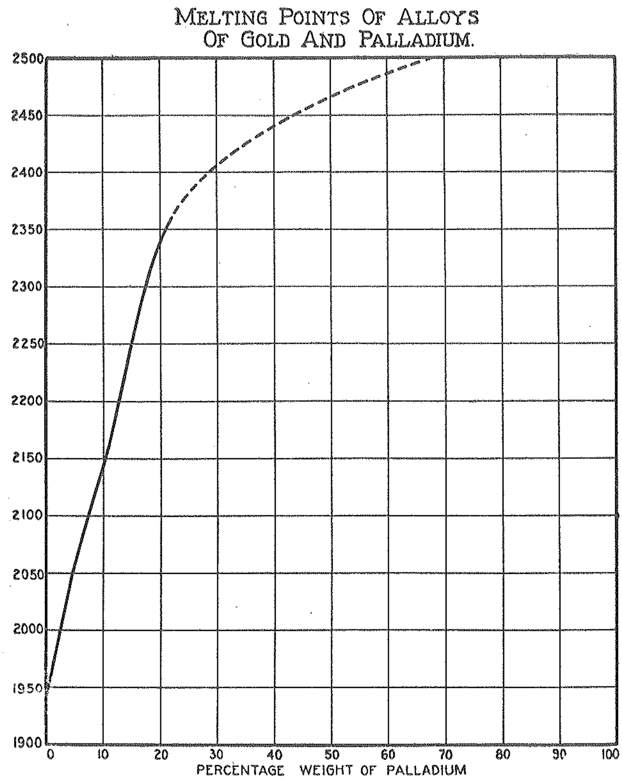
TABLE 2

MELTING POINTS OF BINARY ALLOYS

GOLD, 1945° F, 1063° C SILVER, 1761° F, 960° C Gold 95%—Silver 5% 1945° F 1063° C Gold 90%—Silver 10% 1945° F 1063° C Gold 85%—Silver 15% 1943° F 1062° C Gold 70%—Silver 30% 1942° F 1061° C	GOLD, 1945° F, 1063° C PLATINUM, 3190° F, 1755° C Gold 95%—Platinum 5% 2015° F 1102° C Gold 90%—Platinum 10% 2085° F 1141° C Gold 85%—Platinum 15% 2165° F 1165° C Gold 80%—Platinum 20% 2260° F 1228° C
GOLD, 1945° F, 1083° C COPPER, 1980° F, 1083° C Gold 95%—Copper 5% 1840° F 1004° C Gold 90%—Copper 10% 1735° F 946° C Gold 85%—Copper 15% 1690° F 921° C Gold 82%—Copper 18% 1661° F 905° C	GOLD, 1945° F, 1063° C PALLADIUM, 2820° F, 1550° C Gold 95%—Palladium 5% 2060° F 1127° C Gold 90%—Palladium 10% 2145° F 1174° C Gold 85%—Palladium 15% 2250° F 1232° C Gold 80%—Palladium 20% 2340° F 1282° C

It has been stated that palladium makes gold brittle. This is contrary to the author's findings. More than twenty-five different alloys were made containing from 1 to 30 per cent palladium. All of them appeared perfectly uniform and remarkably malleable, ductile and tenacious.

Palladium also forms excellent uniform alloys with copper, silver, etc., and it is a very valuable adjunct to platinum



5%	Pd.	M.P	2060°F.	1127°C
10%	"	"	2145°F.	1174°C
15%	"	"	2250°F.	1232°C
20%	"	"	2340°F.	1282°C

Fig. 964

in complex gold alloys. Its use, however, is limited on account of the fact that it exerts a strong decolorizing action upon gold, 3-5 per cent turning gold sensibly lighter and 15 to 20 per cent almost white (platinum color).

Fig. 964 illustrates the melting point curve of gold-palladium alloys.

Another remarkable and most valuable property that palladium possesses is the fact that, although the melting point, 2820 degs. F. (1550 degs. C), is considerably lower than that of platinum, a given percentage of palladium (by weight) will increase the melting point of gold more than an equal amount of platinum, and in view of the fact that platinum in considerable percentages does not alloy uniformly with gold, it is well to use palladium, as it alloys uniformly with gold in all proportions. Therefore, in alloys where color is no object, palladium may be incorporated to very great advantage.

Gold and Metals In Group II

IRIDIUM

Iridio platinum is usually employed in place of pure platinum on account of its greater hardness and durability. When experimenting with the series of binary alloys previously discussed, it naturally occurred to the author that gold alloyed with iridio platinum instead of pure platinum would prove superior to gold alloyed with pure platinum. A number of alloys were attempted and the results obtained were found invariably inferior to alloys of gold and pure platinum. The unsatisfactory results should have been anticipated because it is well known that iridium will not alloy with gold uniformly, but segregates on account of its extremely high melting point and high specific gravity. It is quite certain that in attempting to make the alloy, the following occurred: When the iridio-platinum was brought into the gold, the heat used was sufficient to melt the platinum and set free the particles of iridium which did not go into solution with the gold platinum mixture, but suspended and then segregated in the same way as if free iridium were added to gold without the presence of the platinum.

The experimental alloys were made of pure gold and 15 per cent iridio-platinum and compared with alloys made of pure gold and 15 per cent platinum. On rolling both to equal gauge, polishing and etching, the gold-platinum alloy was found quite uniform, whereas some sections of the gold iridio-platinum alloy (?) were harder and higher fusing, while other sections were softer and lower fusing than the gold-platinum alloy. In addition, all the gold-platinum-iridium mixtures appeared streaky and non-uniform, even to the naked eye, while the gold-platinum alloys appeared almost perfect, even under the microscope.

Numerous other experiments were made along these lines, and in spite of the fact that some have advocated the use of iridio-platinum instead of pure platinum in alloys, it is the author's conclusion that pure platinum is far superior to iridio-platinum as an alloying element with gold.

OSMIUM

No attempts have yet been made to form alloys with osmium, as it is even higher fusing than iridium and therefore poor results may be anticipated. The author expects, however, to experiment with osmium shortly to determine if there is any possible benefit to be derived from it, because alloys of Os. per cent are claimed to be superior to alloys of Ir. per cent.*

RHODIUM

Rhodium is a metal of the platinum group that will prove of considerable benefit if sufficient of it can be obtained at a moderate cost. It is quite similar to palladium. It also has a low specific gravity, 12.1, and is considerably higher fusing than platinum (according to U. S. Bureau of Standards).

The author has not experimented with it in the pure state, but procured a quantity of it in the form of platinum containing 10 per cent rhodium. This platinum-rhodium alloy was used for a cosiderable time instead of pure platinum. The alloys were quite satisfactory, but the advantages over pure platinum as an alloying agent are so slight and the cost so high that it appeared advisable to discontinue its use at the time.

GOLD AND METALS IN GROUP III

A discussion of gold and metals in Group III will be found in the section on Gold Solders, page 1036.

GOLD AND METALS IN GROUP IV

Some time after the introduction of recent casting processes, it became apparent that in order to utilize such processes to advantage, alloys other than ordinarily obtainable would have to be made in order to insure satisfactory results. The ordinary plate golds obtainable when cast in small bulk were too soft and frail, and the sections had to be cast larger and heavier than normal and were therefore objectionable.

A number of experiments were made in attempting to cast the various clasp metals and the results obtained were very unsatisfactory. At this time began to appear literature re-

* F. Zimmerman. Alloy of Platinum and Osmium, U. S. Patent No. 1055119.

garding industrial alloys, both ferrous and non-ferrous, with the so-called rare, or little known, metals, such as nickel, cobalt manganese, tungsten, vanadium, etc., enumerated in the table of elements under group 4.

Some remarkable results were obtained in various industrial steels, brasses and bronzes and it was not unreasonable to expect that some of these rare metals could be utilized to advantage in the formation of gold alloys for casting purposes.

In view of the fact that there was no precedent to follow and no literature on the relation of these metals to gold obtainable, it can readily be understood that the author's attempts to alloy these rare metals with gold were more or less empirical and the results obtained were no better than should have been anticipated. Meeting with such poor success, the author proceeded with the series of researches into both the binary and complex alloys of gold with the elements in groups one, two and three, and the resultant formulæ developed are given in the following pages.

Since then a number of experiments have been made by other investigators in attempting to utilize some of the rare metals, such as nickel, tungsten, molybdenum, titanium, etc., as substitutes for iridio-platinum. The results so far have not proven successful.

This non-success will not appear strange to those familiar with both the chemical and physical characteristics of the elements mentioned. Unless some radical method of handling these metals is evolved iridio-platinum will continue to retain the position it occupies. (See "elastic" gold under clasp metals.)

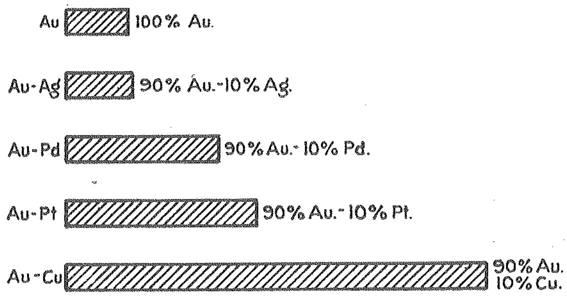
The author has not by any means given up hope of the possibile utilization of some of the "rare" elements in connection with alloys for casting. He is now engaged in a series of experiments which have already shown promising results and he hopes to have data of importance available for publication in the near future.

Section II

A New Series of Alloys

From the preceding data on the properties of the binary alloys of gold with the metals in group one, certain conclusions may be drawn and data obtained and it then becomes a comparatively simple matter to form complex alloys for our requirements. Before proceeding to formulate a complex alloy, it will be well to consider again the hardness conferred upon gold by the metals in group one.

As will be seen from Fig. 965, pure silver has practically no effect on gold as far as increasing the hardness. Palladium has some hardening properties and it is well to bear that in mind when formulating an alloy. Platinum has considerably



COMPARATIVE HARDNESS OF BINARY ALLOYS OF GOLD WITH 10% Ag., Pd., Pt., AND Cu.

Fig. 965

more hardening power than palladium and is a factor, but copper is the most valuable agent of them all and in proceeding to formulate the complex alloys we must consider the copper as the principal hardening agent and the others as adjuncts.

GOLD FOR CROWN, BRIDGE AND PLATE WORK

Bearing in mind the hardening power and the effect on melting point produced by the alloying elements, let us consider such a formula as the following:

Formula of Gold Plate No. 1

	Per Cent
Gold	88.0
Platinum	7.5
Palladium	2.5
Silver	2.0
Total	100.0

Melting point, 2075 degs. F., 1135 degs. C.

This alloy is equivalent in hardness to ordinary 22k. gold, containing 91.6 per cent gold, 3.5 to 4 per cent copper and 4.5 to 5 per cent silver—100 per cent. Now, as the copper is the active hardening agent in the 22k. gold, and as we know from the preceding data that platinum and palladium exert somewhat less than half of the hardening influence of copper, it will be seen that the total of 10 parts platinum and palladium are about equal in hardening power to the 3.5 to 4 parts of copper usually present in 22k. gold, and thus we get an alloy equivalent in hardness to the ordinary 22k. plate.

The silver content, 2 parts, is no factor whatever, except as a color modifying agent, because it is an object to adhere to a certain standard of color throughout the whole series of alloys. As there is no copper present in this alloy, it is absolutely non-oxidizable, but the great advantage that an alloy of this character possesses over ordinary 22k. plate is the fact that its melting point is much above that of ordinary 22k. gold, approximately 225 degs. F. to 250 degs. F. higher, and instead of sweating a band and floor it may be very easily soldered with pure gold or 22k. plate and resoldered with the same or lower grade plate gold innumerable times without any danger of burning or blistering.

Any, or all, of the alloys in the series following plate No. 2 may be safely used as solders on plate No. 1, thus permitting many soldering operations *without danger of burning the gold,* as may occur in sweating, or the danger of the solder (if poor quality) burning into and alloying with the gold, as often occurs when using the so-called "easy flowing" solders. It is evident, therefore, that this alloy offers a great many advantages over the ordinary 22k. plate gold.

GOLD PLATE NO. 2

As has been impressed by Dr. Peeso, it is absolutely essential to use for removable bridge work a hard, durable gold such as U. S. coin gold. It may be well at this time to state that U. S. coin gold contains 90 per cent pure gold and 10 per cent copper, whereas the so-called coin gold obtainable from most supply houses contains, as a rule, some silver, which softens it and makes it *work more easily,* and it therefore does not possess the strength and durability required.

The following formula replaces coin gold most satisfactorily:

Formula of Gold Plate No. 2

	Per Cent
Gold	84.5
Platinum	8.5
Palladium	2.0
Silver	0.5
Copper	4.5
Total	100.0

Melting point, 1975 degs. F., 1080 degs. C.

In this formula, in order to obtain the equivalent hardness of coin gold, it is necessary to use copper. We can again readily see just how the hardening properties of the alloying elements are utilized. We have 4.5 per cent copper and the platinum and palladium replace the rest of the copper, thus giving us an alloy equal to U. S. coin gold. This oxidizes, of course, to a slight extent, but the oxidation is not objectionable, and this alloy can be used to replace coin gold practically for every purpose and may be soldered with other alloys in the series which have the same color. When soldered with casting gold, B or C, the attachment of the floor to a band cannot open up during the final soldering unless deliberately abused, because the soldered junctions are actually higher in melting point than ordinary gold plate.

The fusing point of this alloy is approximately 225 degs. F. higher than coin gold, and it possesses all the advantages over coin that the No. 1 formula has over 22k. gold.

These alloys, Nos. 1 and 2, can be utilized to great advantage in the construction of swaged plates, both full and partial, especially where it is desired to make the plates of two or three thin layers, on account of the high melting point of the alloys which permits of thorough soldering of the laminæ without danger of burning. When used in conjunction with the other alloys in the series, these golds enable the operator to produce dentures far superior to those made from the golds ordinarily employed on account of increased strength, minimized bulk and perfect color harmony throughout the whole structure.

It should be borne in mind that high fusing golds, such as these, cannot be "sweated" advantageously. This is a characteristic of all gold alloys high in platinum metals, on account of the total absence of or minimum oxidation. The "sweating" of an alloy such as coin gold is facilitated by the fact that the high oxidation of the copper content helps to prevent the flow of areas not fluxed.

ALLOYS FOR PROSTHETIC CASTING

As has been previously stated, in order to cast sections of bridge work, saddles, partial plates, etc., it is essential to have alloys that are rigid in the cast form to obviate the necessity for increased bulk. Again, the value of the hardening properties of the alloying elements becomes apparent, as in the following:

Formula of Casting Gold "B"

	Per Cent
Gold	80.0
Platinum	9.5
Palladium	2.5
Silver	1.0
Copper	7.0
Total	100.0

Melting point, 1900 degs. F., 1035 degs. C.

We have here 7 per cent copper and a total of 12 per cent of the platinum metals which makes an alloy considerably harder than coin gold. When cast, this alloy is about midway in hardness between rolled coin gold and clasp metal. The melting point of this alloy is about 50 degs. F. below pure gold. It is intended for use with the nitrous oxide plow-pipe and should be melted with same, if a considerable quantity of gold is to be cast. Sufficient quantities for small castings can be melted with the ordinary blow-pipe. The copper content being comparatively low permits of the use of the nitrous-oxide blow-pipe without any material change or deterioration of the alloy, if a suitable reducing flux is used in connection with it.

This alloy corresponds in color with plates Nos. 1 and 2 and may be used to cast cusps or cusps and contours directly to bands of either plate No. 1 or plate No. 2. It makes a particularly suitable gold for cast occlusal surfaces on account of its hardness and durability.

The next formula is a modification of "B" and brings out an interesting point in connection with the effect of copper and the platinum metals on the decrease and increase of melting points.

Formula of Casting Gold "C"

	Per Cent
Gold	80.5
Platinum	6.5
Palladium	2.0
Silver	2.0
Copper	9.0
Total	100.0

Melting point, 1800 degs. F., 980 degs. C.

We note in this formula an increase of two parts of copper and a decrease of a total of 3.5 parts platinum and palladium, the consequence being that the melting point is dropped by the increase of copper and by the decrease of the platinum metals. The melting point is dropped about 100 degs. F. and brought down to approximately that of 22k. gold. This lowering of the melting point permits this alloy to be melted readily for large or small castings with an efficient illuminating gas and air blow-pipe. It is identical in strength, hardness, color, etc., with casting gold "B" except the fusing point and resistance to the nitrous-oxide blow-pipe flame. If the latter is used, precaution must be taken to use a reducing flux and not superheat the metal. This applies to coin gold, too, if same is cast. Excessive heat, if applied with the nitrous-oxide plow-pipe, and lack of a suitable reducing flux will permit the oxidation of considerable copper and the dissemination of oxide throughout the casting.

GOLD FOR INLAY CASTING

Since the introduction of the casting process, pure gold has been generally advocated for cast fillings, etc., on account of its supposed minimum shrinkage, softness and malleability and consequent ease with which the margins could be burnished to eliminate the cement line of an inlay.

A good many operators have failed to cast pure gold satisfactorily and claim that they can cast inlays with scrap gold and produce better and sharper margins. To those who have not experienced this difficulty it may appear very strange, but, nevertheless, it is a fact that alloyed gold, when properly alloyed, and under fair casting conditions, invariably casts with sharp, true margins, whereas pure gold has very often failed to accomplish the purpose, both at the hands of the author and many others.

It may be well to consider that the casting of scrap gold of indefinite composition is rather a hazardous and usually unsatisfactory procedure, and a great many operators recognizing that fact are using 22k. gold, coin gold, etc., with better results than they have been able to obtain with pure gold.

It is a well-known fact that pure platinum, pure palladium and pure silver absorb hydrogen, oxygen and other gases while in the molten state and retain some of the gases upon solidification. It is not generally known, but nevertheless true, that pure gold absorbs nitrogen, hydrogen and oxygen, and retains a considerable percentage of one or more of the absorbed gases upon solidification.* This tendency on the

* T. K. Rose (in Metallurgy of Gold), quoting Roberts-Austen.

part of the metals mentioned to absorb gases is minimized and sometimes entirely eliminated by alloying and a small percentage of copper, palladium or platinum will materially alter the behavior of pure gold upon solidification. Castings made with a slightly alloyed pure gold will be found to possess sharp margins and practically equal to pure gold in color, ductility and facility of burnishing, but comparatively free from cavities or blow-holes, such as are often found in the unalloyed gold castings.

A number of cases under observation have shown that fillings of slightly alloyed gold do not, after a period of wear, present the same pitted surface so characteristic of cast pure gold fillings under the same conditions.

The rounding of the margins in cast pure gold fillings is usually accompanied by a separation of the residue button from the casting, which takes place just prior to the completion of solidification. This occurs particularly when a comparatively large sprue is used and more especially when a large residue button is used at the same time. An explanation of this occurrence may reasonably be attributed to the following: If the sprue is quite large and the gold residue button large, the residue remains fluid for a considerable period of time after the casting pressure has been applied and there appears to be a tendency for the large button to draw to it the gold of the casting through the medium of the large gate (the sprue). A large button of gold very often draws only part of the sprue to it, thus separating the connection between the residue button and the casting and arresting the exercise of the casting pressure which would otherwise be transmitted from the button to the sprue and then to the casting proper. For those who wish to use pure gold for casting it is suggested that the quantity of gold used in the casting operation should not exceed more than three pennyweights above the amount actually required for the casting proper, and also that the sprue be no larger than 16 gauge B. and S. This will serve to lessen the area of connection between the casting and residue button so that this area (the sprue) may solidify more rapidly and in conjunction with the smaller button, which naturally freezes more rapidly, tend to prevent the separation previously discussed.

Another point that is well to consider is the fact that alloying of gold reduces the surface tension and cohesion of the molecules while in a molten state and increases the fluidity, thus facilitating the flow of the metal, requiring less pressure to force the gold into the mold, and consequently lessening the *danger of distorting the mold.* (See investment compounds for casting.)

Formula of Casting Gold "A"

	Per Cent
Gold	97.0
Platinum	1.5
Palladium	0.3
Silver	0.3
Copper	0.9
Total	100.0

Melting point, 1945 degs. F., 1063 degs. C.

This alloy makes an efficient substitute for pure gold, as the comparatively small amount of alloy does not harden the gold sufficiently to prevent burnishing, nor does it affect the color perceptibly. Copper is the most suitable agent for increasing the fluidity and the small percentage used does not materially harden the gold. The drop in melting point is compensated for by the platinum, and the small percentage of silver counteracts the coloring effect of the copper on the gold, the consequent alloy possessing practically the same melting point as pure gold and producing, almost invariably, *sound castings without the special precautions* which must be taken when pure gold is used.

This alloy will be found suitable for use in teeth close to others, with fillings or inlays made of pure gold, in order to maintain color harmony.

As all the alloys in the series, excepting the casting gold A and the elastic alloy described later, are practically of a uniform color and somewhat lighter (grayish red) and less conspicuous than pure gold or coin gold, it has been found advisable to also formulate an alloy for casting inlays to harmonize in color with the rest of the series.

Formula for Casting Gold "D"

	Per Cent
Gold	95.0
Palladium	3.3
Silver	0.4
Copper	1.3
Total	100.0

Melting point, 1945 degs. F., 1063 degs. C.

In this alloy, the palladium decolorizes the pure gold and raises the melting point. The copper brings it back to the pure gold standard and by the addition of the small percentage of silver to counteract the reddening effect of the copper a color effect is obtained in perfect harmony with the rest of the series.

This gold is quite soft and malleable and may be burnished with practically the same facility as pure gold. This question of burnishing margins of inlays is rather a more or less indefinite procedure. It is the author's opinion that very little effective burnishing (spinning) can be done on inlay margins and that only after the margins are stoned down to an extremely thin edge. Experience has shown that it is advisable to use hard and durable alloys for inlays, especially those intended to aid in supporting bridge work and then only when supplemented with posts or dowels.

This alloy D can be combined with B or C to obtain harder alloys, with no difficulty and no change in color, thus enabling the operator to obtain practically any degree of hardness for special requirements in inlay casting.

Section III

Clasp Metals

The alloys known as clasp metal, or platinized gold, as ordinarily obtainable, have been used, with poor results, for casting sections of bridge work, etc., and are being used to a large extent and with but mediocre results as a substitute for iridio-platinum for crown posts, dowels, etc. The ordinary clasp metal is also used to a considerable extent for posts or dowels in the construction of cast base crowns, with usually poor results on account of its brittleness, especially after it has been cast again. There appear to be about four distinct types of clasp metal obtainable at the supply houses.

The following formulæ are nearly exact and types one and two readily indicate the particular role that copper plays as a hardening agent.

Type one represents a class of clasp metals of which there are several on the market. They contain a trace of platinum, so that they may legally be called platinized gold, and a very high percentage of copper. The copper content confers a high degree of hardness and elasticity upon the alloy, but during subsequent heating (soldering and annealing) and working, the alloy softens considerably and loses a good deal of the original elasticity and sometimes becomes very brittle, especially when overheated.* As the melting point is quite low, soldering with even a comparatively low fusing solder is apt to endanger the integrity of the alloy more often than not.

FIG. 3

COMPOSITION OF CLASP METALS.

CONSTITUENT METALS.	Type 1*	Type 2*	Type 3*	Type 4**	"Elastic" Gold
GOLD	63	65	63	65	64
SILVER	14	15	17	6	1.5
COPPER	21	13	7	7	7.0
PLATINUM	2	7	13	18	11
PALLADIUM	....	....	....	4	16.5
COMPARATIVE MELTING POINT	1600°F 870°C	1725°F 940°C	1860°F 1015°C	1960°F 1070°C	2100°F 1150°C

*From analysis.
**Is known commercially as "high-fusing" clasp metal.

Type two represents a class of clasp metals which contain a larger percentage of platinum and less copper. This alloy, while not quite as elastic before annealing, retains its elasticity after annealing or soldering, better than type one, and makes a quite satisfactory material for clasps for vulcanite work, etc., if not excessively heated and otherwise abused.

Neither of the two alloys is suitable for work requiring repeated soldering operations. Posts or dowels made of these alloys and cast against usually show a partial fusion, and although this fusion is not always evident, the posts if cast against break away (at the junction) ultimately. These alloys are absolutely unfit for the making of split pins.

Type three offers a much better material. It contains still less copper and more platinum, but has not sufficient strength and elasticity. For want of a better material it has been used for the construction of split pins for a number of years. In addition, the fusing point, although higher than that of types one and two, is too low, and when attempting to solder the

* Gold-silver-copper alloys containing over 15 per cent copper are quite brittle, very non-uniform, and variable in behavior upon annealing.

solid portion of a split pin with coin gold, the metal is apt to fuse partly, becoming granular and brittle, and the finished pin is apt to give out in use. The type three clasp metal has been cast against with fair results, but the danger of burning it is imminent.

In the three types of clasp metals, under discussion, is demonstrated the value of copper and its superiority over platinum as a hardening agent and the value of platinum in raising the melting point lowered by the copper.

A number of experiments were made to improve the type three clasp metal and it can readily be seen from formula of type four how comparatively simple it was to do so, having established the properties of the binary alloys as a foundation. By raising the platinum to 18 points, the melting point and the elasticity were increased somewhat. Even at this stage the advance in melting point appeared insufficient, and, as it was deemed advisable to avoid more platinum on account of the danger of its not alloying uniformly, palladium, which alloys readily, was added and the melting point increased to a total of app. 100 degs. F. above type three. No more palladium was used on account of its decolorizing action. With the comparatively small content (4 per cent), the color of the alloy is still quite goldlike.

This alloy has been used with uniformly good results. It may be soldered safely with coin gold (for split pins) and may be cast against safely if a comparatively heavy gauge of wire (above 16 g. B. & S.) is used.

In view of the fact that for split pins, dowels for cast base crowns, etc., color is no object, it was deemed advisable to raise the melting point even above that of type four and the elastic gold was formulated, using a considerable percentage of palladium. The palladium, of course, decolorized the alloy completely, but raised the melting point very considerably, and, in conjunction with the copper and the considerable percentage of platinum, produced an elasticity even beyond that of type four and a melting point very considerably higher.

This alloy can be soldered with perfect safety with pure gold or anything below that in melting point. It may be cast against with perfect safety (except very thin wire) and retains its strength and elasticity after any reasonable number of soldering operations that it may necessarily be subjected to. *It may be soldered very readily and with better union than iridio platinum. It is much more rigid than ordinary iridio platinum and possesses elasticity that is prac-*

tically absent in all of the iridio platinum alloys, and it may therefore replace the latter and ordinary clasp metal for a great many purposes.

In the making of split posts of the elastic gold it is advisable to solder the area that is intended should remain solid with coin gold, as it offers a strong color contrast to the comparatively white elastic gold.

The line of demarkation between the solid and the split portions of the post will be then readily distinguished. As the coin gold is of sufficiently high melting point it will not reflow during later soldering operations.

The comparative hardness and the elasticity of the four types of clasp metals and the "elastic" gold is approximately as illustrated in the following:

Fig. 6

COMPARATIVE ELASTICITY AFTER ROLLING AND ANNEALING ONCE

Type One	Type Two	Type Three	Type Four	"Elastic" Gold
10	9	8	9+	10+

Fig. 7

COMPARATIVE LOSS OF ELASTICITY AFTER SOLDERING AND ANNEALING THREE TIMES

Type One	Type Two	Type Three	Type Four	"Elastic" Gold
2–3	1–2	1+	1	.5–1

Types one and two become very brittle if overheated during soldering. Type three is subject to same to a lesser degree, and type four only rarely. The "Elastic" gold appears practically immune to temperatures below the melting point of pure gold.

Clasp metal should always be annealed before use, as manufacturers often neglect to do so after the rolling or drawing operations.

Section IV

Gold Solders

In order to obtain the desirable uniformity of color in a denture without subsequent gold "washing," it was necessary to formulate solders to correspond in color with the other alloys. Incidentally, it is well to consider the imposition that has been practiced upon the profession by some of the unscrupulous manufacturers of gold solders.

For many years a great many in the profession have been under the impression that gold solders stamped 18k. were actually 18k. (75 per cent gold) in fineness. This was not so, and a number of the manufacturers were producing, and are still producing, solders marked 18k., etc., anywhere from two to six karats below the mark. In addition, the solders mentioned are not only deficient in gold content, but contain many deleterious alloying elements, such as high percentages of cadmium, iron, etc., in order to complete the required total content of metals in the solders.

On the other hand, the reputable manufacturers have consistently stated that their solders were approximately two karats below the mark and intended for use on that karat of plate. The reputable manufacturers have recently started to stamp the actual fineness on their solders and the others have followed suit; but some manufacturers still persist in the practice of misrepresentation by not actually furnishing the gold content indicated by the fineness stamp on the product.

ALLOYS OF GOLD WITH METALS IN GROUP 3

Besides zinc, the other three metals in Group 3, namely, cadmium, tin and aluminum, are being used to a very large extent as alloying elements in making gold solders. Cadmium if used in large percentages, debases the alloy very considerably and renders it practically unfit for use in the mouth.

Tin is also used to a considerable extent, as it lowers the melting point of gold very considerably, but it renders the gold quite brittle and aids materially in the tendency of the solder to burn into the work, which property is characteristic of all the so-called easy flowing solders. The term "easy flowing" is undoubtedly a misnomer. Rather, these solders melt "easy," but do not flow easy. They ball up and stick and if the heat is forced to induce flow, they burn into the work with consequences too well known to require further discussion.

The value of aluminum as a constituent of gold solders is yet to be proven. It is a constituent of most of the patent commercial alloys used by jewelers in compounding their solders.

Solders made according to the following formulæ will be found satisfactory in color, strength and fusing point, although higher in fusing point than the so-called easy flowing solders for which there seems to be a "popular" demand. They will be found to flow readily if the work on which they are to be used is brought up to the proper temperature.

FORMULÆ FOR GOLD SOLDERS

SOLDER No. 84

M. P. 1650° F, 900° C..	Gold	84.0%	20	Karat fine.
	Copper	7.5%		
	Silver	5.5%		
	Zinc	3.0%		

SOLDER No. 76

M. P. 1550° F, 840° C..	Gold	76.0%	18	Karat fine.
	Copper	11.5%		
	Silver	8.5%		
	Zinc	4.0%		

SOLDER No. 68

M. P. 1450° F, 785° C..	Gold	68.0%	16½	Karat fine.
	Copper	14.5%		
	Silver	12.5%		
	Zinc	5.0%		

The first and second, 84 and 76, will be found sufficiently low in melting point for all ordinary operations, and where Dr. Peeso recommends the use of his No. 21 and No. 19 solder. The number 68 solder, although higher in actual gold content than the best so-called 18k. solder obtainable, is still too low a grade to be used in general work, especially in fixed bridge work, but may be used in connection with removable bridge work or plate work, because in that work or repair work there is required at times a lower fusing solder.

Section V

Compounding of Gold Alloys

Although the new series of alloys, made with practically no deviation from the formulæ which are given herein, may be purchased from the supply houses, the author considers it well to give a number of directions to those who may desire to compound the various alloys.

It is not practical to make a small quantity, especially if for plate gold or solder, which is to be poured into an ingot mold and rolled. The higher the melting point of the alloy, the more necessary it is to have a comparatively large quantity and it is well not to attempt less than five ounces for plate gold and three ounces for solder. The elastic alloy should be made in even larger quantity, as it freezes very rapidly.

It is practically impossible to alloy platinum or palladium with gold in the small blast furnace which the practitioner is likely to have in his laboratory. For all alloys with platinum metals (made on the small scale previously mentioned) it is well to alloy the gold and the platinum metals (rolled very thin) first on a charcoal block, using the nitrous oxide and illuminating gas blow-pipe, or preferably the oxygen and illuminating gas blow-pipe. A number of the alloyed nuggets can then be placed in a crucible on top of the required silver and copper content, covered with a suitable reducing flux and melted, poured into an ingot mold and rolled or drawn.

When copper is to be used, it is essential that same be chemically pure and especial precaution must be exercised to prevent oxidation as far as possible, which latter can be accomplished by the use of a strong reducing flux. (See under fluxes.)

A slight excess of copper should always be added to allow for some loss which invariably occurs.

If the alloy that it is intended to make is to be used for casting purposes, the procedure is the same as previously described, excepting that the metal, when properly molten, can be poured into a pail of water and thus granulated. This procedure saves the labor of rolling the ingot and the granulated form of gold is as convenient to use for casting as any other.

In all cases, just before pouring the contents, the crucible should be well shaken to insure a thorough admixture of the metals.

Some writers advocate the preparation of alloys for casting in the following manner: Melt the gold, feed the platinum (very thin) into the molten gold and then add copper, etc. It is impossible to make a uniform alloy in this manner, especially if copper is used, because a considerable amount of the copper is oxidized on account of direct contact with the blow-pipe flame and in the author's hands the directions previously given have been found to work out admirably.

In compounding solders where zinc and copper are the constituents it has been advocated that brass which contains copper and zinc be used in order to prevent the loss of zinc through oxidation and volatilization. This is a very dangerous practice and the results are very unsatisfactory, because it is impossible to obtain a commercial brass that does not contain a considerable percentage of lead, tin, and traces of antimony, etc., which are all very harmful substances and invariably tend to make the solders brittle. It is therefore necessary to first make an alloy of chemically pure zinc and chemically pure copper in a proportion of, say, one part zinc and two parts copper. This alloy, when properly melted, is granulated by pouring into water and then, if carefully gathered, dried and weighed, the loss of zinc can be determined. The necessary additional copper to make the required alloy is then calculated and added when compounding the solder.

It is well, of course, to make a considerable quantity of the copper zinc alloy, as the cost is slight and the prepared alloy is then available when wanted. It has been stated that zinc volatilates very readily from solders. This is quite contrary to the author's findings. The small percentage of zinc as given in the formulas herein is quite stable after remelting several times. The authors who claim this strong volatilization of zinc may have been dealing with a solder of unknown constitution in which they suspected zinc, but which probably contained a high percentage of cadmium, which volatilates quite readily.

SECTION VI

REFRACTORY MATERIALS

INVESTMENT COMPOUNDS FOR SOLDERING

The normal contraction of gold from the molten to solid state is approximately 2 per cent. The contraction of gold solder is practically the same, although some of the constituents have a higher contraction than gold, but when combined in an alloy the movement is practically the same.

While possibly there may be a slight difference between the contraction of solder and gold, a considerable contraction occurs nevertheless and is the cause of a great deal of trouble.

A number of soldering investment compounds on the market are claimed by the manufacturers to possess *neither expansion nor contraction and therefore perfect.* Granting, for the sake of the argument, that such is the case, we still have the contraction of solder to contend with and how are we to produce a soldered bridge or denture that will fit and go into place accurately when a number of the units in the work have been drawn together by the contraction of the solder?

Unfortunately, we have not merely the contraction of the solder to contend with, but we have a much more prolific cause of disaster. For example, we have a number of completed sections, such as castings, to join together where but a very small quantity of solder is to be used, and yet after soldering we find that the finished piece is contracted and distorted and will not go into position. The fact of the matter is, that practically all the commercial compounds shrink upon heating when brought up to the proper temperature for soldering.

In some commercial investment compounds, the shrinkage is extremely high, fully six or seven per cent, so it is evident that the principal cause of the trouble lies not so much in the actual contraction of the solder as it does in the great contraction of the average investment, even before the case is quite hot enough to apply the solder.*

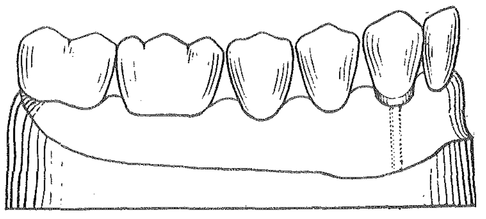


Fig. 968

Fig. 968 shows an ordinary simple bridge assembled and ready for investment. The porcelain facings are spaced as

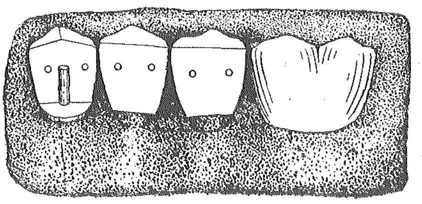


Fig. 969

per instructions from time immemorial. Fig. 969 shows the case invested and the distinct spacing of the backings.

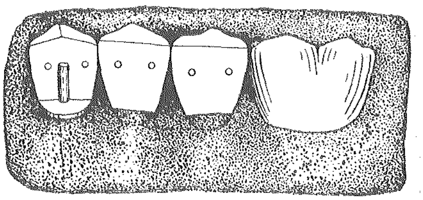


Fig. 970

The case is then heated, and if an examination of the investment is made with a magnifying glass, just before placing it on the soldering block, it will be noticed that the *units have been drawn together,* as in Fig. 970, and when the case

* See papers of J. G. Lane in Dental Cosmos and Dental Digest, 1910-14. Also M. A. Ward in Dental Cosmos. These contributions are very interesting and the most valuable that have appeared pertaining to the subject.

is soldered and cooled, the facings are very apt to be checked on account of having been brought together into very strong contact.

When attempting to place back on the cast, difficulty is encountered, but as the plaster yields, the bridge is forced

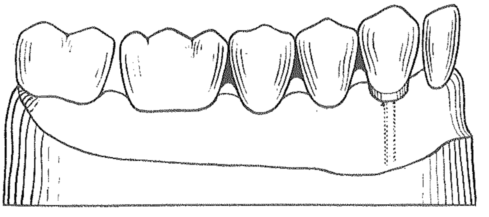


Fig. 971

down and then becomes evident the loss of the contact points, as illustrated in Fig. 971.

This discrepancy will not be considered by some operators as a serious factor. In fact, those who solder directly on the cast destroy the evidence for the time being. If it is a fixed bridge, it is forced home some way or other and let go at that, but, on the other hand, if a removable bridge, even as small in dimension as the one illustrated, it is practically impossible to place it in position and the matter is a most serious one, as a good many operators have found.

Some writers advocate completing the dummies and then placing them in perfect contact to prevent the shrinkage of the solder used to unite the sections. This is practically impossible, because the metallic units are infinitely stronger than

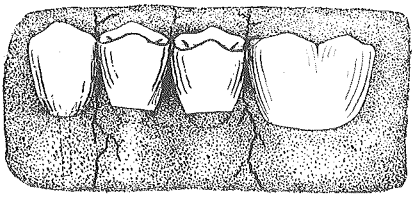


Fig. 972

the investment and expanding under heat will invariably split the investment (see Fig. 972), and thus often cause a serious distortion in the soldered piece.

There seems to have been, as a search of the literature has shown, absolutely no consideration given to the movement of the refractory mass that holds the parts in situ during the preliminary heating and final soldering operations.

The author's aim in experimenting has been not merely to produce an investment compound that would not shrink, but one that would *actually expand,* move in unison with the solid invested metal, and *spread the units* sufficiently so that when a reasonable amount of solder is flowed to connect the units, the *contraction of the total piece would be neutralized by the expansion of the investment.*

Before attempting to formulate an investment compound possessing such properties, it is necessary to consider the chemical and physical properties of refractory materials which may be employed in the compounding of investment materials.

In one of the well-known books on crown and bridge work,* the following appears.

> "Many substances may be used in combination with plaster of paris, which is necessarily the basis because imparting the property of crystallization, and which must be incorporated to the extent of at least 50%.
>
> "The remaining proportion may be then composed of such materials as will, by virtue of their characteristics and physical properties, meet such requirements. The following are serviceable:
>
> Powdered Silex, Pulverized Pipe Clay,
> Fine Asbestos, Powdered Fire Brick,
> Beach Sand, Magnesium Oxide,
> Marble Dust, Pumice Stone.
>
> "A combination of any of these ingredients in varying proportions with the proper quantity of plaster will usually possess the necessary qualities, etc., etc."

Before even considering a compound of *expanding properties,* it is well to thoroughly understand the properties of plaster of paris and the other materials enumerated in the list of suitable refractories in order to see if it is possible to even produce an investment compound that will *at least not shrink* under heat.

PLASTER OF PARIS

Plaster of paris, $Ca\ SO_4$ (calcium sulphate), is made by burning gypsum rock. In the process of burning, most of the water is driven off. The phenomena of recombining with water and crystallizing is well known and need not be discussed here. It is universally employed as the binder for all investment compounds used both for soldering and casting. It *shrinks very strongly upon heating,* but for want of a better material must be employed.

The *more plaster* used in an investment compound, the harder the resultant mass will be and the *more shrinkage* will take place. As will be shown subsequently, any *such proportion as the 50 per cent mentioned by the author quoted is abso-*

* Goslee's Principles and Practice of Crown and Bridge Work, pp. 36-37.

lutely out of question, because it has been found, so far, impossible to compensate for this contraction of the binder by the addition of any other material, even if possessing the property of expansion.

POWDERED SILEX

Silex is the commercial term applied to silicon dioxide ($Si O_2$), which is the main constituent of rocks, stones, clays and many other minerals. A great deal of it is also found in a free state and in the form of quartz, rock crystal, flint, opal, chalcedony, etc. The so-called silex is often practically pure $Si O_2$. However, different varieties of silicon dioxide exist, and although all of a similar chemical composition they possess varying physical properties.

Silica obtained from quartz or rock crystal consists of sharp crystalline particles and possesses a high specific gravity, 2.6 to 2.8. It expands considerably upon heating, but loses this property gradually upon reheating frequently or fusing completely.* The melting point of pure silica is approximately 3,200 degs. F.

Another variety of silica that exists quite as frequently as the crystalline is an amorphous form which possesses a lower specific gravity, 2.2 to 2.4. It has very little expansion upon heating and some varieties of the same type do not expand at all.**

Still a third variety exists in a tabular form and is extremely light and porous. It is known as diatomaceous earth or kieselguhr. Its specific gravity is 1.6 to 1.8. It is mined in very great quantities and used very extensively as a heat insulating agent, but contracts very strongly and therefore is totally unfit for use as part of a dental refractory compound.

As stated before, these various forms of silica can be obtained in almost a pure state and are alike chemically, but the term "powdered silex" means nothing unless a particular type is specified, and the individual who is not conversant with the matter is as likely as not to purchase and use a grade of least expansion. *The crystalline variety, of high*

* Utensils made of fused silica are replacing platinum ware to a great extent in chemical work. As the coefficient expansion is very small (.00000054 per ° C), it is possible to subject crucibles, casseroles, etc., to rapid changes of temperature without danger of breakage. Apparatus suitable for dental purposes is manufactured by the Thermal Syndicate, Ltd., of New York.

** Both surface and volume expansion of silica must be considered in selecting the grades of silica to be used.

specific gravity, expands considerably under heat, and in this fact lies the solution of the whole problem.

A mixture of 50 per cent plaster of paris and 50 per cent silica, even if the latter is of the variety possessing the highest expanding properties, contracts very considerably when brought up to the temperature required for soldering or casting operations.

In order to be brief, the author will state that *all the other items in the list of suitable materials have a positive shrinkage,* with the exception of beach sand. The objection to the latter is the fact that it is often quite impure and the iron and alkalies that form the major portion of the impurities usually act as a flux and thus lower the melting point.

It is well to state that magnesium oxide and marble dust, which latter is, of course, calcium carbonate, are subject to a particularly strong contraction under heat.

Fig. 973 illustrates the comparative shrinkage of one of the best commercial compounds obtainable. A considerable space

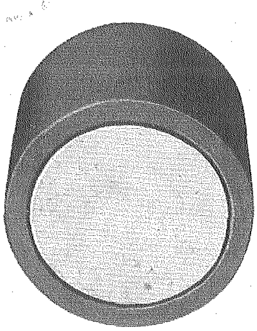


Fig. 973

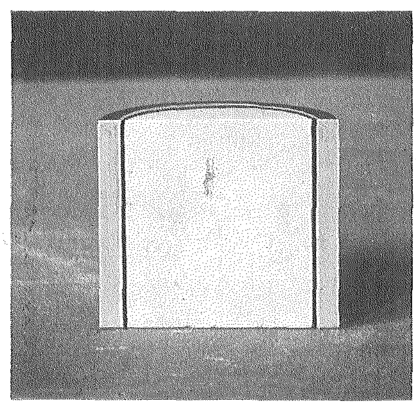


Fig. 974

will be noted between the mass of investment and the rim of the metallic ring in which it was placed after mixing, permitted to set and heated to soldering temperature.

Fig. 974 (in cross-section) shows even more clearly the contraction, after heating, when a straight edge is placed across the top of the flask.

To summarize the whole proposition, the author will state that *in order to produce an investment compound that merely does not shrink, but actually expands sufficiently to follow the movement of a red hot ring, that it is necessary to use a grade of silica as pure as possible and of the highest expansion,* *which means, of course, a grade silica from the quartz group and a grade of plaster of paris of the least contraction.** *As previously mentioned, any such proportion as 50 per cent plaster cannot be used, because the expansion of the best silica, great as it is, is not sufficient to compensate for even the shrinkage of the plaster, hence a lower percentage of plaster and a higher percentage of silica must be used.*

Formula for Investment Compound (Soldering)

		Per Cent
Plaster of paris (Excelsior Brand No. 3)	Parts	33
Silica (fine) (F. F. F.)	Parts	45
Silica (coarser) (M. C.)	Parts	22
Total		100

A compound made according to this formula will be found to expand upon heating to soldering temperature sufficiently to fill a red hot ring, as in Figs. 975 and 976.

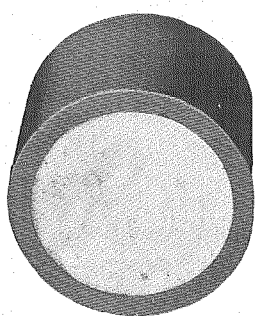


Fig. 975

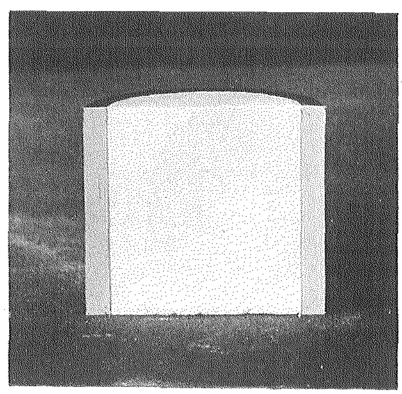


Fig. 976

This property of expansion is sufficient to *counteract the contraction of a normal bulk of solder.* Furthermore, this expansion is sufficient to *follow the movement of invested metallic sections that have been previously completed.* This compound sets promptly and is sufficiently strong to hold the invested parts in situ firmly. It will withstand the action of boiling water (when washing out the wax) without disintegration.

* It is, no doubt, well known that fine plaster contracts more than coarse plaster when subjected to heat. Most of the coarse building plasters are rather non-uniform and do not possess the binding power of the finer plasters. The grade selected is quite uniform and not too coarse to prevent efficient binding of the mass.

Dr. Peeso has long ago demonstrated the great importance of not soldering work directly on the cast. The work should be so assembled that the waxed up structure could be lifted off the cast, which is made of plaster of paris or a more durable material, such as "Artificial Stone" (made from the author's formula) and then transferred to the investment compound. After soldering, the work could be placed back on the cast, which is intact, and required corrections could be made by grinding or trimming where necessary before the structure is even tried in the mouth.

Of course, the author has made numerous and exhaustive experiments to determine the properties and behavior of various refractory materials and it is important that the grades of silica and plaster specified be used.

As the reader can deduct from the preceding, the terms silica and plaster of paris mean very little, because while the different grades of silica are practically alike chemically, they differ very materially physically. To the author's knowledge it is possible to purchase at least three or four hundred different brands of plaster and over a thousand distinct grades of silica with varying percentages of impurities and varying sizes of particles.* There is no intention to claim that this is the last word on the subject. No doubt, other experimenters will succeed in producing as good or even a better compound with other grades of material.

INVESTMENT COMPOUNDS FOR CASTING

The elements of error caused by the physical behavior of the metallic alloys and the refractory materials utilized in the casting process are quite analogous to the conditions that exist in the soldering process. Gold, no matter how alloyed, as far as present knowledge of the subject indicates, *does contract* in the transition from the fluid or plastic state to the solid or frozen state, and an inlay investment compound that possesses the property of expansion will at least in a measure compensate for the contraction of gold.

It is not the author's aim here to exhaustively discuss casting problems in general. He simply wishes to suggest a

* The materials used in the formulæ given were obtained from W. B. Daniels, 252 Front street, New York City, who is a dealer in minerals and chemicals. He will supply the ingredients for both the soldering and casting compounds in quantities suitable for the requirements of the practitioner. Of course, it must be remembered that such comparatively cheap materials are, as a rule, sold by the ton or carload. Hence, Mr. Daniels' willingness to furnish these materials in small quantities at a moderate price deserves commendation.

formula for what he considers a better investment compound than is purchaseable and to point out some of the physical phenomena of existing conditions. Before discussing the formula, it is well to first consider some of the conditions that have to be dealt with. We have not only the contraction of gold to contend with, but we also have the contraction of the wax, and that is a most serious factor indeed. *The contraction of wax is usually productive of a greater degree of error than the actual contraction of gold.*

This subject has been covered most thoroughly by Dr. C. S. Van Horn of Bloomsburg, Pa., in his articles in the Dental Cosmos,* and his conclusions are yet to be controverted.

The conditions which he successfully corrects are the following: *After the removal of a wax pattern from the mouth at body temperature, it contracts considerably upon reaching room temperature and still more when invested with cold water.* His method consists of *investing the pattern at approximately 110 degs. F.*, which increase in temperature not merely compensates for the contraction of the wax, but also expands the wax to *almost completely counteract the shrinkage of the gold.*

In addition, he uses an expanding investment (made from the author's formula) and the total expansion of the wax, coupled with the expansion of the investment, enables Dr. Van Horn to produce the most accurate fitting inlays the author has ever seen.

A study of Dr. Van Horn's technique will amply repay anyone who is desirous of obtaining better results.

Dr. James G. Lane of Philadelphia was among the first to point out the value of silica as an ingredient of inlay investment compounds, on account of its expansion and consequent ability to counteract the contraction of plaster of paris (the binder). The formula that he used (plaster 25 per cent and silica 75 per cent) expands considerably. Dr. Lane was also among the first to point out the fact that a hot mold was stronger than one that was heated and allowed to cool.

In the utilization of the casting process, there are a great many important factors to be considered, among them *the fusing point of the investment compound which constitutes the mold; the relation of this degree of fusibility to the temperature of the mold at the time the molten metal enters it; the temperature of the molten metal at the time it enters the mold and the pressure used to force the molten metal into the mold.*

* 1911, pp. 664, 472, 1109; 1912, pp. 890, 973; 1914, p. 940.

The fusing point of an investment compound, made of plaster of paris and pure silica, is under 3000 degs. F. Some of the commercial investment compounds, which are made with impure silica containing a considerable percentage of iron and feldspar, which latter contains alkalines, such as sodium and potassium, are often considerably lower fusing, consequently when superheated gold is cast into such a comparatively fusible investment a partial union is bound to take place, with the consequence that the gold partly unites with the investment and the resultant casting is quite rough and inaccurate.

The strong possibility of such a condition as described leads the author to state his opinion on that apparently never ending controversy regarding the casting of gold in a *hot or cold flask*. This point has been argued time and time again, some operators claiming that they obtain better results by casting into a hot flask and others maintaining the reverse. In order to discuss the subject intelligently, we must also bear in mind the degree of heat that is utilized for melting the metal to prepare for its entrance into the mold.

Let us first consider the following:

HOT OR COLD MOLD — USING ILLUMINATING GAS AND COMPRESSED AIR BLOW-PIPE

We will discuss this phase first, because the great majority of castings are accomplished by using the ordinary gas and air blow-pipe. The maximum temperature that it is possible to produce with artificial gas and compressed air is approximately 2450 degs. F. The temperature of the investment in the casting ring when red hot is about 1300 degs. F. If this ''red hot'' flask is placed on the casting apparatus and a quantity of gold, say, 5 dwts., placed in the crucible, it will take about two and a half minutes' exposure to an efficient blowpipe flame to bring the gold to the proper state of fluidity to enter the mold. In the meantime, the ''red hot'' mold (on the casting apparatus) has cooled considerably and the actual temperature of the cavity in the mold at the time the gold enters it can be safely calculated not to exceed 900 degs. F. Therefore, casting into a ''red hot'' flask with an ordinary gas and air blow-pipe is done with the mold not red hot, but at a temperature approximately 900 degs. F.

In casting into a so-called ''cold'' flask, using the same blow-pipe and quantity of metal, it will be found that it takes longer, say four minutes, to bring the metal into a state of fluidity, and although the flask is at room temperature when the process of melting the gold is started, the subjection of the mold to the flame of the efficient blow-pipe for a period of approximately four minutes raises the temperature of the mold to an extent of nearly 700 degs. F. Therefore, when it is attempted to make a casting with the ordinary gas and air blow-pipe in a so-called ''cold'' flask, the temperature of the mold at the time the gold enters it is approximately 700 degs. F.

Upon considering both conditions and comparing the temperatures of the molds, namely, 900 degs. and 700 degs., it will be readily seen that there is *comparatively little difference between the two* at the actual time that the casting is done, and consequently both the ''hot mold'' and cold mold'' advocates are right, strange as that may appear, providing, of course, that the ordinary gas and air blow-pipe is employed.

The author's experiments along this line have shown conclusively that it is hardly possible to superheat the gold with an ordinary gas and air blow-pipe or bring the gold to such a temperature that it will unite with the investment at any stage of the procedure, and it is the author's firm opinion that in the hands of the careless or inexperienced operator, the *ordinary gas and air blow-pipe is a positive insurance against superheating* the gold, and therefore insures a casting satisfactory, at least as far as errors consequent to the superheating of gold are concerned.

HOT OR COLD MOLD — USING ILLUMINATING GAS AND NITROUS OXIDE OR OXYGEN BLOW-PIPE

Here we have a totally different and quite often a dangerous condition to contend with. While the ordinary gas and air blow-pipe is capable of producing temperatures only somewhat beyond 2400 degs. F., it is possible to obtain, without difficulty, 3400 to 3500 degs. F. from nitrous oxide and illuminating gas and over 4000 degs. F. from pure oxygen and illuminating gas. It may be well at this time to call attention to the fact that the often used term ''Oxyhydrogen'' is incorrect when used in connection with illuminating gas because of the fact that in order to produce an oxyhydrogen flame it is necessary to have both oxygen gas and hydrogen gas, whereas ordinary illuminating gas contains less than half of its volume of hydrogen and the balance is principally methane (carbon, etc.).

It is rather difficult to avoid superheating gold when applying such extreme temperatures and extreme caution must be exercised by the operator.

As a rule, the cold flask is indicated when using extreme temperatures for melting the gold, because the gold melts very rapidly (15 to 20 seconds), and comparatively little heat is transmitted to the mold. The mold is then comparatively cool, and even if somewhat superheated gold is cast it is not so apt to unite with the investment as when both the gold and the mold are superheated.

The author has very often made failures of castings on account of superheating the gold and he wishes to impress strongly the fact that extreme caution must be exercised in this connection.

The nitrous oxide or oxygen and gas blow-pipe offers advantages over the ordinary gas and air blow-pipe as a means of producing heat rapidly, but the maximum temperature attainable with the ordinary gas and air blow-pipe acts as a sort of an insurance against superheating and, in fact, if efficiently used, produces satisfactory casting results in all ordinary operations.

One of the most prolific causes, in fact, probably the greatest cause that is productive of faulty castings, is the excessive pressure used in forcing metal into the mold. The principal reason for this is due to the fact that in the majority of casting apparatus, there is no provision for obtaining a definitely measured and indicated amount of force. It takes just so much and no more pressure to force gold into a given mold and hold it there until solidification begins. Excessive pressure will not, under ordinary conditions, prevent the normal contraction of gold, because the *mold into which the gold is cast yields and hence will distort in the same proportion as excessive pressure is applied.* It may be true that a pressure *of 2,000 pounds per square inch may totally prevent contraction, but where is the mold that will stand that pressure?*

It is unfortunate that more operators do not realize the true value of an efficient casting apparatus, such as the Taggart, and the false economy resulting from the use of an intrinsically faulty or makeshift device.

By using a grade of silica of *maximum expansion* and a grade of plaster of *minimum contraction,* it is possible to produce an investment compound as follows:

Formula for Investment (Casting)

Plaster (Excelsior Brand No. 3)	Parts	29
Silica (Fine) (F. F. W.)	Parts	71
Total		100

The plaster is the same as is used in the soldering investment. The silica is similar to the fine grade utilized in the soldering investment formula, but it is purified and combines with water readily without releasing dirt, scum, etc.,* and consequent bubbles. An investment made from this formula will be found to expand slightly more than Dr. Lane's formula, although the plaster of paris content is higher and, for the same reason, somewhat stronger and more resistant to excessive pressure.

COMPOUNDING OF INVESTMENT MATERIALS

It is a well-known fact that very few commercial investment compounds are uniform in composition. In other words, although manufacturers claim that their formulæ are adhered to, there appear variations in batches purchased at different times. This is due to the fact that insufficient attention is paid to testing the different batches of raw material and also to the faulty compounding due to the large quantities mixed at a time. One commercial preparation has been found, on the contrary, quite uniform, for the simple reason that the manufacturer pays especial attention to the testing of the raw materials and compounds the mixture in comparatively small quantities (200 to 300 lbs. to the mix).

In mixing the plaster of paris and silica, it is not necessary to do any sifting, because the specified materials may be obtained evenly and definitely graded. All that is required is a *thorough mixture without excessive trituration.*

A very efficient small mixing apparatus may be obtained from J. H. Day Co., Cincinnati, Ohio. It is known as the "Hunter" (experimental size) and will handle from seven to eight pounds of material. The ingredients are weighed out, placed in the container and the apparatus revolved slowly for 25 to 30 minutes. This produces a uniform and intimate mixture without crushing or grinding the plaster. This point is very important, and if smaller quantities are mixed in a mortar, it is important to use very light pressure in order not

* Bubbles and froth produced upon attempting to combine investment compound and water are often caused by dirt or such impurities as mica, etc., contained in the silica.

to crush the plaster particles. The mixed material, of course, should be properly stored and protected against moisture.

INVESTMENTS, DIRECTIONS FOR USE

The soldering investment should be mixed quite thick. The thicker, the better, up to a certain limit, of course. If mixed too dry, the plaster of paris content does not obtain sufficient moisture to crystallize properly and act efficiently. A good consistency is 41 to 42 grammes powder to each 15 c.c. water, or 26 dwts. (Troy) to one-half fluid oz. water.

The inlay investment should be mixed in a proportion of 32 grammes powder to 15 c.c. water, or 20 dwts. (1 Troy oz.) powder to ½ fluid oz. water. This quantity is sufficient to fill an ordinary inlay flask.

These proportions produce a mixture that allows ample time for manipulation, provided considerable time is not spent in adding a little more water, a little more powder, etc. *The setting time of the plaster naturally controls the setting time of the whole mixture, and as the action of retarding agents added to control the set of plaster is sometimes indefinite and often harmful, it is advisable not to attempt to interfere with the normal setting time of the plaster.*

The compound, if mixed without any unnecessary delay, sets sufficiently slow for all ordinary operations. It is the author's practice to have on hand a number of cork-stoppered bottles containing the dry compound (weighed) and a number of rubber-stoppered vials containing water (measured). The accurately measured powder and water are thrown simultaneously into the mixing bowl and having no bubbles or froth (as with graphite compounds*) to contend with, the mix can be made ready for use in from 30 to 40 seconds, thus allowing ample time for coating the pattern and imbedding in flask. This method is superior to using the automatic weighing apparatus furnished by some of the compound manufacturers, as they are often either inaccurate or not sufficiently "flexible."

It is not advisable to attempt to invest more than one pattern at a time. When a larger mix is to be made for a

* Most of the compounds that contain flake graphite are very difficult to mix on account of the air content in the flakes and their tendency to "float." Such a compound requires a considerable period of time to mix, and therefore a retarded plaster is usually employed. Nodules, or "ghosts," on castings occur frequently because the material is not "dormant" until "set." A manufacturer of such a compound claims that it is the plaster and not the graphite that causes the bubbles. This statement appears quite contrary to the facts. Kerr's "Graphite" Investment is made with previously treated graphite and it is the best commercial preparation that the author knows of.

larger flask, three to five per cent more powder than a given quantity of water demands is not only permissible, but advisable.

Another advantage in using measured and stored water lies in the fact that it is, when used, at room temperature and not at hydrant temperature, and the *room temperature water does not induce a further contraction of the wax* pattern during the process of investing.

HEATING OF INVESTMENTS

The soldering investment may be heated quite promptly upon setting. Boiling water does not affect it materially and the wax may be washed out thoroughly, the case fluxed and immediately placed on the heat, moderate at first and then brought up quite rapidly to a good red heat prior to the actual soldering operation.

It is the inefficient and insufficient heating of the invested work that is partly to blame for the "popular" demand for "easy flowing" solders. Properly heated investments facilitate the flow of normal or even high fusing solder.

A small quantity of potassium sulphate or sodium chloride may be used to hasten the setting of the investment, but that is rarely, if ever, necessary, because it sets quite promptly if mixed to the proper consistency.

The inlay investment should be permitted to set for at least thirty minutes to insure a fair crystallization (so-called "initial set") of the plaster. The flask should then be placed over a low heat and kept there until the moisture disappears and the wax begins to diffuse and carbonize. The heat is increased somewhat during the latter part of this operation and still further increased until the mold is brought up to either a dull red heat (for cold mold) or a bright red heat (for hot mold).

The initial stages of heating must be a temperature that will not permit the wax to run out of the mold, as it is important that the wax be absorbed in the mold. Forced heating and a generation of steam during the initial stages of the drying process will force the wax out of the mold and produce a rough interior which in turn will show its effects upon the casting, the resultant casting being rough, incorrect, and usually unfit for use. It is, of course, essential to confine and concentrate the (higher) heat in order to bring the mold to the proper temperature within a reasonable period of time.

Prolonged heating of the investment is even more dangerous than underheating, as plaster of paris, which is the binder, *shrinks in proportion to the time that it is exposed to heat.* The total heating operation for an ordinary mold (inlay, etc.) should not exceed fifty minutes, or an hour at most. It may be divided into three periods, say twenty-five to thirty minutes for low drying heat, then increased somewhat for ten to fifteen minutes, and finally subjected to the highest heat for not more than from ten to fifteen minutes.

It is permissible not to heat a case until two or three hours after the investment has been mixed, but if it is permitted to stand for a day or two and loses all moisture, if then heated and cast, the resultant casting is apt to be very poor. It is hard to determine the actual principle involved, and it is not important to do so, but the fact does exist. In addition, under such conditions, the investment is very apt to crack or split upon heating. The author usually heats and casts into "green" molds, but has found that a dry mold, if moistened prior to heating, appears to behave almost as well as a "green" mold. If the mold is only a few hours old it is moistened slightly, but if it is more than a day old it is placed in water until saturated to the extent of a "green" mold.

Both the soldering and casting investment compounds are practically immune to "checking" or "cracking" even under the most severe heating conditions.*

Section VII

Fluxes

FLUXES FOR SOLDERING AND CASTING

For sweating, soldering or melting metals in the construction of bands, crowns, bridges or castings, the selection and use of the proper flux or fluxes is a matter of the utmost importance, especially if the metals or alloys used are oxidizable or volatile when subjected to heat.

Ordinary borax, or calcined borax, has been the principal flux used for this purpose. It has been almost universally used by jewelers and the dentist has followed suit. There is,

* This fault is inherent in most investment compounds; the causes are numerous and principally due to the producers ignoring the physical laws governing the selection and compounding of materials for the purpose. One of the principal errors in this connection is the attempt to form a "concrete-like" mass without realizing that there is a very great difference in the behavior of dental investment compounds and concrete used in building operations.

however, a considerable difference between the class of work that the jeweler and the dentist perform.

In dental soldering, we use higher grade solders and a considerably higher heat, during the various operations. As ordinary borax melts at a comparatively low temperature, it does not act as efficiently during the higher temperature stages as the requirements demand. The tendency of borax when considerable heat is applied is to liquefy strongly and run down to the deep portions, leaving the other portions, that it is desired to solder, insufficiently protected. Dr. Peeso recognized this long ago by using a combination of borax and boric acid, which combination melts at a higher temperature than borax alone, does not liquefy so readily, stays on the surface and protects the work longer and is more efficient in every way.

An efficient flux that has served very satisfactorily in the author's hands for a considerable period of time is the following:

Formula for Soldering Flux

C. P. Borax Glass (fused)	Parts	55
C. P. Boric Acid (not fused)	Parts	35
C. P. Silica	Parts	10
Total		100

The ingredients are placed in a clean clay or sand crucible and brought to a fair red heat. They combine quite readily and when quite fluid the mixture is poured into cold water. As this glass is quite soluble, it must be removed from the water as soon as possible, dried and pulverized to pass an 80-mesh sieve. It may be pulverized without difficulty, as the particles are very frail and brittle.

This flux may be used either in the powdered form or compounded with "*vaseline*," to form a paste, or dissolved in boiling water and the saturated solution used. In the liquid form, it will be found suitable for all general operations where the work can be heated so as to drive off the moisture and thus leave a coating of the flux, as in bands, crowns, etc. When the work is in an investment, the grease flux will be found most useful, as it may be applied just after the case is washed out and still warm. The carrier (vaseline) flows down into the deep portions and crevices, carrying the particles of flux along. The powdered dry flux can be used on invested work under the blow-pipe when more flux is required. Strips of solder can, of course, be coated with either the liquid or the grease flux and heated prior to use.

This soldering flux in a powdered form will also be used as the base for both the reducing and oxidizing fluxes to be discussed.

It is important that the forms of borax and boric acid specified be adhered to because of the variable amount of water that these materials contain when purchased.

The formula of borax glass is $Na_2B_4O_7$, whereas ordinary borax, either powdered or crystals, contains a considerable proportion of water which is evident from the formula $Na_2B_4O_7 + 10H_2O$. Therefore the borax glass is preferable to the ordinary borax containing water because it occupies much less space and is, therefore, more convenient to handle in small crucibles. However, if ordinary borax is used the water content must be calculated and provided for in weighing out the ingredients. The boric acid used does contain water, as will be seen from the formula H_3BO_3, because it is more stable than the fused boric acid B_2O_3 and more readily obtainable. The silica should be pure and in the form of a fine powder so that it may combine readily.*

REDUCING FLUX

In connection with the casting process, it is necessary to treat buttons of gold, both during casting and before recasting, with a flux that will take care of the acquired impurities. Very often there have appeared statements to the effect that a mixture of potassium nitrate and borax be used to cleanse buttons before recasting. This statement has been, in a good many cases to the author's knowledge, misunderstood. Potassium nitrate is an excellent oxidizing agent and does remove base metals, but its use in treatment of casting buttons is contra-indicated, because generally when casting gold alloys containing copper, etc., it is desired to *retain the base metal, the copper, in a reduced metallic form and not in an oxidized form.* Consequently, if a *flux* is to be used it must be of a distinctly *reducing* nature.

Reducing fluxes are used extensively in assaying and smelting operations and their properties are well known. In the case of casting, it is rather difficult to utilize all the benefit that may be derived from a reducing flux on account of the

* The grade (F. F. W.) used in inlay casting investment is quite suitable.

difficulty of applying same to the molten metal which is exposed to the blow-pipe flame which drives off the flux almost as fast as it is applied. Therefore, to obtain any considerable benefit from a reducing flux, it is necessary to not merely apply same while the gold is fluid under the blow-pipe, but also to sprinkle an additional amount in the manner described in the following: After placing flask on casting apparatus, place button or nuggets of gold into crucible, melt without flux until the mass of gold assumes a spheroidal form and completely covers the sprue hole. Then apply some flux by sprinkling, continue melting until the gold is in a proper state of fluidity for casting, then remove flame, add some more flux and instantly apply the casting pressure.

Formula for Reducing Flux

Soldering Flux (Base)	Parts	40
Borax Glass	Parts	30
Argol	Parts	25
Animal Charcoal	Parts	5
Total		100

Argol is the commercial term for crude potassium bitartrate, $KHC_4H_4O_6$ (cream of tartar), and has a higher reducing power than pure cream of tartar. If the latter is used it should be increased to about 25 parts and the soldering flux and borax glass content reduced in proportion.

A flux of this character will practically prevent the bringing into the casting of oxidized material and can be used to advantage in remelting and cleansing buttons of gold for recasting.

The author's procedure for this operation is as follows: After a casting is made, the residue button is placed into hydrofluoric acid for 15 or 20 minutes, removed and melted with the blow-pipe in a charcoal block, using the reducing flux, which, in addition to reducing the oxidized copper in the button, combines with the silica, traces of which may still adhere to the button. After the button is melted and the flux used has segregated into a globule, the blow-pipe is removed and a small quantity of ammonium chloride is sprinkled on the button. As soon as the button has solidified, and while still red, it is plunged in dilute hydrochloric or sulphuric acid. Most of the glass formed by the flux will splinter off. If any considerable quantity adheres, it may be removed by boiling in the same acid.

OXIDIZING FLUX

Potassium nitrate is a most excellent oxidizing agent and removes base metals, the only objection being the strong fumes which are given off during the melting process. Although the operator should rarely attempt to do refining, it is well to have a suitable oxidizing flux that will not give off the objectionable fumes characteristic of potassium nitrate.

Formula for Oxidizing Flux

Soldering Flux (base)	Parts	55
Potassium Chlorate	Parts	20
Sodium Perborate	Parts	25
Total		100

This flux will be found useful for revivifying buttons of gold which are contaminated. It is sufficiently powerful to volatilize such impurities as tin, cadmium, bismuth, etc. It will combine with adherent investment compound and not attack copper very strongly, so that a button of gold that has been used several times and is quite sluggish and dirty can be usually brought into good shape without difficulty.

A button treated with this flux should be cleansed in acid, as previously described, and then *remelted with the reducing flux* prior to use for casting.

In cases of refining, where a stronger action is required, the potassium chlorate and sodium perborate can be increased to obtain the same efficiency that a high percentage of potassium nitrate would give without the objectionable fumes characteristic of the latter.

It is expected that prepared flux made according to the formulas given will be very shortly available from the supply houses. Until such time, a modification of the soldering flux formula, which also acts as a base for the reducing* and oxidizing fluxes, is given herewith for the benefit of those who have not the facilities for fusing and pulverizing the material. These ingredients make a flux which appears to work much

* There are a number of better reducing agents than those suggested by the author used industrially. They are not mentioned because of either difficulty of application under casting conditions, or on account of not being obtainable in small quantities. A study of the methods used in deoxidizing copper, brass and bronze is suggested to those particularly interested.

more satisfactorily than ordinary borax or any of the secret preparations purchaseable.

Formula for Soldering Flux (Substitute)

C. P. Borax Glass	Parts	50
C. P. Boric Acid	Parts	43
C. P. Sodium Silicate (dry powd.)	Parts	7
Total		100

This is mixed thoroughly in a mortar and must be fine enough to pass an 80-mesh sieve.

The author trusts that his remarks upon the importance of producing castings with all the metal in a reduced form and not in a partially oxidized form will be given some consideration by the reader, as this problem, on an immeasurably larger scale, has been and is one of the most important ones in the application of industrial alloys, and is being coped with successfully.

TABLE 4
MELTING POINTS OF THE NEW SERIES OF ALLOYS AND STANDARD DENTAL GOLDS

°F	Alloy	°C
2100	* "Elastic" Gold	1150
2075	*Plate No. 1	1135
1975	*Plate No. 2	1080
1960	Type 4 Clasp	1070
1945	Pure Gold	1063
1945	*Casting Gold "A"	1063
1945	*Casting Gold "D"	1063
1945	"Green" Gold [App. Au. 80%—Ag. 20%]	1061
1900	*Casting Gold "B"	1035
1900	Light 22K Plate	1035
1860	Medium 22K Plate	1015
1860	Type 3 Clasp	1015
1825	Dark 22K Plate	995
1800	*Casting Gold "C"	980
1760	Light 20K Plate	960
1735	Coin Gold (21.6K)	946
1725	Type 2 Clasp	940
1650	*Gold Solder No. 84	900
1625	Gold Solder for 22K	885
1600	Type 1 Clasp	870
1550	*Gold Solder No. 76	840
1525	Gold Solder for 20K	820
1450	*Gold Solder No. 68	785
1425	Gold Solder for 18K	770

The ten alloys marked * constitute the new series. They are all uniform in color with the exception of "Elastic" Gold, which is similar to platinum in color, and Casting Gold "A," which is similar to pure gold in color.

Some of the Applications of the New Series of Alloys in the Peeso System of Removable Bridgework

As will be seen from the preceding table, the series of alloys offers a wide range of variation in melting point over the ordinary alloys, thus facilitating the performance of successive soldering operations.

CONSTRUCTION OF BANDS, FLOORS AND INNER CAPS

As has been previously stated, coin gold is the most suitable alloy for the construction of bands, floors, etc. It is therefore necessary to use its equivalent in the new series of alloys. The band should, therefore, be made of the No. 2 plates (M. P. 1975 degs. F., 1080 degs. C.), and united* by soldering with the next lowest fusing alloy, namely, Casting Gold "B" (M. P. 1900 degs. F., 1035 degs. C.).

The band is also prepared of No. 2 plate and attached with Casting Gold "B" (the pliers grasping the band at previously joined portion).

The method will make, for all intents and purposes, a seamless cap. The melting point of the soldered junctions will be still considerably above that of coin gold. The tube may be then attached with the No. 84 solder.

Outer caps for telescope crowns are made in exactly the same manner. As the hardness and tenacity of the No. 2 plate is the same as that of coin gold, the same gauges of plate are to be used as with coin gold. The casting gold, if used as solder, should be of practically the same thickness as ordinary gold solder, app. 27 or 28 gauge B. & S., or preferably thinner (30 to 32 g.).

OUTER HALF BANDS AND TELESCOPE CROWNS

After completing the inner cap, the outer half band and floor are made of suitable gauge No. 2 plate and the split pin is attached and the half band united to the floor with the No. 84 solder.

For telescope crowns, the outer band is made of the No. 2 plate and the joint soldered with Casting Gold "B." The wings are made of No. 2 plate and soldered to the band with Casting Gold "C." The cusp is swaged of No. 1 plate (higher fusing than pure gold), filled with Casting Gold "C" in the same manner as a pure gold cusp is filled with coin gold and

* See Dr. Peeso's method of band preparation for sweating.

attached to the previously completed outer band and wings with No. 84 solder.

If the cusp is to be cast, Casting Gold "B" or "C" should be selected according to the blow-pipe used and attached to the contoured band with No. 84 solder.

As all of the alloys of the series used in this operation are of the same color and the No. 84 solder is actually 20k. fine, there will be no line of demarkation evident in the finished work.

INLAY ABUTMENTS

The shell for the inner inlay may be cast with Casting Gold "D" and adapted to the cavity by burnishing. The tube is then soldered and completed with No. 84 solder. The outer inlay matrix can then be made, using the comparatively soft but high fusing plate gold No. 1 and Casting Gold "C," instead of pure gold and coin gold.

CONSTRUCTION OF SADDLES

The saddles, if swaged of platinum, may be reinforced with Casting Gold "B" or "C," instead of coin gold, or the saddles may be swaged of No. 1 plate (softer than No. 2) and reinforced with Casting Gold "C." If the saddles are to be cast, Casting Gold "B" or "C" should be selected according to the blow-pipe used.

CONSTRUCTION OF DUMMIES

In constructing the dummies (if all porcelain), the bases and dowels may be cast with either "B" or "C" and attached to the saddles with the 84 or 76 solder.

They may also be made by burnishing 34 g. pure gold backings to the prepared porcelain crowns, fitting and soldering dowels made of "Elastic" gold or type four clasp metal to the backings (or boxes) and attaching the completed backings to the saddles with 84 and 76 solder.

REMARKS

The author cannot close without calling attention to the fact that a broad conception of the scientific principles involved in the chemical and physical behavior of the various materials utilized in connection with the construction of prosthetic restorations is a most potent factor toward the attainment of the ideal.

He has been aided materially in arriving at the conclusions presented herein by the kindness of Mr. H. C. Ney, president of the J. M. Ney Co., who unstintingly placed at the author's command all the facilities of their metallurgical research laboratory in Hartford. ("Dental Metallurgy," Weinstein.)

Iron

PHYSICAL PROPERTIES

Atomic weight, 55.84. Specific gravity, 7.84. Melting point, 1530° C. Malleability, 9th rank. Ductility, 4th rank. Tenacity, 3d rank. Conductivity of heat, 11.9. Conductivity of electricity, 14.8. Specific heat, 0.1138.

Iron, like gold has been known and used since the earliest times. It is almost universally distributed over the earth in some form or other. The oxide of iron in the form of red and yellow ochre is the principal coloring pigment in clay, sand and rocks. The ores of iron are also found in almost every country on the face of the globe. These are in the form of oxides, carbonates and sulphides, and their name and chemical composition, according to Bloxam, are given in the table below:

Common Name.	*Chemical Name.*	*Composition.*
Magnetic iron ore.	Protosesquioxide of iron.	$Fe_3\,O_4$.
Red haematite.	Sesquioxide of iron.	$Fe_2\,O_3$.
Specular iron.	Sesquioxide of iron.	$Fe_2\,O_3$.
Brown haematite.	Hydrated sesquioxide of iron.	$2\,Fe_2\,O_3\,3H_2\,O$.
Spathic iron ore.	Carbonate of iron.	$Fe\,O\,Co_2$.
Clay iron stone.	Carbonate of iron with clay.	
Black band.	Carbonate of iron with clay and bituminous matter.	
Iron pyrites.	Bisulphide of iron.	$Fe\,S_2$.

Iron very rarely occurs native, owing to its strong affinity for oxygen and other non-metallic elements. It is found native in meteorites and in minute particles in basaltic rocks, but not in quantity sufficient to be of recognized value.

Magnetic iron ore is the protosesquioxide of iron, and is commonly called lodestone when strongly magnetic, and possesses the property of attracting small particles of iron similar to a horseshoe magnet. It furnishes a most excellent quality of iron, examples of which are the Wootz steel and the Swedish iron.

Red haematite, so called from its dark, blood-red color, is a sesquioxide of iron. It is a remarkably abundant ore, being found all over the world, and contains about 70 per cent iron, 30 per cent oxygen.

The sesquioxide sometimes occurs as a steel-gray mineral, and it is then called *specular iron ore.*

Brown haematite is also a very common ore of iron, and is the *hydrated sesquioxide* of iron, containing about 15 per cent water. It is sedimentary in character and is often mixed with wood, clay and sand. The *lake ores* of Europe and this country are of this variety.

Spathic iron ore is the carbonate of iron and occurs crystallized in veins and beds, and also in globular masses. When first mined it is yellow, but soon turns brown on exposure to air. Most of the iron used by the Krupp iron works of Essen is derived from this ore.

Clay ironstone is the carbonate of iron with clay, and contains about 34 per cent of iron. It often occurs with or accompanies coal formations, of which it is the characteristic ore.

Black band. When clay ironstone contains more than 10 per cent coaly matter it resembles shale, slate or cannel coal, and is a valuable ore for the reason that the coal it contains is sufficient to burn or roast it.

Iron pyrites is the bisulphide of iron and is of a bright yellow, crystalline structure, with a distinct metallic luster. It is largely used in the manufacture of sulphuric acid, but is not, to any extent, of value as an ore of iron.

REDUCTION OF IRON ORES

Most iron ores containing carbon dioxide or sulphur are roasted to drive off these elements or combinations and to reduce the ore to an oxide. The ore is then mixed with certain proportions of calcium carbonate (limestone), which acts as a flux, and with coal, charcoal or coke, and thrown into a blast furnace. Under the influence of heat and the blasts of air which are directed into the bottom of the furnace the fuel is converted into CO_2. As this ascends in the furnace it passes over the red-hot fuel in the higher portions and is converted into CO.

The carbon monoxide thus formed reduces the ore to the metallic state by combining with the oxygen with which the iron is united and becomes CO_2 gas, which is thrown out of the furnace, leaving the iron free and uncombined. This sinks through the slag (the calcium carbonate which has united with the earthly impurities of the ore) to the bottom of the furnace, where it is retained in a fluid condition until sufficient quantity has accumulated, when the furnace is tapped. The slag from time to time is removed through openings placed higher in the furnace than that from which the iron is drawn.

The metal is drawn off from the furnace and conducted into a ditch or trough formed in the sand, and from this into lateral openings in the form of half cylinders, called pigs. In this condition it is crude *cast iron,* and can be used in this form for many purposes or be refined by subsequent operations and reduced to the purer condition of steel or wrought iron.

For general purposes iron is used in three distinct forms, as *cast iron, steel* and *wrought iron,* all consisting of iron with more or less carbon.

Cast iron contains the largest percentage of carbon, the quantity varying from 1½ to 7 per cent. Steel contains from 1 to 1½ per cent of carbon, and wrought iron contains the smallest percentage of the three varieties, having less than ¼ of 1 per cent.

PRODUCTION OF WROUGHT IRON

Wrought iron is produced from cast iron by extracting most of the carbon present. This is accomplished by remelting pig iron and directing a blast of air upon the heated surface of the molten metal to remove some carbon and other impurities that may be present, after which it is cast into molds, and is now known as plate metal.

The second step is designed to more fully free the metal from its carbon, and this is done by the process called *puddling.* The ingots of plate metal are introduced into a reverberatory furnace, and again melted. At a certain stage oxide of iron is added to the molten metal and the mass mixed, or puddled, as it is called, with long iron bars, until the oxide of iron is diffused through the molten metal.

Under continued heat the oxygen in the last mass added unites with the carbon in the plate metal and forms CO_2, which escapes as a gas. After a time the mass assumes a pasty condition, when it is divided into balls of about 90 pounds each, removed from the furnace and subjected to intense pressure by rolls and converted into bars or blooms.

Two or three of these blooms are again heated and welded together, and the rolling process repeated once, twice and sometimes three times, depending on the quality of the iron desired. In this changed condition it is tough and fibrous and elastic, its malleability, ductility and tenacity has increased, and it is now capable of being welded, a property which cast iron does not possess.

PRODUCTION OF STEEL

Steel is made in two ways, first by direct process from cast iron, which is known as the *Bessemer process,* and from wrought iron by the *cementation* process.

THE BESSEMER PROCESS

The Bessemer process consists in melting cast iron in large crucibles called converters, capable of holding several tons, and when in a molten condition, directing a blast of cold air upon its surface. The oxygen in the air unites with the carbon in the molten metal and frees the iron from carbon in this manner to a greater or less extent, depending on the length of time the process is continued. The best results are attained by purifying the iron to as great a degree as possible, and afterward adding a given quantity of cast iron containing a known percentage of carbon.

THE CEMENTATION PROCESS

The Cementation process consists in placing bars of wrought iron in fire brick muffles, together with alternate layers of charcoal, and sealing the charge in so as to exclude the air. Heat is then applied to the exterior of the muffle and maintained for 7 or 8 days.

Upon examination it will be found that the fibrous structure of the iron has become granular and that its hardness, elasticity and sonorousness have increased.

It is more brittle and less malleable and ductile than before. Its surface is covered with blisters, and in this condition is known as *blister steel.* By arranging it in bundles, subjecting it to heat and the blows of a trip hammer, it is rendered dense and compact.

This reduces it to a condition known as *shear steel.* This process is sometimes repeated, and it is then known as double shear steel. When blister steel is remelted and cast into ingots it is known as cast steel.

HARDENING AND TEMPERING STEEL

Steel possesses the property of being rendered so hard that no tools of ordinary form or composition will affect its surface. This is accomplished by heating it a full (cherry) red, and suddenly chilling it by plunging in water or some medium that will rapidly conduct away the heat. This is called *full hardening*. For many purposes steel in this condition is too hard for use, and its hardness must be reduced or *tempered* to meet the required purposes.

When instruments are shaped to proper form they are first full hardened. The surfaces are then polished so that the colors which appear on subsequent heating, and which indicate the varying degree of hardness, may be accurately observed.

The polished steel is now passed back and forth through a Bunsen flame or heated in any other manner, if more convenient, until the proper color appears, when the instrument should be suddenly cooled to prevent further reduction of its hardness. Sometimes an alloy of tin and lead, which melts at a known temperature, is used for drawing the temper to the required point.

Bessemer steel usually contains such a small percentage of carbon that it is not possible to render it *full hard*, and, consequently, it cannot be *tempered*.

All dental instruments, especially edge tools, should be made from the finest tool steel.

The following table indicates the various colors as they appear on steel when drawing the temper, the yellows appearing first. It also indicates the alloy that may be used for securing any given temper:

TEMPERING STEEL			ALLOYS FOR TEMPERING		
Temperature	Color.	Temper.	Lead.	Tin.	Melting points.
215°—232°C	Very faint yellow to pale straw color....	Lancets, razors, surgical instruments, enamel chisels..................	7.85	4	215°—232°C
243°C	Full yellow..........	Excavators, very small cold chisels.............	10	4	243°C
254°C	Brown..............	Pluggers, scissors, pen knives..................	14	4	254°C
265°C	Brown with purple spots..............	Axes, plain irons, saws, cold chisels—large.......	19	4	265°C
276°C	Purple..............	Table knives, large shears.....................	30	4	276°C
287°C	Bright blue..........	Swords, watch springs.........................	48	4	287°C
293°C	Full blue............	Fine saws, augers.............................	50	4	293°C
315°C	Dark blue...........	Hand and pit saws.............................	Boiling oil.		315°C

Platinum

Platinum was discovered in 1735 in the province of Choco, Colombia, South America, in the sands of the river Pinto. The credit of this discovery belongs to Antonio de Ulloa, a Spanish naval officer and explorer. Six years later an Englishman, a Mr. Wood, who was traveling in Jamaica, secured some specimens of this metal and presented them to Watson, a noted chemist at that time, who recognized in them the presence of an unknown metal. Some years later Schaffer, who was examining the new metal, declared it to be "white gold." In Spain it was called "platina del Pinto," which, translated, means "little silver of the Pinto," and from which the present name, *platinum*, was derived.

In 1803 Wollaston discovered two other metals associated with platinum, viz., palladium and rhodium.

About the same time Tennant discovered iridium and osmium.

In 1828 Berzelius analyzed *polyxene*, the Siberian platinum mineral, and found it contained platinum, iron, palladium, iridium, rhodium, osmium and copper. With the exception of iron and copper, these metals largely constitute what is known as the platinum group.

DISTRIBUTION

Platinum is found in many parts of the world, South America, Australia, Canada, United States and Mexico — all yielding moderate amounts.

Recently some discoveries of vein platinum in Wyoming have been made which promise to be very productive.

The largest bulk of the world's supply comes from Russia, whose platinum placers and mines have become world renowned.

The total production in that country from 1824 to the present time amounts in round numbers to 250,000 pounds.

Platinum was used as money in Russia from 1828 to 1845. During this period the volume of coinage amounted to 4,250,000 roubles, or about $3,000,000.

The production of platinum during the period of its coinage was greatly stimulated, which, however, almost entirely ceased when it was demonetized.

The great demand for platinum in recent years for electrical, chemical and general scientific purposes has been so marked that the metal is being as eagerly sought for as is gold in all of the principal productive fields of the world. On account of the great demand and limited supply, it ranks in value very much above gold.

OCCURRENCE

Platinum usually occurs in nature in placer deposits, similar to gold, frequently accompanying the latter in the alluvial deposits of rivers.

The mother lode, from which the placer deposits are derived, consists usually of serpentine or magnesium iron silicate, which is closely related to chrysolite.

Placer platinum usually occurs in rounded grains, flakes or pellets. Occasionally nuggets of medium size are found, and in two or three instances large ones weighing from 15 to 21 pounds have been discovered. The largest one mentioned is preserved in the Demidoff museum.

PHYSICAL PROPERTIES

Pure platinum is a very soft metal, tin white in color. It is not readily acted on by acids, with the exception of nitro-muriatic, in which it is readily dissolved. It does not oxidize even at very high temperatures, and for this reason fills a place in the arts and sciences for which the oxidizable metals are unsuited.

MALLEABILITY

Platinum is very malleable, and can be beaten out into extremely thin foil, in which form it is used for many purposes. It ranks sixth in this quality among the other metals.

DUCTILITY

This metal can be drawn into extremely fine wire. Dr. Arendt states that a cylinder of platinum 5 inches long and 1 inch in diameter can be drawn into a wire sufficiently long to encircle the globe. The fine wire used in microscopic eye-pieces is made by coating platinum wire with silver and drawing this composite wire to the finest possible state, then dissolving off the silver with nitric acid.

TENACITY

In point of tenacity platinum occupies third rank. This property is so marked in platinum as to render it especially valuable for dowels in crowns and for the truss work in porcelain bridges. The addition of from 10 to 15 per cent of iridium greatly increases its tenacity, as well as its hardness, elasticity, infusibility, and resistance to chemical action.

SPECIFIC GRAVITY

The specific gravity of platinum is 21.4, two others having greater density — osmium 22.47 and iridium 22.40. These three are the heaviest of the metals.

CONDUCTIVITY OF HEAT

Platinum is low in heat conductivity. Compared with silver at 100, it ranks 8.4. Its co-efficient of expansion is low, being only .0009. For this reason it is especially valuable for the pins of porcelain teeth, since the expansion of both the metal and porcelain is nearly the same, and, consequently, there is less liability of fracturing the porcelain in baking.

CONDUCTIVITY OF ELECTRICITY

Compared with silver, which ranks 100 in conductivity of electricity, platinum ranks 14.5, or, in other words, this metal offers about seven times more resistance to the passage of a current than does silver.

FUSING POINT

Platinum fuses at 1755 deg. C., the oxyhydrogen blowpipe or the electric arc being required to effect it.

Dr. L. E. Custer of Dayton, Ohio, has devised a simple yet effective method of fusing platinum scrap, the outline of which is here given:

The first method consists in fastening the positive end of a wire capable of carrying a 110-volt current into a carbon block. An ordinary battery plate will answer the purpose. To the negative pole is attached an electric light carbon of ordinary size. A resistance coil, lamp or electric furnace should be included in the circuit capable of furnishing from 8 to 12 ohms resistance to prevent the fuses from blowing out.

It is necessary to make the positive and negative connections as described, as when so arranged the fusing can be accomplished more rapidly and with less noise than when reversed.

With 12 ohms resistance from 6 to 8 pwts. can be fused at once, while with 8 ohms an ounce can be melted at one time. By keeping the edge of a bulk heated and adding a fresh supply, the mass can be elongated indefinitely. As much as 10 ounces have been melted in this manner in the form of a rod, and the rod afterward drawn into a fine wire.

Platinum fused in this manner is harder than new platinum, the cause assigned being due to a small per cent of carbon uniting with the platinum.

To obviate this hardness a second method was devised, which is as follows:

A piece of heavy platinum wire is attached to the positive terminal, and this is laid on a block of lime so shaped as to serve as a receptacle for the scrap. The other terminal consists of a brass rod five-eighths of an inch in diameter and 8 inches long, covered most of its length with wood to insulate it. In the exposed end a slit is made, in which a nugget of platinum of at least one-half oz. weight is fastened. Too small a piece would fuse in the arc. The scraps are laid on the platinum wire forming the positive terminal, which is placed in the depression in the lime block. The arc is established by interposing a stick of carbon between the negative pencil and the scrap, and, when established, quickly removing it. This step is necessary to prevent the scrap fusing to the nugget on the negative end.

The eyes should be protected by wearing glasses of the darkest variety, as the arc light is intensely brilliant. This

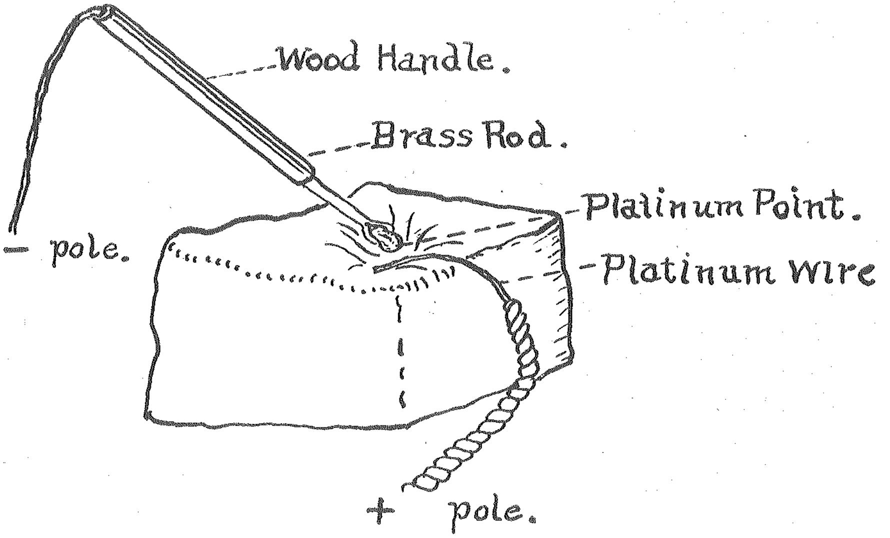


Fig. 977

method of fusing platinum is recommonded as practical for dental laboratory procedures.

In a fused condition platinum absorbs oxygen, and when cooling "spits" as the gas is given off, none of it being retained or *occluded* when cold.

When a jet of hydrogen is directed on spongy platinum, the latter begins to glow, and the gas ignites.

Platinum black is formed by adding platinum chloride solution to a boiling mixture of 3 parts of glycerine and 2 parts of caustic soda. The platinum is thrown down as a black powder. In this form it absorbs about 800 times its volume of oxygen from the air.

USES

Platinum is used for many purposes in dentistry, especially in combination with porcelain. It is used as base plates for continuous gum dentures, the metal parts and trusses in continuous gum dentures, the metal parts and trusses in porcelain crown and bridge work, as a matrix material in inlay work, for pins in porcelain teeth and for electric furnace construction. It is also used in combination with gold in the form of foil, for filling teeth, being harder and more neutral in color than pure gold. It requires more care in condensation than pure gold, however, to develop its welding property in the highest degree.

In the chemical, electrical and scientific fields, it has a wide range of usefulness, being utilized in many instances for purposes for which no other metal is adapted.

ALLOYS

Its principal alloys for dental purposes are its combinations with iridium, for hardening and increasing its tenacity, and gold in the composition of solders for platinum, and for clasp metal.

It is also combined with silver, the resulting alloy being harder than either of component metals and less oxidizable than silver. This alloy is known as *dental alloy,* and is used to a considerable extent in Europe as a base for artificial dentures.

DENTAL ALLOY

Silver	70 or 80
Platinum	30 or 20

Gold solder can be used in conjunction with this alloy.

PLATINUM SOLDER AND CLASP METAL

These formulas are given in connection with the alloys of gold.

Iridium

Iridium is one of the metals of the platinum group, and resembles the latter in some respects, but is much harder. When combined with platinum, the resulting alloy has greater tenacity and hardness than platinum, and, therefore, for this quality alone it is valuable for dental uses.

The specific gravity of iridium is 22.40, atomic weight 192.65, and fusing point 2350 deg. C.

On account of its hardness, it is used alone and in combination with osmium for watch and compass bearing, the knife edges of delicate balances, and for the nibs of gold pens. It ranks in value somewhat higher than platinum.

Silver

Silver is found in many parts of the world, but the Western Continent has the richest and most extensive deposits known.

It is impossible to briefly enumerate the many practical uses found for this metal.

It is brilliant white in color, very soft, malleable and ductile, and moderately tenacious. Its specific gravity is 10.53, specific heat .056, and it fuses at 960.5 deg. C. It is the best known conductor of heat and electricity, and is taken as the standard of measurement of all of the metals in these properties, being rated at 100.

ORES OF SILVER

Silver sometimes occurs *native*, but is more often associated with other metals and with non-metallic substances. One of the principal ores of silver is the sulphide $Ag_2 S$, called *argentite*. This is grayish black in color, and is readily fusible. It contains about 87 of silver. Pyrargyrite $Ag_3 Sb S_3$. Silver copper glance (Ag Cu) 2S. Stephanite $Ag_5 Sb S_4$, with lead as argentiferous galena and in several other combinations.

REDUCTION

The reduction of silver is accomplished by three principal methods.

First. Amalgamation.

Second. By the wet method.

Third. By the lead method.

AMALGAMATION

In the first process, the silver, after being reduced to a chloride, is amalgamated with mercury, from which it is recovered by distilling the latter off. There are three different methods of recovery of silver by amalgamation, each of which is more or less complicated, and in this treatise it is not advisable to enter into the details of them.

WET METHOD

There are several wet processes, all of which depend upon the solubility of the sulphide and chloride of silver in water, or some other solvent, from which the silver is thrown down by a precipitant, usually copper.

THE LEAD METHOD

By this method the silver is concentrated in a quantity of lead, from which it is recovered by cupellation.

Cupellation consists in heating an alloy of silver and lead in a porous cupel, or shallow crucible, made from prepared bone ash. Under the influence of heat, the lead is oxidized and absorbed by the porous cupel, while the silver remains in the crucible.

USES IN DENTISTRY

Silver occupies a prominent place in the dental office and laboratory. It is the principal metal used in the compounding of dental amalgam alloys. It is used as an alloying agent with copper and gold in the various gold plates and solders used in the laboratory.

Were it not for the fact that sulphur has such a strong affinity for silver, as to readily discolor it, the latter would have a much greater range of usefulness. For the reason mentioned, although it possesses most of the necessary requirements, silver is not suitable as a base for artificial dentures, nor for crowns and bridges. Before the introduction of vulcanite, however, it was used extensively as a base plate because of its cheapness as compared with gold or continuous gum dentures.

It is not possible to attach teeth to silver base plates with vulcanite, because the sulphur in the rubber acts on the silver, forming silver sulphide. It disintegrates the rubber to such an extent that all attachment of vulcanite to base plate is destroyed or never effected.

Silver is not readily acted upon by oxygen, but when fused it mechanically absorbs about 22 times its volume of this gas. The "spitting" so noticeable when fused silver solidifies, is due to the forcing out or escape of the oxygen, nearly all of which is expelled.

This peculiar affinity between oxygen and silver in a fused state renders the production of sharp castings of this metal a difficult matter.

ALLOYS OF SILVER

U. S. coin silver is composed of 90 parts silver and 10 copper. The latter is added to harden the silver, which, unalloyed, is almost as soft as pure gold.

In Great Britain and Europe the profession is using an alloy composed of silver and platinum for dental purposes.

It does not discolor quite so readily as silver alone, but is not by any means free from the action of sulphur. It is more rigid than coin silver, and in some mouths can be worn for a long time without discoloring.

In compounding this alloy, the rule commonly followed of melting the highest fusing ingredient first is reversed. The platinum is rolled into a very thin ribbon, the silver melted, and the platinum gradually fed into it. The two metals will unite at a temperature far below the fusing point of platinum.

Silver solders are composed of silver and copper, with some other ingredient, usually zinc, to reduce the fusing point. The following are standard formulas for some of the solder used in the dental laboratory and by jewelers:

Low fusing.		High fusing.	
Silver	6	Silver	6
Copper	3	Copper	2
Zinc	2	Zinc	1

A method followed by jewelers is to take a silver coin, add one-half its weight of spring brass wire, and fuse under a flux. Solder prepared in this manner usually flows readily.

Purple of Cassius, a pigment used to impart a pink color to porcelain enamel, is formulated as follows:

Silver	432 grs.
Gold	48 grs.
Tin	36 grs.

The gold, silver and tin are melted together in the order named, and granulated by pouring into cold water, repeating the process several times to insure thorough mixture of the metals.

The granulated alloy is then treated with nitric acid to remove the silver, the residue is a brown powder of unknown composition, but containing gold and tin, which is called Purple of Cassius, and which, as before stated, will produce varying shades of pink in porcelain, according to the amount used. It may also be prepared by adding a solution of stannous and stannic chlorides to auric chloride.

The Chemistry of Photography

Some of the salts of silver, as the bromide and the iodide, are exceedingly sensitive to the influence of light, and when exposed to it are readily reduced to black metallic silver on being subjected to the action of various reducing agents.

Photographic plates or films are coated with a layer of gelatin emulsion, containing one or both of the salts mentioned. The emulsion is applied to one side of the plates only, in the dark, or with ruby light, allowed to dry, after which they are wrapped in light-proof paper, packed and sealed in boxes or packages, in which condition they must be kept until ready for use.

When a plate so prepared is placed in the plate-holder of the camera and light is transmitted to it through the lens, the various areas of the plate are affected in different degrees by the light which falls upon them, according to the depth or intensity of the shadows and lights of the view reflected and the time of exposure. Where no light falls, the silver salt is unaffected. Medium shadows produce moderate decomposition, while bright light affects the silver salt most intensely. When an exposed plate is examined under ruby light, no visible alteration in the film can be seen until brought to view by *developing*.

To develop the latent image and make it visible, the plate is immersed in a liquid developer. The silver salt upon which the strongest light was directed is first and most readily decomposed by the developer, being resolved into metallic silver. The portions not so strongly affected by the light are acted upon more slowly, and on developing show correspondingly lighter shadows. When the image shows up distinctly and clearly, the development must be stopped immediately; otherwise the plate will become fogged from the action of the developer on the less affected portions of the silver, which will in time be reduced.

The development is arrested and the plate cleared up by immersing it in a solution of hyposulphite of soda, which dissolves out the unreduced silver bromide, but does not act readily on the metallic silver. The heavy shades and shadows are formed by the reduced or metallic silver, which is held in suspension in the film of gelatin and thus accounts for the varying degrees of intensity of the *negative*.

The *hypo*, as it is called, must be removed by thorough washing before the negative is exposed to the light, otherwise the silver salt which is dissolved by it, but not yet removed, will thicken the shadows and the transparency of the plate be affected.

Many kinds of developers are in use, each having some peculiar quality which renders it specially adapted for some particular purpose. The following expresses in a general way the chemical action which occurs in the use of any of the standard developers:

$$3AgCl + 3FeSO_4 = 3Ag + FeCl_3 + Fe_2 (SO_4)_3.$$

The negative is a reverse of the object photographed, the light shades being dark and the dark tints light. To obtain a positive or true likeness, a similar process is carried out, the silver salts again being the sensitized factor in the paper on which the picture is to be printed. In printing, the dark areas of the negative produce light tints on the paper, and the light, dark, according to the facility with which the light passes through negative and decomposes the silver in the sensitized paper.

Ag.I., the iodide, Ag.Br., the bromide, and Ag.Cl., the chloride, are used in photography.

COPPER

Copper was one of the first metals known to the ancients, probably because it is found so widely distributed over the earth. From it weapons, ornaments, and useful implements of all kinds were made. The ancients employed a method of tempering edge tools made from this metal, which is now considered a lost art.

Copper is distinguished from all other metals by its red color. It is very soft, malleable, ductile and tenacious. It fuses at 1083° C., or a little below pure gold. Copper is an excellent conductor of electricity, ranking 97.8, silver being 100. Its specific gravity is 8.9, specific heat, .093 and atomic weight, 63.57.

Copper is not readily oxidized in dry air at ordinary temperature, but is easily affected under the influence of heat. In moist air a green carbonate is quickly formed, and when acted upon by acid fumes, it oxidizes rapidly.

ORES

Copper frequently occurs native in large masses, particularly in the Lake Superior region. The most common ores of copper are tabulated below:

$Cu\ O_2$ — cuprite, or red oxide.
$Cu\ O$ — Melaconite, or black oxide.
$Cu\ Fe\ S_2$ Chalcopyrite — copper pyrites.
$Cu\ CO_3\ Cu\ H_2\ O_2$ — Green malachite.
($2\ Cu\ CO_3\ Cu\ H_2\ O2$) — Blue malachite.
$Cu_2\ S$ — Chalcocite — Copper glance.

REDUCTION

The ores of copper are reduced by two principal methods, known as the *dry* and the *wet* method. In the dry method the ore is subjected to treatment in the reverberatory furnace, which drives off impurities and leaves it free as a sulphide. It is then strongly heated with sand, which reduces it to an oxide. The oxide is then mixed with some form of carbon and subjected to a very high temperature. The oxygen, in combination with the copper, unites with the carbon to form CO_2 which escapes, leaving the metal free.

When the wet method is employed, the ore is mixed with rock salt and calcined, which converts the copper into a soluble cupric chloride. The calcined ore is then lixiviated with water, and from the resulting solution the copper is thrown down in a metallic state by the addition of scrap iron.

USES

Copper is used for many purposes, and in great quantities, unalloyed, especially in the electrical field. On land, and under the sea, hundreds of thousands of miles of copper wire are laid, and by means of the telephone and telegraph, communication with most parts of the civilized world is possible in a few minutes or hours' time at most.

In every dynamo and motor, copper wire is used, and in numberless instances a single machine contains many miles of wire.

It is used in the manufacturing and chemical industries, and occupies a field no other metal can fill.

ALLOYS

Copper forms the basis of two prominent classes of alloys — brasses and bronzes — and occupies a minor but important place in the composition of many other useful and valuable alloys, particular in the compounding of gold plate and solder.

BRASS

Under this head may be included most of the alloys of copper and zinc. Brasses, with a wide range of strength and color, can be produced by alloying copper and zinc together in varying proportions.

Name and Color.	Copper.	Zinc.
Pinchbeck (reddish yellow)	88.8	11.2
Sheet brass (yellow)	84	16

Name and Color.	Copper.	Zinc.
Similor (yellow)	80	20
Brass wire (bright yellow)	70	30
White brass (very light)	34	66
Common brass (full yellow)	64	36

Machine brasses, bearing metal, pump valves, steam whistles, cog wheels, etc., usually contain some tin, in addition to copper and zinc.

BRONZES

Bronzes are metallic alloys, composed principally of copper and tin. They cast with great clearness of outline, and are, therefore, extensively used in making statues, medals, busts, and were also formerly much used in making cannon and field ordnance.

	Copper.	Tin.	Phosphorous.	Zinc.
U. S. ordnance bronze	90	10		
Phosphor bronze	90.34	8.90	.76	
Statuary bronze	84.42	4.30		11.28
Speculum metal	66.66	33.34		
Bell metal	72-85	28-15		

Aluminum bronze consists of: Copper, 90; and aluminum, 10 parts. This alloy very much resembles gold in color, is not readily tarnished, has pronounced elastic property, can be turned and engraved, and fuses at about 860° C.

Aluminum

Although aluminum is the most abundant metal in the earth's crust, it never occurs *native*. It forms the basis of the felspar rocks, which when disintegrated by the action of the elements, lose their potassium and sodium. The residue is silicate of aluminum, or common clay, which is found almost everywhere. Clay containing impurities and coloring matter as iron oxides is known as sienna, umber, ochre, Fuller's earth, etc., according to composition.

It also enters into the composition of slate rocks, mica, pumice stone, and is found in many other forms too numerous to mention.

It occurs in crystalline form as an oxide, and among the many interesting and curious results of this combination, may be mentioned the ruby, garnet, sapphire, emerald, topaz and amethyst. Corundum and emery, substances in crystalline form and extreme hardness, used for grinding and polishing purposes, are also included in this class of oxides.

REDUCTION

Most of the aluminum at the present time is produced at the gigantic electrical works at Niagara Falls, N. Y., and is obtained by the electrolytic process.

The principle of reduction depends upon the power, the fused double fluoride of aluminum and potassium or sodium has of reducing the ores of aluminum. The apparatus consists of a large iron box, lined with carbon, in which there is a receptacle for the ore about 4½ feet long by 2½ feet wide and 6 inches in depth.

The carbon lining acts as the cathode. There are usually 40 anodes, consisting of carbon cylinders 3x10 inches, supported above the pot in which the ore is placed, their lower ends resting in the bath of fused fluorides. The heat is developed by the resistance of the fluoride to the passage of the current from the anode to the cathode. The ore to be reduced is placed in the bath of fluoride, and renewed from time to time as that in the pot becomes reduced.

The resistance, and consequently the heat, increases as the ore is reduced, which, by means of an incandescent lamp attached to the furnace, becomes apparent to the furnace attendant by the brightening of the lamp, when he immediately replenishes the charge.

The ore introduced in the furnace is an oxide, and the reaction under heat is due to the oxygen in combination with the metal uniting with the carbon of the anodes forming CO_2, which escapes, leaving the metal free. The process is continuous, being carried on day and night. The metal is drawn off every twenty-four hours, 100 pounds per furnace being the usual amount reduced in that length of time. As there are more than 100 of these furnaces in operation in a plant, the yield per day is about 10,000 pounds. A current of 20 volts and 1700 amperes is required to effect the reduction.

PHYSICAL PROPERTIES

Aluminum is a white metal, with a slightly bluish tint, resembling zinc in color. It is soft and workable, capable of taking a high polish, and does not discolor appreciably on exposure to air, moisture or sulphur. It is not readily acted upon by nitric or sulphuric, but can readily be dissolved in hydrochloric acid or solutions of caustic potash or soda.

Aluminum is very malleable, ductile and quite tenacious, ranking eighth in respect to the latter property. It is a moderately good conductor of heat and electricity, ranking about half way between silver and platinum.

Its specific gravity is 2.6, the lightest of all of the metals except magnesium. Its atomic weight is 27.1, specific heat .0956, its melting point 658.7° C.

Aluminum is soft, and in working it, files soon clog. It is best to use single rather than cross-cut files, and when clogged they may be cleaned by dipping in a solution of caustic soda and washing in hot water. In annealing, aluminum should not be heated above 200° C. The proper heat is attained when a soft wood stick will leave a brown streak when drawn across the heated surface.

SOLDERING

It is very difficult to solder successfully, although this operation can be accomplished under proper conditions. The difficulty is supposed to be due to a film of oxygen adhering to the surface, which by means of the known fluxes can only with difficulty be removed.

Many formulas for fluxes and solders have been proposed, some of which are successful when applied with skill. The following solder and flux is recommended as being successfully used in the manufacture of aluminum jewelry:

Zinc	80	or	85	or	90
Al.	20	or	15	or	10

The soldering iron is dipped in a mixture of copaiba balsam, 3 parts; Venetian turpentine, 1 part; lemon juice, a few drops.

Another method recommended by Page and Anderson consists in spreading powdered silver chloride along the joint to be united, and applying common solder with a blowpipe.

USES

Aluminum can be applied in many ways in dentistry. It makes an excellent base for dentures, 16 or 18 gauge plate being recommended, and the teeth attached with vulcanite. Although not as lasting as some other bases, on account of the action upon it of the fluids of the mouth, its lightness, cleanliness and good conductivity commend its use.

Baseplates are frequently cast over models of investment material, which to a limited extent are satisfactory, but as the density of such casting is frequently imperfect, the action of the fluids of the mouth is more rapid than upon swaged base-plates.

On account of its extreme lightness, aluminum is employed to a considerable extent in the manufacture of physical apparatus of all varieties. It is especially valuable for light balance weights, instrument handles, etc. In powder form it is used as a paint, which is not readily acted upon by the air or moisture.

ALLOYS

As mentioned elsewhere, aluminum with copper makes an excellent bronze, which is used for many purposes. It also unites with zinc to form alloys used as solders for the metal itself.

Silver and aluminum unite readily, and produce alloys of commercial importance.

The silicate of aluminum, or kaolin, the double silicate, feldspar and the oxide of silicon, form the basis of porcelain teeth, and the porcelain bodies used in continuous gum, crown, bridge and inlay work.

It is not generally known that aluminum can be used as a whetting agent, like the ordinary oil stone. A keen, smooth edge, not possible to secure with fine oil or water stones, can be developed on fine edge instruments, and especially razors, by using a true plane slab of aluminum and oil.

Combined with magnesium, a very important alloy known as magnalium is formed. It is used in the making of fine instruments, such as mathematical instruments, balances, etc.

Zinc

The ancients were familiar with the ores of zinc, since they were able to compound brass, but the separation of the metal itself from its ores is of comparatively recent date.

ORES

The carbonate, sulphide, silicate and oxide are the principal ores of this metal, the formulas of which are as follows:

$Zn\ CO_3$— calamine or carbonate.

$Zn\ S$ — zinc blend or sulphide.

$Zn\ O\ Si\ O_2$— willemite or silicate.

$Zn\ O$ — red zinc ore or oxide.

REDUCTION

Those ores, other than the oxide, are reduced by roasting to an oxide. In this form the ore is mixed with coke or charcoal, and heated in a retort. The carbon unites with the oxygen of the ore to form CO_2 and the zinc volatilizes and is condensed in receivers.

Usually some slight amount of oxide passes over with the zinc, which can be removed by remelting.

PROPERTIES

Zinc is bluish white in color. It tarnishes readily in moist air or when heated, an oxide being formed on the surface. When exposed to the vapor of, or fluids containing, carbonic acid, a film of zinc carbonate is formed. It is soluble in most of the acids, and is more readily acted upon by alkaline solutions.

Its fusing point is 419.4° C. Specific gravity, 7; atomic weight, 65.37, and specific heat, .0956. It ranks low in malleability, ductility, and tenacity, on account of its crystalline character, which renders it brittle at ordinary temperatures. When heated to a temperature between 100° and 150° C. it can be rolled and drawn into wire, becoming both malleable and ductile, and retaining these properties in a degree when cold.

Considerable contraction occurs in passing from the fused to the solid state.

USES

For many years zinc was about the only metal in use for constructing dies for swaging baseplates, but Babbitt's metal has largely taken its place. The advantages claimed for it were its hardness and ability to stand the stress of swaging without the face of the die becoming mutilated, and that its contraction in cooling compensated for the expansion in the plaster model. It does not seem possible, however, that uniform contraction without warpage can readily occur, and therefore, it is best to compensate for the expansion of the plaster model by scraping properly and use a die metal that will not perceptibly contract, such as Babbitt's metal.

When zinc is used for dies, lead can be used for counterdies, as there is enough variation in their respective melting points to obviate the melting of the zinc by the lead when the latter is poured upon the die.

A coating of whiting and alcohol painted over the exposed surface of the die will further tend to prevent the fusion of the zinc and union of the two metals in counterdie construction.

The oxide of zinc enters into the composition of oxyphosphate and oxychloride dental cements. In fact, the powder of these cements is nothing more than the refined oxide of zinc, either pure, or containing some pigment to slightly color it.

The liquid constituent of the oxyphosphate consists of glacial phosphoric acid in distilled water, reduced to a syrup-like consistency by evaporation.

The oxychloride liquid is made by adding one-half ounce of crystalline chloride of zinc to two drams of distilled water, allowing it to stand for two or three days, then drawing off the clear liquid. Both liquids should be kept in tightly stoppered bottles to prevent deterioration.

Zinc has a wide range of application in the chemical, scientific and industrial fields. In recent years there has been an increasing demand for it as a precipitant of gold in the cyaniding process of recovery. Its use in the electrical field for cheap and efficient battery work is fully as great as ever, while in foundry work there seems to be a greater demand for zinc than ever in the compounding of brasses, some of the formulas for which are given in connection with copper. Zinc is used for coating iron to prevent oxidation (galvanized iron), in the development of hydrogen gas, and for very many other useful purposes.

Cadmium

Cadmium is usually found associated with zinc as a sulphide, and is recovered in the refining of zinc. As it is more volatile than the latter, the vapor first given off is directed into a separate chamber and condensed, the product being cadmium with some zinc and oxides.

Redistillation further refines it.

Cadmium resembles tin in color, and is capable of taking a high polish. It is subject to slow oxidation on exposure to air. It is malleable, ductile and slightly tenacious. It fuses at 320.9° C., has a specific gravity of 8.54, and specific heat of .0567. Its principal ore is greenockite.

ALLOYS

Cadmium enters into the composition of a number of alloys, among which might be specifically mentioned one frequently used in cast base lower dentures, instead of Watt metal, the formula of which is as follows:

Tin, 16.
Cadmium, 1.

Cadmium also is one of the component metals of "Wood's Alloy."

Lead

Lead might be called an abundant metal, yet the constant and increasing demand for it for old as well as new purposes is so great that its value is constantly being enhanced.

It occurs in nature in several forms, the principal ones of which are here mentioned:

($Pb S$)— Galena or sulphide.
($Pb CO_3$)— White lead or carbonate. (Cerussite.)
($Pb Cr O_4$)— Crocoesite or chromate.
($M O_4 Pb$)— Wulfenite.
($Pb So_4$)— Sulphate.

Lead ore carrying silver is designated as argentiferous galena.

REDUCTION

The ores are first roasted to reduce them to oxides and sulphates. Upon raising the temperature of the furnace these two compounds react on themselves, as indicated, lead and SO_2 resulting:

$2Pb O + Pb S = SO_2 + 3 Pb$ and
$Pb SO_4 + Pb S = 2SO_2 + 2 Pb$.

PROPERTIES

Lead is a bluish gray metal, so soft that it can be readily cut or scratched, quickly tarnishes in the air, forming a *sub-oxide,* but is not readily acted on by water, hence its extensive use in plumbing operations.

Its fusing point is 327.4° C. Specific gravity, 11.4. Atomic weight, 207.10, and specific heat, .0314. It is quite malleable and ductile, but is deficient in tenacity.

USES

The principal use of this metal in the laboratory is for counterdies, being used unalloyed with zinc, and in the proportion of 1 of tin to 7 of lead with Babbitt's metal dies.

ALLOYS

Common tinners' solder consists of lead and tin in varying proportions, those having the most tin being considered the best.

Grade	Tin	Lead
Fine	2	1
Common	1	1
Coarse	1	2

Another series of valuable alloys in which lead plays an important part is given in the section on bismuth.

The alloys given in the section on tempering steel also form an important series in which lead is the principal metal employed.

TIN

Tin occurs usually as a native oxide, $Sn\ O_2$, in crystals of quadratic form, usually colored by manganic or ferric oxide.

REDUCTION

The ore is first washed and stamped, then roasted to drive off any arsenic or sulphur that may be present, at a temperature that will not fuse the ore. It is then mixed with fine anthracite coal and smelted for five or six hours, when, after thorough stirring the melted metal is drawn off. The reaction during the process is as follows:

$$Sn\ O_2 + 2\ C = Sn + 2CO.$$

PROPERTIES

Tin is a white, soft, lustrous metal, quite malleable, somewhat ductile, but with very little tenacity. It fuses at 231.9° C., and is not perceptibly volatilized at ordinary temperatures. It does not oxidize readily, and for this reason is largely used as a coating or protection for iron plates. In this form it is known as the *sheet tin* of commerce.

When a bar of tin is cut, it appears to be devoid of crystalline structure, but if the surface is etched with dilute acids, its crystalline character becomes apparent. When a bar of tin is bent, it emits a peculiar creaking sound, known as the *tin cry*, and which is undoubtedly due to the sliding or rearrangement of the crystalline facets.

The specific gravity of tin is 7.3, and its specific heat 0.0562.

USES

Tin is used in the dental office and laboratory in the form of foil for filling teeth and for covering plaster models in vulcanite work, to give a finished surface to rubber. After being vulcanized, the foil is removed. It is questionable whether this is a good plan to follow, since the model is enlarged by the addition of the foil, which must impair the close adaptation of the denture to the tissues.

Tin is also one of the principal ingredients in the composition of dental amalgam alloys, from 22 to 35 per cent being used with 77 to 65 per cent of silver.

HASKELL'S BABBITT METAL

It is also used in the composition of fusible alloys and counterdie metal, and forms in conjunction with copper and antimony a hard and practically non-contractile die material, known as Babbitt's metal.

The formula for Haskell's Babbitt metal is Cu 1, antimony 2, tin 8 parts.

The counterdie metal used in conjunction with Babbitt's metal is: Lead 7, tin 1 part. The tin is added to reduce the melting point of the lead. Babbitt's metal melts at 260° C., while the fusing point of lead is 327.4° C. If lead is poured upon a Babbitt metal die, the heat is sufficient to fuse the latter, and union of the two will very likely occur.

This undesirable result is obviated by the addition of tin to lead in the proportions before mentioned, which gives an alloy with a fusing point of about 225° C.

MERCURY

Mercury sometimes occurs in nature free, though it is commonly found as the red sulphide Hg. S., called cinnabar. It is frequently found forming an amalgam with silver, and also in the form of a protochloride or native calomel.

DISTRIBUTION

Mercury is found in Spain, Corsica, Mexico, California, Peru and China.

At the present time California produces a greater bulk than any other country in the world. The ore is very rich in mercury, yielding as high as 70 per cent, while the ore from the Spanish mines, the next largest producers, yields only 38 per cent.

COMBINATIONS

Mercury forms two oxides, mercurous oxide, Hg_2O, and mercuric oxide, Hg O. It also forms two chlorides of prominence, $HgCl_2$— *corrosive sublimate* — a powerful disinfectant, and $Hg_2 Cl_2$, called *calomel.*

Vermilion — or mercuric sulphide, Hg. S.— a brilliant red color, is used extensively as a pigment in paints and for the coloring agent in the manufacture of red and pink rubber and celluloid.

As is well known, mercury is extensively employed for thermometers, barometers, etc., and for many other useful purposes in the arts and sciences.

ALLOYS OF MERCURY

Mercury unites with many of the metals to form amalgams. It is used very extensively with dental alloys for the filling of teeth.

PROPERTIES

Mercury is silver white in color, tarnishes slightly in air, but is not acted upon by water. It is tasteless and odorless. It is liquid at ordinary temperature, boils at 357.3° C., and can be solidified by subjecting it to a temperature of —38.9° C. It contracts noticeably in passing from the liquid to the solid state, and assumes a crystalline form. When solid it can be flattened out under hammer blows, thus proving that it is malleable. In this condition it can also be welded, and can be cut into shavings with a knife.

The specific gravity of mercury is 13.6, specific heat .0333, and its atomic weight 200.6.

REDUCTION

Mercury is obtained from the native sulphide in two ways. The first method consists in crushing the cinnabar ore and mixing with lime. The mixture is then placed in cast-iron retorts, which are connected with earthenware receivers partially filled with water. Upon the application of heat the sulphur combines with the calcium and forms calcium sulphide, while the mercury is distilled over and condensed in the receivers.

$4HgS + 4CaO = 3CaO + CaSO_4 + 4Hg$. The second method of recovery consists in exposing the ore directly to the oxidizing flame, and conducting the mercurial vapor with suitable apparatus into condensers.

Nickel

Nickel is a silvery white metal, with a brilliant luster, which does not tarnish readily in air. It is as tenacious as iron, is ductile, hard, and somewhat malleable. It is slightly magnetic, resembling iron somewhat in this respect. Its specific gravity is 9, increased by hammering to 9.93. Specific heat .1108. Atomic weight 58.68, and fuses at about 1452° C. Nickel is used extensively with copper to form german silver — an alloy which, on account of its color, hardness, tenacity, and many other good qualities, is used in large quantities for innumerable purposes.

A common formula for german silver is: Copper 55, zinc 25, nickel 16 parts each.

The hardness and strength of steel is increased by the addition of a small per cent of nickel. This alloy is known as armor plate, and is used in the construction of warships.

USES

This metal is made use of to a great extent for plating purposes, since it does not readily tarnish, is not easily oxidized, and can be quickly and firmly deposited upon iron, steel, brass, german silver, and copper, by electro-deposition.

Bismuth

Bismuth is a crystalline metal of a gray-white color, with a decidedly reddish tinge. On account of its highly crystalline character it can be easily pulverized. It is almost totally lacking in the qualities of malleability, ductility, and tenacity. Its specific gravity is 9.75, and specific heat 0.0308. Fuses at 271° C. Atomic weight 208.

Bismuth is the most diamagnetic element known, a sphere of it when suspended close to, is repelled by a magnet.

Bismuth is very useful in the composition of fusible alloys, reducing the fusing points of the more difficultly fusible ingredients, and imparting clearness and sharpness of outline to castings made from such alloys.

In conjunction with tin and lead, it forms a number of alloys which are in constant use in the dental laboratory. The following is a partial list of such alloys:

FUSIBLE ALLOYS

Name	Bismuth	Tin	Lead	Cad-mium	Mercury	Antimony	Melting Point
Hodgen's metal	8	3	5			2	105° C.
Mellotte's "	8	5	3				100° C.
Essig's "	3	5	3				96° C.
Darcet's "	4	1	3				96° C.
Rose's "	2	1	1				95° C.
Newton's "	8	3	5				94° C.
Onion's "	5	2	3				92° C.
Wood's "	4	1	2	1			65° C.
Lipowitz's "	15	4	8	3			63° C.
Darcet's "	2	1	1		10		45° C.

In compounding alloys of this character they should be melted under charcoal to prevent oxidation, and stirred with a stick of soft wood just before pouring, to prevent the lead from separating.

When cadmium or mercury are incorporated, the other metals should be melted first, and these added just before pouring, to prevent volatilization.

Antimony

Antimony usually occurs as a sulphide, and with other metals, as silver, iron and copper. It is reduced by heating the sulphide with scrap iron, iron sulphide being formed and the antimony set free.

PROPERTIES

It is extremely low in malleability, ductility and tenacity, being crystalline in structure and very brittle. The atomic weight of antimony is 120.2, fusing point 630° C., specific gravity 6.7, specific heat .0508.

Its principal uses in dentistry are as a component of Haskell's Babbitt metal and for certain low-fusing alloys. It is also used extensively in the manufacture of type for printing, as alloys containing antimony expand in cooling, thus insuring sharp castings.

Primarily common Babbitt meetal is an anti-friction alloy, and that intended for such purpose contains a larger percentage of copper and antimony, while it is softer and more easily defaced than that prepared after the formula of Dr. Haskell. (See page 1087.)

Britannia metal is an alloy used for making spoons, teapots, trays, etc., and is composed of several metals and in different proportions.

The following is one of the formulas much used: Copper 1.85, tin 81.90, antimony 16.25. Zinc, lead and bismuth are also used in some of the formulas of this alloy.

Tungsten

Tungsten occurs combined with ferrous oxide in the mineral called wolfram, or wolframite, $FeWO_4$, also with calcium in the mineral called scheelite, $CaWO_4$. These are called the tungstates of iron and calcium, respectively.

Its principal use until recently was as a mordant in dyeing and a fireproofing material for cotton goods. It has also been used as a hardening component for steel, usually in the proportion of from 5 per cent to 9 per cent.

PHYSICAL PROPERTIES

The fusing point of tungsten is 3000 C. Atomic weight, 184. Specific gravity, 19.2. Acids have but slight effect upon the metal at ordinary temperatures. It is very difficult to convert the powder, in which form it is usually sold commercially, into a solid, on account of its extremely high fusing point. By heavy compression into definite form, and the application of an electric current of high amperage, coupled with careful swaging, the rod or bar of compressed powder is gradually rendered compact and the granules sufficiently coherent to enable it to be drawn out into wires of various sizes, even as fine as the 1/1000 of an inch.

At high temperatures it is readily oxidized, unless protected from the air. This deleterious property, however, does not inhibit its use for electric lamp filaments, since it is placed within a vacuum globe or one filled with nitrogen. In either case the oxygen is excluded, and consequently oxidation does not occur.

USES

Dr. Weston A. Price, of the Scientific Research Commission of the N. D. A., presented a paper on metals and alloys at the meeting in Rochester, N. Y., in July, 1915, in which some of the valuable points of this metal were disclosed. In that he showed that the high fusing point of tungsten, its low range of expansion, its great rigidity and hardness, rendered it extremely valuable in prosthetic operations.

A bar of this material, threaded, coated with palladium or gold to prevent oxidation, and invested in a matrix for a complex inlay, the wire extending mesio-distally through the casting, practically inhibits the contraction of the gold on itself, which, without such control, always occurs in cooling. Its rigidity, coupled with great tensile strength, renders it specially valuable for dowels in crowns and inlays.

The principal disadvantages are its oxidation at soldering and casting temperatures and the difficulty in fusing any of the metals to it in the open air because of such oxidation.

The solution offered was to coat the wire with an alloy of Pd-Au or PdAg., after which gold may be cast or soldered to it readily.

To illustrate its hardness, mention was made of the fact that a phonographic needle of tungsten will outwear two hundred of the standard hard-steel points in common use. The possibilities of this metal for use in cutting instruments was suggested, when the methods of working it are better developed.

The Measurement of Plate and Wire

In all scientific and mechanical fields, the accurate determination of weights, dimensions and strength of materials, when such measurements are called for, is a recognized necessity; the same holds true in prosthetic procedures, for without a reasonably accurate knowledge of the strength of the various materials entering into the structure of replacements, the prosthetist's efforts will often prove inefficient.

Gold, platinum, and various other metals, are reduced from *ingot* form to *plate* by means of a device called a *rolling mill.* This may be done in the dental laboratory with proper equipment.

More often, however, the prosthetist obtains the precious metals in plate form, direct from the supply houses.

In either case, it is essential that the laboratory be equipped with suitable measuring devices for testing the different gauges of material used.

The measurement of the thickness of gold and platinum plate and the gauging of the diameter of wire in an intelligent manner — that is, so that a just estimate may be formed of the relative thickness and strength of the materials being used — aids materially in the planning and construction of successful prosthetic substitutes of all classes.

With this end in view, the prosthetist should become familiar with, and can to advantage apply in practice, the methods and instruments used by scientists and artisans in other lines of work.

Various measuring devices are in use for determining the thickness of plate and the diameter of wire, as well as for

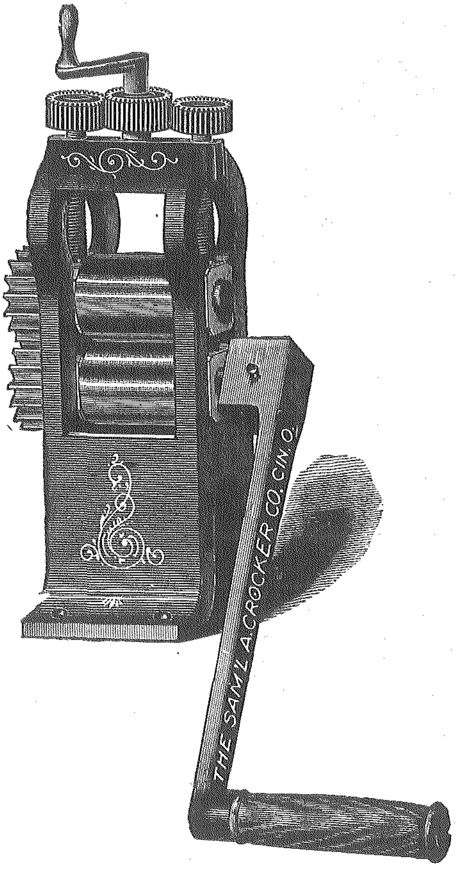


Fig. 978.— A Common Type of Rolling Mill

sundry other measurement readings. These instruments are known under the common name of *gauges, calipers,* etc., the forms of which vary, depending upon the purposes for which they are designed.

THE UNIT OF MEASUREMENT OF GAUGES

The unit of measurement of gauges used in England and the United States is generally the fractional part of an inch and of the millimeter.

LACK OF UNIFORMITY OF THE VARIOUS GAUGE SYSTEMS

With exceptions to be noted, most of the various gauge systems do not show a uniformly decreasing ratio from thick to thin measurements, but the steps between the various gauge numbers appear to have been arbitrarily established, without following any fixed standard.

THE BIRMINGHAM GAUGE

This is true of the *Birmingham,* also known as the *English Standard,* and again as *Stub's Soft Iron Wire Gauge,* so called to distinguish it from *Stub's Steel Wire Gauge.* The discrepancies noted are plainly apparent in this gauge, as will be seen by examining the first few largest numbers.

DISCREPANCIES OF THE BIRMINGHAM GAUGE

No. 0000 = .454 of an inch.	No. 0 = .340
No. 000 = .425	No. 1 = .300
Difference .029	Difference .040
No. 000 = .425	No. 1 = .300
No. 00 = .380	No. 2 = .284
Difference .045	Difference .016
No. 00 = .380	No. 2 = .284
No. 0 = .340	No. 3 = .259
Difference .040	Difference .025

To summarize, the difference between the first seven numbers of the Birmingham gauge is as follows: .029—.045—.040—.040—.016—.025.

The Birmingham gauge was for years used extensively, but not exclusively, in this country, in machine-shop practice and various other fields. Some wire and plate manufacturers used one gauge, some another. More or less confusion and misunderstanding naturally resulted, since no one gauge system was accepted as standard and each varied slightly from the others.

THE BROWN AND SHARP GAUGE

To correct the discrepancies noted, the Brown & Sharp Manufacturing Company of Providence, R. I., designed a gauge having approximately the same range of measurement as the Birmingham, but the various gauge numbers, from the largest downward, decrease in a definite ratio.

This gauge has proven so satisfactory that it has been generally adopted in this country, and is now known as the *American Standard Gauge.* It should not, however, be confounded with the *United States Standard Gauge,* which was designed for, and approved by, Congress in 1893, and is used in determining duties and taxes levied by the United States Government on sheet and plate iron and steel.

The principle on which the Brown & Sharp gauge is constructed is as follows: Two straight bars of steel are fitted together at one of their ends, and permanently fixed in such manner as to form a divergent space between the two, about one-half inch across at the outer end of the gauge. The gauge numbers are marked on the inner edges of the arms, next the divergent space. The general form of this gauge is similar to the jeweler gauge. (See page 1096.)

No. 0000, or .46 of an inch, is the largest dimension of the gauge, and from this all of the other gauge dimensions are, either directly or indirectly, derived.

The next lowest dimension — No. 000 — is obtained by multiplying its predecessor, .46, by 0.890522, which is equivalent to deducting 10.9478 per cent. Each succeeding lower number is obtained in a similar manner, by multiplying the last determined gauge length, or thickness, established, by the decimal above given.

It will thus be seen that any gauge number under 0000 is approximately 10 per cent less than the preceding higher, or greater than the succeeding lower number. The steps between the various gauges represent gradual and uniform decrements as the gauge numbers, although rising numerically, become thinner. The last gauge of the scale is No. 40, or .003144 of an inch thick, although still thinner numbers can be correctly formulated by the plan given.

Forms of Gauges

THE JEWELER'S GAUGE

The jeweler's gauge is based upon the same general principle as the original Brown & Sharp gauge, viz., two rigidly fixed, diverging arms. These are graduated on the inner margins so as to read in multiples of one-thousandths of an inch.

Although the form of gauge just described is suitable and very convenient for measuring wire and small rods, it is not well adapted for gauging plate, because the edge of the latter is very frequently marred in shearing, so that a marginal reading, in such cases, will seldom be accurate. Some form

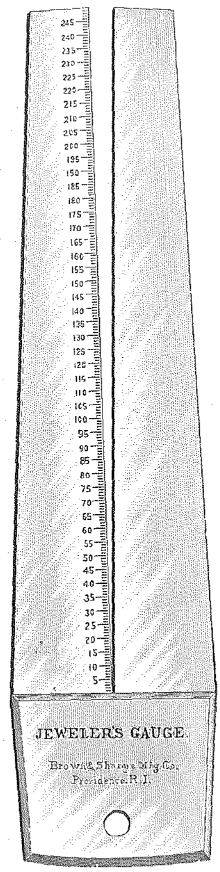


Fig. 979.— A Jeweler's Gauge Reading to the 1-1000 of an Inch

of appliance capable of passing beyond the margin of the plate, and calipering undisturbed surfaces, is, therefore, necessary for securing accurate measurements.

THE PLATE AND WIRE GAUGE

One of the most common forms of plate and wire gauge in use consists of a steel disc about two and one-half inches in diameter and one-eighth of an inch thick. In the periphery of this disc are accurately cut and numbered slots, which represent the thickness of the various gauge numbers of the system used. To measure a piece of plate or wire, the various slots of the gauge are applied to the piece until a neat fit is obtained, or, in case the piece being measured is not of exact gauge thickness, the two proximating gauges are found, one of which is larger and the other smaller than the wire or plate being calipered. This form of gauge, as before stated, is

Fig. 980.— An Ordinary Form of Gauge for Plate and Wire

satisfactory for measuring standard thickness of plate and wire, but is not adapted to accurate and universal readings, when the materials are not standardized.

THE MICROMETER CALIPER

An instrument of this type consists of a U-shaped steel frame, the arms of which are parallel. One arm is threaded and contains the adjustable screw, by means of which readings are made. The other arm holds an adjustable stop, which is never moved except for adjustment purposes, when the instrument is worn or sprung. The face of the stop and the end of the screw, presented toward it, form exactly parallel planes. The object to be gauged is placed, one side against the face of the stop, while the screw in the other arm is brought in contact with the opposite side. The reading is made in the screw spindle and on the hub, or nut, through which it passes. In the following description, the micrometer graduated to read to the 1/1000 of an inch, will be used as an example of this general type. Some of the more recent forms have a vernier attachment, by means of which readings can be made as fine as the 1/10000 of an inch.

The screw spindle has a hollow head in the form of a deep sleeve, which telescopes over the cylindrical extension of the nut of the frame. As the screw is turned toward or away from the stop in the opposite arm, the sleeve rotates and travels with it. The inner end of the sleeve is beveled and graduated into 25 equal parts, and numbered 0, 5, 10, 15, 20, while 25 is reached on the complete revolution to 0. When the screw is closed and in close contact with the stop, the 0 of the sleeve stands opposite the 0 on the nut. The screw pitch is 40 — that is, there are 40 threads to the inch on the spindle. By multiplying the divisions on the sleeve by the number of threads to the inch on the spindle, it will be seen that 1,000

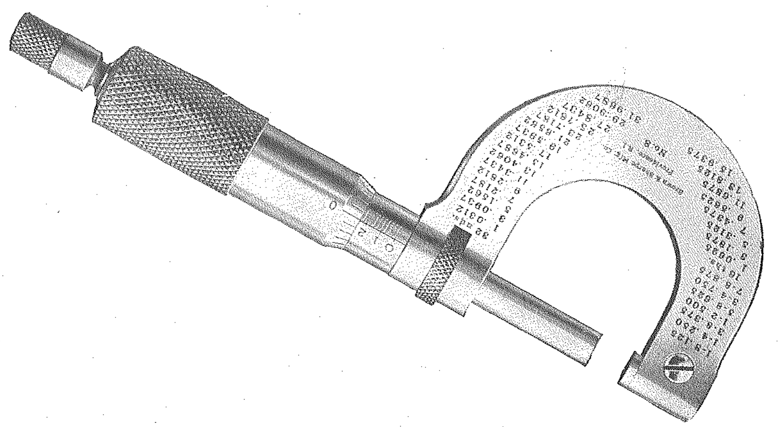


Fig. 981.— A Micrometer Gauge Reading to the 1-1000 of an Inch

divisions must pass the longitudinal line on the hub in moving the screw outward one inch. Each division, therefore, registers the 1/1000 of an inch movement of the screw toward or away from the stop in the opposite arm. To facilitate rapid readings of pieces of considerable thickness, the hub is also graduated. The space between the gradations on the hub, or nut, is equal to the distance between contiguous threads. As the screw is turned once around, in opening, an unexposed gradation appears on the hub under the edge of the sleeve, showing that the screw has been moved 25/1000 of an inch. Every fourth gradation on the hub is accordingly numbered, the beginning or closed position of screw being 0, the fourth division 1, or 100/1000; the second 2, or 200/1000, etc.

In using this gauge three sources of error must be kept in mind, viz., imperfect paralleling of the piece being measured, with the face of the screw; excessive pressure will spring the frame and give imperfect results; slight variation in the pitch of the screw, due to wear.

No dust or dirt should adhere to the screw, stop or piece being gauged. A spring ratchet is frequently applied to the extreme outer end of the screw to insure against excessive force being applied in making measurements.

Various Systems of Wire and Plate Gauges and Their Equivalents in Thousandths of an Inch

For convenience in finding any required gauge, the wire and plate gauge numbers are given on the right and left sides of the table.

No. of Wire Gauge.	Brown & Sharp American Standard	Difference between Consecutive Numbers in Decimals.	Birmingham or Stub's Wire.	Washburn & Moen Co. Wire.	Imperia Wire Gauge.	Stub's Steel Wire.	U.S.Standard for Plate.	Piano W. & M. Wire Gauge.	No. of Wire Gauge.
000000	....	....	....	....	.464	....	.46875	.0095	000000
00000	....	....	....	....	.432	....	.4375	.010	00000
0000	.46	....	.454	.3938	.400	....	.40625	.011	0000
000	.40964	.05036	.425	.3625	.372	....	.375	.012	000
00	.3648	.04484	.38	.3310	.348	....	.34375	.0133	00
0	.32486	.03994	.34	.3065	.324	....	.3125	.0144	0
1	.2893	.03556	.3	.2830	.300	.227	.28125	.0156	1
2	.25763	.03167	.284	.2625	.276	.219	.265625	.0166	2
3	.22942	.02821	.259	.2437	.252	.212	.25	.0178	3
4	.20431	.02511	.238	.2253	.232	.207	.234375	.0188	4
5	.18194	.02237	.22	.2070	.212	.204	.21875	.0202	5
6	.16202	.01992	.203	.1920	.192	.201	.203125	.0215	6
7	.14428	.01774	.18	.1770	.176	.199	.1875	.023	7
8	.12849	.01579	.165	.1620	.160	.197	.171875	.0243	8
9	.11443	.01406	.148	.1483	.144	.194	.15625	.0256	9
10	.10189	.01254	.134	.1350	.128	.191	.140625	.027	10
11	.090742	.01105	.12	.1205	.116	.188	.125	.0284	11
12	.080808	.00993	.109	.1055	.104	.185	.109375	.0295	12
13	.071961	.00885	.095	.0915	.092	.182	.09375	.0311	13
14	.064084	.00788	.083	.0800	.080	.180	.078125	.0325	14
15	.05768	.00702	.072	.0720	.072	.178	.0703125	.0343	15
16	.05082	.00625	.065	.0625	.064	.175	.0625	.0359	16
17	.045257	.00556	.058	.0540	.056	.172	.05625	.0378	17
18	.040303	.00495	.049	.0475	.048	.165	.05	.0395	18
19	.03589	.00441	.042	.0410	.040	.164	.04375	.0414	19
20	.031961	.00393	.035	.0348	.036	.161	.0375	.043	20
21	.028462	.00350	.032	.03175	.032	.157	.034375	.0461	21
22	.025347	.00311	.028	.0286	.028	.155	.03125	.0481	22
23	.022571	.00278	.025	.0258	.024	.153	.028125	.0506	23
24	.0201	.00247	.022	.0230	.022	.151	.025	.0547	24
25	.0179	.00220	.02	.0204	.020	.148	.021875	.0585	25
26	.01594	.00196	.018	.0181	.018	.146	.01875	.0626	26
27	.014195	.00174	.016	.0173	.0164	.143	.0171875	.0663	27
28	.012641	.00155	.014	.0162	.0149	.139	.015625	.719	28
29	.011257	.00138	.013	.0150	.0136	.134	.0140625	.076	29
30	.010025	.00123	.012	.0140	.0124	.127	.0125	.080	30
31	.008928	.00110	.01	.0132	.0116	.120	.0109375	....	31
32	.00795	.00098	.009	.0128	.0108	.115	.01015625	....	32
33	.00708	.00087	.008	.0118	.0100	.112	.009375	....	33
34	.006304	.00078	.007	.0104	.0092	.110	.00959375	....	34
35	.005614	.00069	.005	.0095	.0084	.108	.0078125	....	35
36	.005	.00061	.004	.0090	.0076	.106	.00703125	....	36
37	.004453	.00055	....	....	.0068	.103	.006640625	....	37
38	.003965	.00049	....	....	.0060	.101	.00625	....	38
39	.003531	.00043	....	....	.0052	.099	....	....	39
40	.003144	.00039	....	....	.0048	.097	....	....	40

Tables of Some of the Various Gauge Systems in Use

The table of gauges which is here appended will enable any one to determine accurately, by means of a micrometer gauge, the relative thickness of plate and wire, regardless of what system of gauging has been used by the manufacturer in its production.

Attention is specially called to the table of piano-wire gauges, as it is at variance with the other systems tabulated. The diameters, or thicknesses, of the gauges in this system increase as the numbers rise numerically. Since piano wire is used extensively in orthodontic operations, those engaged in this specialty will find the table of assistance in judging the relative thickness of the various sizes of wire employed.

Practically all supply houses use the American Standard, also called the Brown & Sharp gauge, for gauging the precious metals. For this reason, therefore, distinction should be made between the American Standard gauge, which is almost universally employed for the purpose mentioned, and the United States Standard gauge, the principal use of which, as before stated, is in the measurement of iron and steel plate, and is seldom used in prosthetic operations.

CHAPTER XXXIII

A BRIEF HISTORY OF PROSTHETIC DENTISTRY

An exact and detailed history of the treatment of dental lesions, spanning the period from very ancient to modern times, however interesting and instructive it might prove, has not been and never can be written, because of lack of accurate and consecutive data.

Many of the records of earlier times on this subject are incomplete, or sadly lacking in detail; some have been lost; and still others now in existence are only copies of manuscripts having a much earlier origin.

Some of the original old records now remaining, rest in government archives of Old World countries, or in the libraries of their universities.

To the uninitiated student of dental lore, many of these historic treasures, written in a foreign, dead, or almost undecipherable and forgotten language, have been until recently as completely out of his reach as though they never existed.

The efforts of a number of men, fitted by training and experience, and conveniently located near to these manuscript depositories as well, have been directed to clearing up and collating such ancient and mediæval historical data of medicine and dentistry as are available. Notable among these the names of Prof. George Ebers, a celebrated German Egyptologist, and Dr. Vincenzo Guerini, of Naples, Italy, stand out most prominently.

THE EBERS PAPYRUS

In 1873 Professor Ebers obtained from "an inhabitant of Luxor, Upper Egypt," a manuscript written in hieratic characters on papyrus paper, which upon deciphering proved to be the most complete, as well as probably the most ancient of the early records relating to the treatment of disease, both general and dental.

Two translations of this manuscript have been made, one by Professor Ebers in 1875, and the other by Dr. Heinrich Joachim in 1890. Quoting from Guerini, the scope and antiquity of this manuscript is made apparent:

"Lepsius, and with him the greater part of Egyptologists are of the opinion that the Ebers papyrus is not an original work at all, but simply a copy of medical writings of still earlier date, belonging to different epochs, and which were collected and reunited to form a kind of manual on medicine.

ANTIQUITY OF THE PAPYRUS

"From some indications existing in the papyrus itself, Ebers has been able to argue, with quasi certainty, that the papyrus was written toward the year 1550 B. C. But some parts of it have their origin in a far more remote epoch; they go back, that is, to thirty-seven centuries or more before the Christian era. In fact, at page ciii of the Ebers papyrus one reads:

"'Beginning of the book about the treatment of the *uxeda* in all the members of a person, such as was found in a writing under the feet of the god Anubis, in the city of Letopolis; it was brought to His Majesty Usaphais, King of Upper and Lower Egypt.' Now, as Joachim remarks, the Usaphais herein named was the fifth king of the first Egyptian dynasty, and he reigned toward 3,700 years before the Christian era. Hence, it may be argued that some, at least, of the writings from which the Ebers papyrus was taken were composed in the very remote epoch to which we have just alluded, or perhaps still farther, for it is impossible to know whether the book, deposited by unknown hands at the foot of the statue of the god Anubis, had been written but a short time previous or at a much earlier epoch."—Guerini.

This suggests a possible age of 5,600 years for some of the prescriptions offered for the relief of pain. The *uxeda* mentioned literally means *a painful swelling,* and might apply to inflammatory conditions, accompanied by swelling, in any part of the body, alveolar abscess included. In fact, specific mention is made in several places, of remedies for the cure of "growth of the uxeda in the teeth (alveolar abscess?) and also "bennut blisters in the teeth," the latter supposed to mean small fistulous openings to abscesses of dental origin.

No reference of any sort in regard to prosthetic operations is found in the papyrus. It does not follow, however, that prosthesis was not attempted in very ancient times. In fact, positive evidence exists to prove that replacement of one or more teeth was a recognized, although perhaps not common method of practice, almost or quite 3,000 years ago. Mention of this will be made later.

GUERINI'S HISTORY OF DENTISTRY

Within recent years, the most thorough, exhaustive, and painstaking inquiry in ancient and mediæval history of dentistry ever undertaken by one individual, has been carried out by Dr. Vincenzo Guerini, of Naples, Italy. It represents an effort on the part of this distinguished gentleman, quoting his words, to "contribute to the diffusion of exact historical knowledge as to the origin and gradual development of dentistry."

The results of his labours, which represent a vast amount of research work and much financial outlay as well, he has generously presented to the profession in America, through the National Dental Association, as a token of his appreciation of American progress in dental science and development.

That the results of Dr. Guerini's efforts are appreciated, not only by the profession of America, but of the world, goes without saying. His work is frequently quoted by writers on historical dental subjects, and with a feeling of security as to fact, hitherto noticeably lacking in much of the previously available data, because of its questionable authenticity. Much of the contents of the present chapter is based either directly or indirectly upon Guerini's work.

The facts as presented in Guerini's History lead to the belief that the origin of dentistry was coeval with that of medicine; that in all probability, in very ancient times, dentistry as a specialty was not recognized as such, and therefore the treatment of dental lesions came properly within the domain of the medical practitioner.

Although the statement has repeatedly been made that teeth filled with gold and various substances, and prosthetic pieces of different forms, have been found in the sarcophagi of mummies, in the pyramids and necropoli of Egypt, the fact has not been substantiated. Schmidt, Ebers, Virchow and Mummery, all of whom devoted considerable effort to this phase of research, failed to find authentic specimens of the classes of work mentioned. Neither has Guerini, in his examination of ancient specimens or in historical research, found anything to indicate that the very early Egyptians knew "how to insert gold fillings, and still less to apply pivot teeth." He further states, however, that, although the direct proof may be lacking, he *believed* the Egyptians knew how to apply artificial teeth.

He bases his deduction on the following: "And even though it may not be possible to demonstrate this by direct proof, one is equally prone to admit it when one considers on the one hand, the remarkable ability of the ancient Egyptians in all plastic arts, and, on the other hand, the great importance they attributed to beautifying the human body; so much so, that even in so ancient a document as the Ebers papyrus, one finds formulæ for medicaments against baldness, for lotions for the hair, and other kinds of cosmetics. Is it not likely, therefore, that so refined and ingenious a people should not have found the means of remedying the deformity resulting from the loss of one or more front teeth?"

THE PHŒNICIANS

The ancient Phœnicians, a race of Semitic origin, were a thrifty nation of maritime traders. Their country, the northern Palestine Mediterranean coast land, afterwards known as Canaan, consisted of a strip about 15 miles wide and 150 long. It lay between the Lebanon Mountains and the sea, on the borders of which were situated the populous cities of Tyre, near the center, and Sidon to the north. All of the principal ports of the world were known to, and visited by her merchantmen, whose bartering excursions and voyages of discovery brought them in contact with the traders, artisans, and scholars of many lands.

EFFECT OF EGYPTIAN CIVILIZATION ON PHŒNICIA

Beginning about 1700 B. C. Egypt assumed a protectorate over Phœnicia, which was maintained for about three hundred years. This political bond, coupled with mutual commercial exchange, brought the people of the two countries into close business and social relations with each other.

Since the beneficent influence of Egypt's advanced civilization was felt and recognized in the known remote corners of the earth in those times, it naturally followed that Phœnicia, by reason of the connection noted, must have benefited thereby, and appropriated to herself some of the advanced ideas of the older country in culture, fine arts and medical science.

ONE OF THE MOST ANCIENT SPECIMENS OF PROSTHETIC ART

Now, although she has left no papyrus scrolls, no pyramids, no obelisks to commemorate important historical events, Phœnicia has left what Egypt has not, viz., a well preserved specimen of ancient prosthesis. How old this piece may be no one can tell, but that it is very ancient there can be no doubt. The outline of Guerini's history of it is about as follows:

In 1862, Dr. Gaillardot, connected with Renan's Syrian Exploring Expedition, found in the most ancient part of the necropolis of Sidon, a part of the *upper jaw* of a woman, in which the six anterior teeth were united together with gold wire. A central and proximating lateral incisor appear

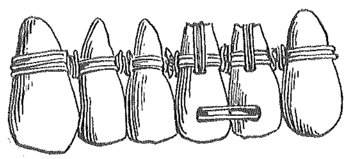


Fig. 982.—Phœnician Appliance Found at Sidon, as Represented in a Cut of Renan's Mission de Phenice (Guerini)

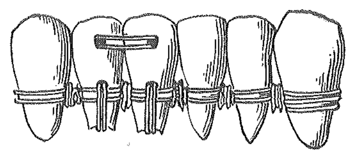


Fig. 983.—The Same Figure Reversed, as It Ought to Be if the Piece Found at Sidon Belonged to a Lower Jaw (Guerini)

to have belonged to another person, and from the manner of their attachment were substituted for lost teeth. This piece is now in the Louvre in Paris. In addition to this prosthetic piece there were also found in the same grave two copper coins, an iron ring, a vase of most graceful outline, a scarab, and twelve very small statues of Egyptian deities, probably a necklace, judging by the holes bored in them.

Concluding his remarks on "Dental Art Among the Egyptians," Guerini says:

"The remains discovered in many of the Phœnician tombs would of themselves alone be sufficient to demonstrate luminously, the enormous influence exercised by the Egyptian civilization on the life and customs of that people. Now, if there were dentists in Sidon capable of applying false teeth, it may reasonably be admitted that the dentists of the great Egyptian metropoli, Thebes and Memphis, were able to do as much and more, the level of civilization being without doubt higher there than in Tyre or in Sidon, or in other non-Egyptian cities."

THE ETRUSCANS

The Etruscans were a people who inhabited Upper Central Italy from about 800 B. C. to 283 B. C., when they were conquered by the Romans. One author has said of them: "Ancient writers concur in representing the Etruscans as the most cultivated and refined people of ancient Italy, and as especially skillful in ornamental and useful arts, in which the ideas and patterns used singularly resemble those of Egypt."—"They made great progress in architecture, sculpture, and painting, and especially in bronze work and gold jewelry."—"They excelled in agriculture, navigation, engineering and in useful public works." (Universal Encyclopedia.)

Guerini says: "They were a laborious and courageous race, not only active in agriculture, in art and commerce, but also brave warriors and hardy navigators. In their long sea voyages the Etruscans frequently visited Egypt and Phœnicia, trading especially in the more flourishing cities, which were at that time Memphis, in Egypt, and Tyre and Sidon in Phœnicia. On the other hand, the Phœnicians, who were also active merchants and navigators, not only visited Etruria and other regions of Italy very frequently, but also established numerous colonies in many islands of the Mediterranean, and especially in those nearer Italy.

"This continual intercourse between Etruscans on one side, and Egyptians and Phœnicians on the other, accounts for the great influence exercised by the Egyptians and Phœnician civilization upon the later developed Etruscan culture — an influence manifesting itself very distinctly in the works of art of the latter, which often have an altogether Oriental character, and not seldom represent scenes drawn from the domestic life of the Egyptians and Phœnicians.

ETRUSCAN DENTAL ART

"As to what concerns dental art, everything leads up to the belief that it was practiced by the Egyptians and Phœnicians earlier than by the Etruscans, whose civilization, as already hinted, is certainly less ancient. Nevertheless, in comparing the dental appliances found in the Etruscan tombs with the sole and authentic dental appliance of Phœnician workmanship known at the present day, we cannot but be struck with the greater superiority of the Etruscan appliances. It is therefore probable that the Etruscans, although they had learned the dental art from the Egyptians and Phœnicians, had subsequently carried it to a much higher degree of perfection than it had arrived at in Egypt or in Phœnicia."

A number of specimens of ancient prosthetic appliances of Etruscan workmanship have been found within recent years, the genuineness of which are unquestioned. Most of these specimens are preserved in various Italian museums. Some of them are illustrated in Dr. Guerini's admirable work, a few of which are here reproduced.

In an excavated tomb at Valsiarosa, near the ancient Falerii, was found an appliance consisting of four gold rings

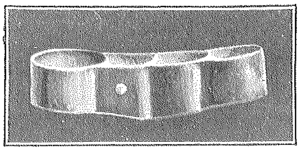


Fig. 984.— Etruscan Appliance Found at Valsiarosa, Destined to Support an Artificial Bicuspid, Now Disappeared (Guerini)

soldered together and fitted to the cuspid, first bicuspid, and first molar. The ring over the site of the second bicuspid, the missing tooth, had a rivet extending through it from buccal to lingual, evidently intended for holding the substituted tooth, which, however, was lost.

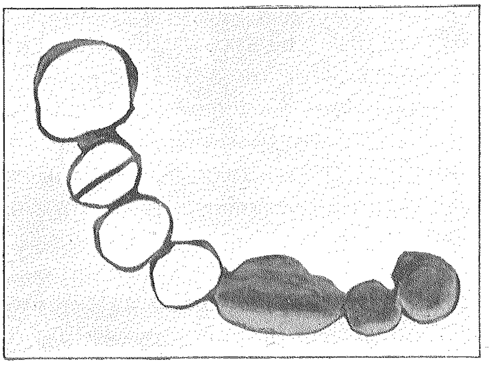


Fig. 985.— Etruscan Appliance for Supporting Three Artificial Teeth, Two of Which Were Made from One Ox Tooth (Civic Museum of Corneto) (Guerini)

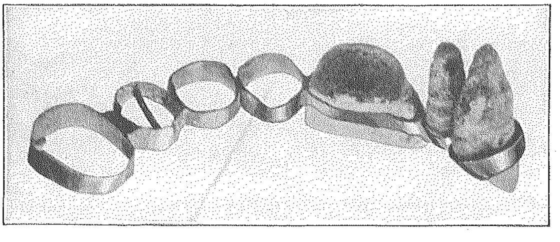


Fig. 986.— The Same Appliance Reversed

Guerini suggests that the substitute tooth may have been made of some destructible material, and had disintegrated, or that it might have been slotted at its base to pass on either side of the rivet, and not having been rigidly fixed within the ring, was dislodged and lost during the excavation. This appliance is now in the museum of Pope Julius, in Rome.

Two appliances similar in character to the one just described will serve to illustrate the general type of the ancient prosthetic pieces found in other Etruscan tombs, and which are supposed to be about 3000 years old. Both of these specimens repose in the civic museum of Corneto, the ancient city of Tarquinii.

The first of these specimens to be described consists of bands of pure gold, soldered together and fitted to the cuspid and lateral on the right, and to the cuspid, first bicuspid, and first molar on the left side. A band of gold containing a rivet extending through it from buccal to lingual, occupies the site of the missing natural second bicuspid, and served for the attachment of its substitute, the latter, however, having become disintegrated or in some manner, lost. A single, elongated band of gold, occupying the space of the three missing anterior teeth, extends from the right lateral to the left cuspid. Fitted within this band and filling the entire space, was a wide ox tooth, grooved longitudinally in its center to represent two central incisors. The space once occupied by these three teeth, having closed slightly, no effort was made to reproduce the lateral incisor. This block was firmly fixed in position by means of two rivets. (Figs. 985 and 986.)

Whether the dentist in this case recognized the prophylactic advantage of keeping the gingival ends of the bands as far removed from the gum line as possible, or was merely

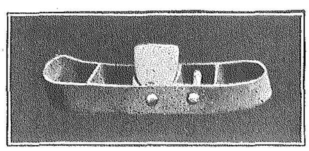


Fig. 987.— Etruscan Appliance for Supporting Two Inserted Human Teeth, One of Which Is Now Wanting (Civic Museum of Corneto) (Guerini)

actuated through motives of convenience in fitting and attaching the appliance, cannot, of course, be determined, but the fact is apparent that the bands occupied a position well toward the incisal and occlusal third areas of the anchor teeth.

The second specimen consisted of two strips of rolled gold, adapted, one labially and the other lingually to the remaining anterior teeth, and soldered at their extremities to form an elongated band. Four small sections of gold, spaced and soldered within this elongated band, divided it into five square spaces. Three of these spaces were occupied by supporting natural teeth. The other two spaces served as sockets to carry the substitutes, which in this case were natural teeth, one of which was missing. The same method of anchorage as previously described — the rivet — was used for attaching the substitute teeth to the gold structure. (Fig. 987.)

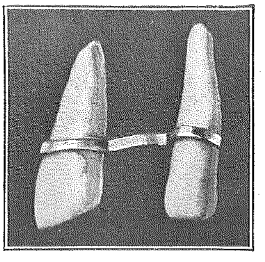


Fig. 988.— Etruscan Appliance Intended to Avoid the Bad Effects of Convergence, or, Perhaps, to Support a Purely Ornamental Artificial Substitute (Museum of Conte Bruschi at Corneto) (Guerini)

These methods of wiring and banding together, with gold, loose natural teeth, and of applying the same means for the retention of substitutes for missing teeth, in the manner described, represent quite fully the first efforts of the early dentists in bridge construction.

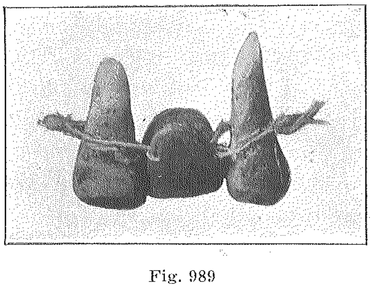


Fig. 989

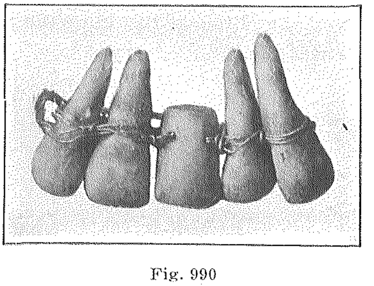


Fig. 990

Examples of Dental Prosthesis as Practiced by the Hindus at the Present Time (Guerini)

The addition of a saddle to rest upon the border, and thus furnish greater support and security to the substitute than was afforded by ligating or banding to the proximating, and adjacent teeth, was evidently not conceived until a much later period.

ANCIENT CROWN WORK

The first and only specimen of ancient gold crown work so far known was found within recent years, at Satricum, near Rome, and is now in the museum of Pope Julius. This crown consists of two pieces of gold, stamped to represent

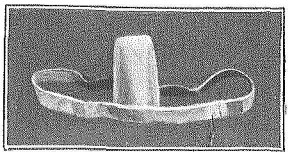


Fig. 991.— Roman Appliance Found at Satricum. Crown of Lower Incisor Made of Gold

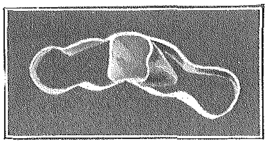


Fig. 992.— The Same Seen from Below (Guerini)

the labial and lingual surfaces of a lower central incisor, and united along the mesio-inciso-distal surfaces with solder, just as the Hollingsworth two-piece anterior crown is joined together. It was held in place by an elongated band which embraced the proximating and adjacent tooth on either side of the crown. The attachment of the band was close to the gingival margin of the crown. (Figs. 991 and 992.)

FIRST REFERENCES IN HISTORY TO PROSTHESIS

Although these ancient specimens of dental prosthesis have been found, and somewhere near the probable time of their construction determined by deductive reasoning, no written records of such or similar work appears until about the beginning of the Christian Era.

In Edersheim's "Life and Times of Jesus, the Messiah," according to Dr. W. C. Miller, in Dental Cosmos, December, 1905, the following statement is found: "Speaking of things purchasable in Jerusalem in the time of Herod the Great, 40 to 4 B. C., 'And then the lady visitor might get anything in Jerusalem, from a false tooth to an Arabian veil, or a Persian shawl, or an Indian dress.' "

Martial, a Latin poet, who lived in Rome during the first century A. D., in a number of his epigrams mentions artificial teeth. Guerini says: "There is therefore, not the least doubt that in the days of Martial, artificial teeth were in use; and that these, as may be seen from the epigram just quoted, were made of ivory and bone; we do not know whether they were formed of other substances. The question, however, arises: In those days did they manufacture movable artificial sets, or was the dental art then limited to fixing the artificial teeth unmovably to the neighboring firm teeth, by means of silk threads, gold wire and the like? The answer to this question may be found in another epigram of Martial, where the latter ridicules a wanton old woman, telling her, among other things still worse, that she at night lays down her teeth just as she does the silken robes.

"It is, therefore, beyond all doubt that, at that period, the manner of constructing movable artificial sets was known; and most probably not only partial pieces were made, but even full sets. In fact, from the verse quoted above we have justly the impression that the poet means a whole set rather than a few teeth. From the words of Martial, it may also be concluded that these dentures could be put on and off with the greatest ease; or, as we may say, by a maneuver as simple as that of removing any articles of wearing apparel; they must, therefore, have been extremely well constructed."

DENTISTRY AMONG THE ANCIENT HEBREWS

In Dr. Koch's "History of Dental Surgery" is found the following from the pen of Dr. H. L. Ambler: "The ancient Hebrews did not have any large amount of mechanical ingenuity, and dentistry with them was in a state of semi-cultivation, but they replaced natural teeth with false ones more than two thousand years ago. A law of the Talmud allowed the women 'to go out on the Sabbath with their false golden or silver teeth.' Some rabbis allowed their people 'to wear the false silver teeth, since these appeared natural, but the use of golden false teeth on the Sabbath was prohibited.' Many teeth were made of wood, and later on from the ivory of the elephant's tusk."

SLOW PROGRESS OF DENTAL PROSTHESIS IN THE MIDDLE AGES

Passing down through the centuries but little progress seems to have been made in denture construction until within the last one hundred and fifty years. It is true that various monographs on medical and dental subjects previous to the date last mentioned, contain frequent references to teeth carved from bone, or ivory, or hippopotamus tusks, but it is more than likely that most of these were partials, held in place with ligatures of silk or gold wire, in the manner already described.

The construction of satisfactory full upper and lower dentures must have been a considerable undertaking in the olden time, considering the manner in which impressions of the mouth were secured and casts were derived from them, and finally the development of adaptation of the block of bone or ivory to the cast by carving and scraping.

FIRST REFERENCE TO THE USE OF MODELS

Brief as it is, the outline of technic of full denture construction as given by Matthias Gottfried Purmann, of Breslau, 1648 to 1721, is the most complete description found up to his time. He was the first to refer to the use of models in dental prosthesis, but he does not state how they were obtained. Here is his outline as given by Guerini:

"The front teeth, or pronouncing teeth, ought, when they are wanting, to be substituted by artificial ones, in order to avoid the defects of pronunciation, as well as to obviate deformity of the mouth, and this is carried out in the following manner: One has other teeth made of bone, or of ivory, according to the number, the size, and the proportions of those wanting; for which purpose one may previously have a model executed in wax, reproducing the particular conditions of the teeth and jaws, in order afterward to make and exactly adjust the whole on the pattern of it; then when the base of these teeth is well fitted on the jaw and small holes have been made in the artificial teeth and also in the natural ones next to them, one applies the artificial teeth in the existing void and fixes them as neatly as possible with a silver wire by the help of pincers."

Because he advised the perforation of the natural teeth for the passage of the silver wire, a method which would prove exceedingly painful, and invite pathological complications as well, Guerini concludes that Purmann simply described, "and not even accurately, a prosthetic method already in use among specialists of that period. * * * On examination of the passage cited above, which, however, is not so clear as might be desired — it would appear that the models of which the author speaks were most probably quite different from those in use now. It is almost certain that the specialists of those days first made a sketch of the prosthetic part to be constructed, using for the purpose a piece of wax, which they modeled partly with the hand and partly carved; and after having tried on this model until it fitted perfectly in the mouth, and was in every way satisfactory, they probably passed it on to a craftsman to make an exact reproduction of it in bone or ivory."

FIRST REFERENCE TO FULL LOWER DENTURES

The first reference to a full lower denture is found in the writings of Anton Nuck, an eminent Dutch surgeon and anatomist, 1650 to 1692. He says, "In the case of all of the teeth of the lower jaw being wanting, the entire dental arch ought to be framed in with a single piece of ivory or tusk of hippopotamus." From this we infer that full upper dentures, being more difficult to retain, were not frequently constructed, else they also would have been mentioned in this connection.

Nuck further recommends that artificial teeth be made of hippopotamus tusk, specially favoring the whitest, which he estimated would preserve its color for seventy years, in preference to ivory, which turned yellow from the action of food, drink, and the saliva.

FIRST RECORD OF APPLICATION OF MINERAL SUBSTANCES FOR DENTURES

Pierre Dionis, a surgeon and anatomist of Paris, in 1690, states that artificial teeth are generally made of ivory, but may be made of ox bone, which will retain its color better than ivory. He also states that Guillemeau constructed artificial dentures from a composition made by fusing together white wax, gum elemi, ground mastic, and powder of white coral and of pearls.

On this Guerini remarks: "This fact is, as everyone can see, most important, for it constitutes the first step toward the manufacture and use of mineral teeth. Dionis tells us that the teeth made of Guillemeau's composition never became yellow, and that it was also very good for stopping decayed teeth. It would seem, therefore, that it could be used as cement is now used."

RETENTION OF PARTIAL DENTURES WITHOUT THE USE OF LIGATURES OR WIRES

While it is possible, and in fact quite probable, that partial dentures had been constructed and used, which were not dependent on the use of the ligatures for their retention, yet no clear statement of this fact has so far appeared. The first attempts to construct easily removable pieces, in all probability, consisted in longitudinally grooving the ends of the partial denture so as to partially embrace the proximating teeth, just as the natives of the Orient now do in their prosthetic restorations. It will therefore be interesting to mention the first record of such practice.

Lorenze Heister, a celebrated surgeon, in 1611 first recommends the use of movable prosthetic appliances of ivory or hippopotamus tusk without special means for fixing them, and further, that they should be removed at night and not be returned to the mouth again until well cleansed.

Johann Adolph Goritz, in 1725, recommended that the natural teeth be preserved by every possible means. He discouraged the use of prosthetic appliances where only a few natural teeth were lost, but suggested that in the worst cases, to avoid defective "pronunciation, or for some other reason (presumably unsightliness) it may be filled by an imitation in soft wood.

Heinrich Bass of Bremen, 1690 to 1754, professor of anatomy and surgery in Halle, recommended the application of "whole dental sets, even in the upper jaw, so long as there be two natural teeth existing to fix the prosthetic piece to." From this we again infer that the construction of full upper cases was not frequently attempted, on account of the difficulty in securing adequate adaptation and guarding against the force of gravity and masticatory stress.

FAUCHARD'S WRITINGS

Pierre Fauchard, born in Brittany, 1690, died in Paris in 1761, has been called the "founder of modern scientific dentistry." He published a work in 1728, entitled "Le Chirurgien Dentiste," consisting of two volumes, which was by far the best exposition on dentistry that up to that time had ever been written.

In olden times, down to a period within the memory of some of the members of the profession still living, there was a tendency on the part of many practitioners to jealously guard with secrecy their methods of practice, especially prosthetic operations, and thus prevent competitors from profiting thereby.

Fauchard's writings cover a wide range of dental subjects and in prosthetic operations he is particularly explicit. He recognized the existence of the petty jealousies alluded to, but was able to rise above them, as his descriptive details plainly show. In reference to this he says: "I have perfected and also invented several artificial pieces, both for substituting a part of the teeth and for remedying their entire loss, and these pieces substitute them so well that they serve perfectly for the same uses as the natural teeth. To the prejudice of my own interests I now give the most exact descriptions possible of them."

While Fauchard did perfect some of the prevailing forms of artificial substitutes and invent others, the greatest benefit he rendered the profession and posterity consisted in having collected and included in his work "the whole doctrine of dental art, theoretical as well as practical, thus setting in full light the importance of the specialty, and giving it a solid scientific basis." (Guerini.)

Interesting as all of Fauchard's writings are, only a few of the principal methods he describes can be here introduced.

TRANSPLANTATION OF NATURAL TEETH

He mentions that in transplanting a tooth, whether recently extracted or not, its root should be grooved horizontally, so that when ligated firmly in position, the alveolar process would eventually be built in the depressions so formed, and as he expressed it, "the tooth will remain mortised and may be preserved for a considerable length of time."

He describes several methods in detail for replacing the loss of two, three, or more contiguous teeth. One of these consisted in carving from ivory, hippopotamus tusk, or bone, each tooth, individually, to be replaced and fixing them together in a single piece by drilling holes and ligating with wire. This was then bound to the natural teeth with gold or silver wire, or silk or linen thread. Another method, instead of ligating the substituted teeth together, consisted of applying a strip of gold fitted into a horizontal groove formed in the lingual surfaces of the carvings, and to which each tooth was attached by means of two rivets. Again, the teeth to be replaced were sometimes carved from a single block of the materials commonly used and attached in the manner previously mentioned.

CROWN WORK IN FAUCHARD'S TIME

Crowns were attached to roots of teeth by means of a metal pivot extending into the root, which in case of enlarged canal had previously been filled with lead. A hole drilled in the lead received the root end of the pivot, while the crown was attached to the projecting end of the pivot with a cement

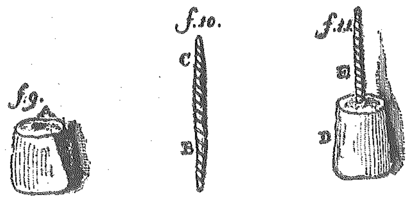


Fig. 993.— Fauchard's Illustration of a Crown of Ivory or Hippopotamus Tusk with Metal Dowel

composed of gum lac, Venice turpentine, and powdered white coral. The crown of a natural tooth was frequently employed in such cases.

MEDIÆVAL BRIDGEWORK

The first mention of fixed bridgework, although not so designated, is made by Fauchard, wherein he describes how a prosthetic piece may be held in position, in case the crowns of the teeth had been lost but the roots were present. Two

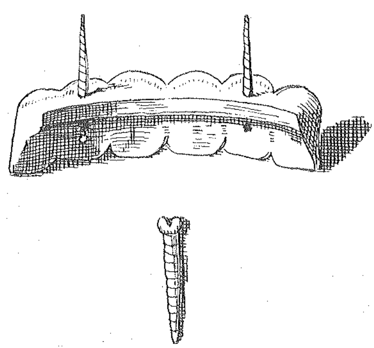


Fig. 994.— Bridge Carved from Ivory, Retained by Two Screws Fitted in Roots of Lateral Incisors (Fauchard)

holes were made in the substitute, corresponding to and in alignment with the canals of two roots, through which pyramidal screws were introduced and screwed firmly into the roots.

FULL DENTURES

Full lower dentures were recommended, with the suggestion that the piece should be so formed as to fit the irregularities of the arch perfectly, when, with the aid of the tongue interiorly and the cheek and lower lip exteriorly, the substitute would be held steadily in place and the patient would be able to masticate with it after becoming accustomed to its presence.

CONSTRUCTION OF FULL DENTURES BY FAUCHARD

Although full upper dentures were constructed long before Fauchard's time, it is evident that they were seldom

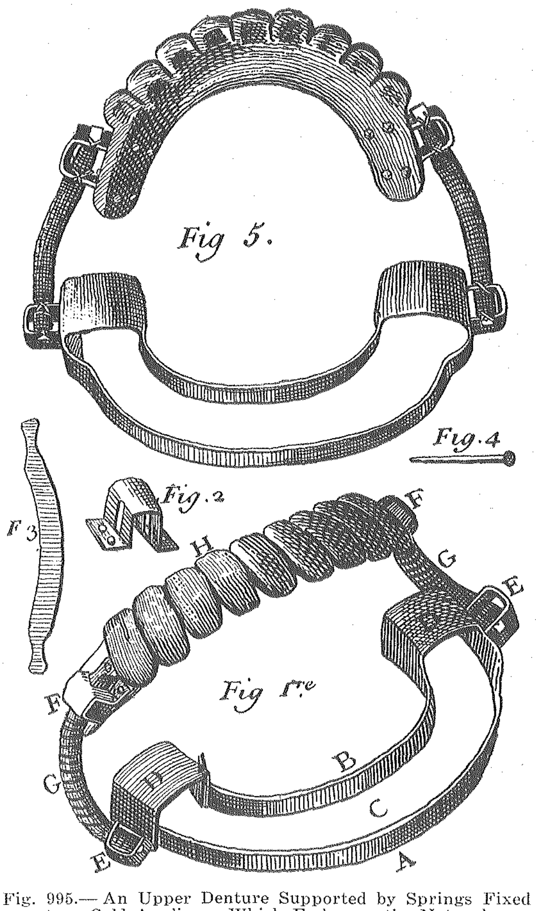


Fig. 995.— An Upper Denture Supported by Springs Fixed to a Gold Appliance Which Embraces the Natural Teeth of the Lower Jaw (Fauchard) (Guerini)

satisfactory. One case is mentioned which illustrates the helplessness and inability of some who were considered otherwise well qualified in the construction of full upper cases. Fauchard says: "In 1737 a lady of high rank, of about the age of sixty, who had not lost any of her lower teeth, but was deprived entirely of the upper ones, applied to M. Caperon, dentist to the King, who was most able in his profession, in the hope that he might be able to furnish her mouth with an upper set. But he said that, 'no tooth whatever being left in existence, every possible point of attachment was wanting, and it would therefore be as difficult to do this thing as it would be to build in the air.' " M. Caperon referred her to Fauchard, who after some deliberation "succeeded in devising a means of applying an upper set of teeth which, in fact, entirely satisfied the wishes and wants of his client." (Guerini.)

The appliance in this case did not include the full complement of teeth, some of the posterior space being occupied by the springs, by means of which, in conjunction with a double bow frame of gold fitted around the lower teeth, the denture was retained in position.

Mention is also made of three successful cases of full upper dentures which were retained without the aid of springs. Several points of interest are seen in Fauchard's own description of these cases, which is as follows:

"One can adapt an entire set of teeth to the upper jaw of much greater simplicity than those described, and which

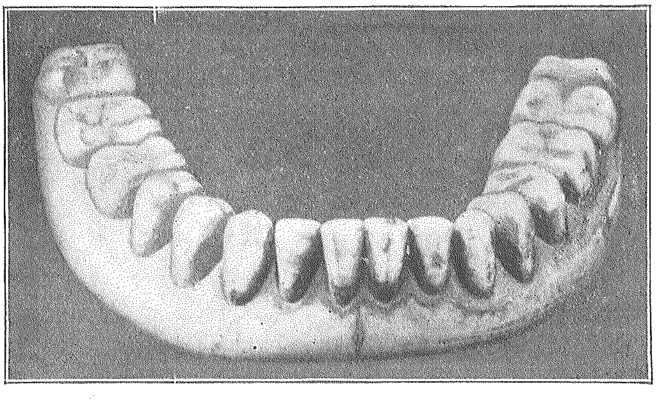


Fig. 996.—Full Lower Set in Hippopotamus Ivory with Human Front Teeth, Seventeenth Century (Guerini's Collection)

is maintained in its place by the sole support of the cheeks and the lower teeth. It must be very light indeed and serves almost solely to improve the appearance and the pronunciation; but when the individual gets used to it, he can also masticate with it. A set of teeth of this kind ought to adhere well to the gums and to be constructed in such a manner that the cheeks may afford it sufficient pressure and support, together with the aid of the lower teeth. These latter sometimes bring it back into its place without anyone perceiving the movement except the wearer himself. Not long since I had occasion to renovate a set of teeth of this kind made by me more than twenty-four years ago and worn by the owner to the greatest advantage. I have since made two others which have proved most useful to the per-

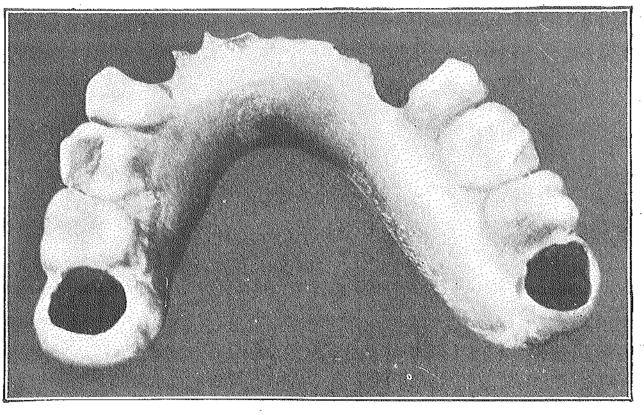


Fig. 997.— Upper Denture in Ivory, at the End of the Eighteenth Century, for a Case in Which the Last Molars and the Front Teeth Were Present (Guerini's Collection)

sons wearing them. It is true that there are few mouths adapted for wearing these sets, so much so that, excepting the three referred to, I have never made any others. To be able to construct similar sets successfully, the dentist must be possessed of skill and ingenuity. Apart from this, they are the most suitable for poor persons who cannot spend much, as they cost less to make."

SUMMARY OF FAUCHARD'S WORK

Fauchard made use of both flat steel and coiled gold wire springs for the retention of both full and partial dentures.

Summed up briefly, the main facts of prosthesis which Fauchard elaborated upon are as follows:

The transplantation and replantation of natural teeth.

The application of both carved and natural crowns to the roots of teeth by means of metal pivots, or by binding them to proximating natural teeth with ligatures of gold or silver wire, or silk or linen thread.

The application of a crude form of bridgework consisting of a carved replacement rigidly fixed to two natural roots by means of two tapering screws passing through the substitute into the root canals.

The carving of partial and full dentures from ivory, hippopotamus tusk, or bone, together with a description of means

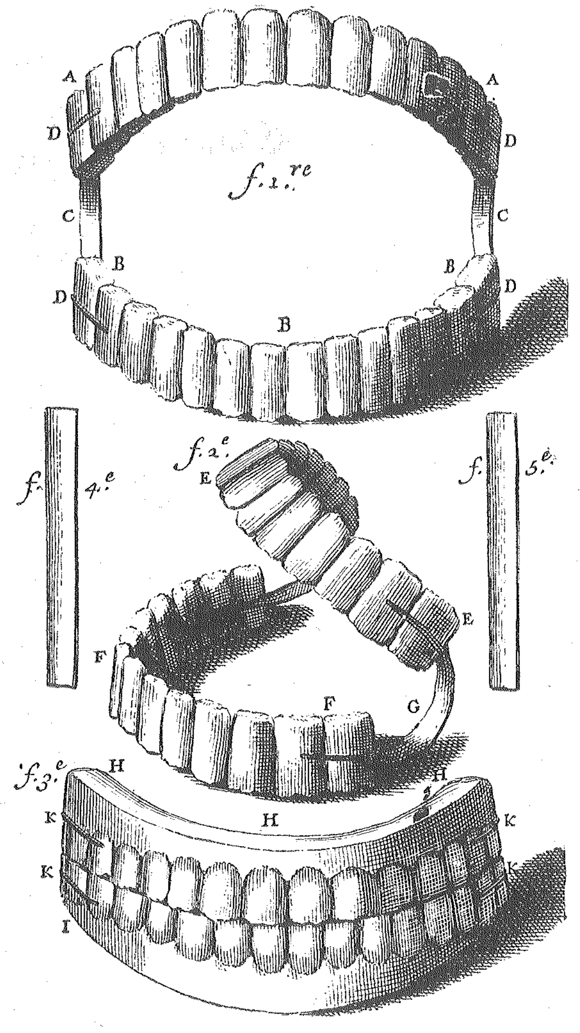


Fig. 998.—Complete Dentures (Fauchard). F^3 Represents an Enameled Denture with Artificial Gums, F^4 and F^5 Steel Springs (Guerini)

of attachment with ligatures, springs and metal cribs, and adhesion.

The enameling of artificial teeth to represent the variations in color of the natural teeth, and the staining or enameling of the gum portion to represent the color of the mucous tissues.

The construction of obturators for correcting defects of the palate.

Finally, the suggestion, but not the development and use, of porcelain for teeth and dentures, as noted in the chapter on porcelain.

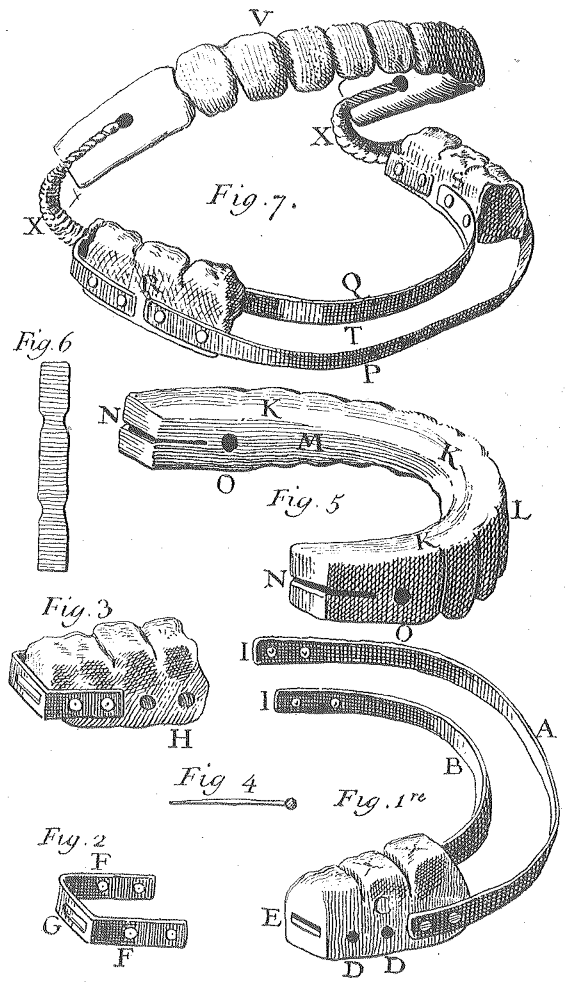


Fig. 999.— A Spring Denture for a Case in Which the Lower Front Teeth Still Exist. Figs. 1 to 6 Illustrate Various Parts of the Apparatus (Fauchard) (Guerini)

BENEFICIAL INFLUENCE OF FAUCHARD'S WRITINGS UPON THE PROFESSION

Undoubtedly, the example of Fauchard in giving freely and unstintingly to the profession, the benefits of his knowledge, experience and improvements, exerted a widespread and beneficial influence on his contemporaries and the men who followed. This is evident from the sparseness of detail in previous writings and the marked tendency of subsequent writers to more fully elaborate their ideas.

That the work of Fauchard was up to date and in some respects in advance of the times is apparent from the fact that although other works appeared at about that time and at intervals afterward, none of importance was presented until eighteen years after the publication just reviewed.

FIRST WORK CONFINED EXCLUSIVELY TO DENTAL PROSTHESIS

In 1746 Mouton published the first work of record confined to dental prosthesis. Most of the methods detailed by Fauchard were included in this later publication, and some new ideas were introduced, among which may be mentioned the application of gold crowns to badly decayed front and back teeth, the front crowns being enameled to correspond in color with the natural teeth.

For the first time mention is also made of the use of spring clasps for the retention of partial dentures.

FIRST MENTION OF PLASTER

In 1756 Philip Pfaff, dentist to Frederick the Great, in a work confined to dental subjects, first describes the use of plaster models. Guerini remarks: "It is therefore to two Germans — Pfaff and Purmann, the latter who, as we have already seen, used wax models — that one of the greatest progressive movements in dental prosthesis is indebted; that is, the method of taking casts and making models, of which method one finds no trace whatever in the authors of antiquity, and which, it would appear, was not known even to Fauchard himself. The wax casts of an entire jaw were taken by Pfaff in two pieces, one of the right half of the jaw, the other of the left, which were then reunited, and one thus avoided spoiling the cast in removing it from the mouth."

FIRST MENTION OF GOLD BASES

In 1757 Bourdet described the use of gold bases for resting upon the alveolar process, to which the replaced teeth were attached by means of small pins and the whole base overlaid with flesh colored enamel, similar to the continuous gum pieces of to-day. He also described another denture in which he carved the three back teeth on either side from the same block of hippopotamus tusk, which formed the base, while the ten anteriors were human teeth fixed to the carved base by means of rivets.

IMPLANTATION OF TEETH

The first mention of implantation of teeth is made by Bourdet, which is related by Guerini as follows: "This celebrated author inveighs bitterly against charlatans and quack dentists, and throws light on all their impostures. It appears, however, that in the midst of this despicable class, so justly condemned by him, there existed a courageous though unscientific operator, to whom posterity would have attributed due honor had his name been handed down, for he was the first, in all probability, to try the implanting of teeth in artificial alveoli. This is, at least, what we deduce from a passage in one of Bourdet's works, in which we read that a charlatan sought to impose on the public the belief that he could make a hole in the jaw bone and plant therein an expressly prepared artificial tooth, which in a brief space of time would become firm and as useful as a natural one. Bourdet adds that an attentive investigation led to the recognition of said tooth being simply that of a sheep. It would appear, therefore, that the operation had been in reality performed, it matters but little whether with the tooth of a sheep or with one of another kind."

Adam Anton Brunner, a German, in 1766, described a method of applying pivot teeth by screwing the pivot into the base of the crown, then enlarging the root canal just enough to tightly embrace the root portion of the pivot. Light hammer blows directed against the crown forced the pivot into the root canal and held it firmly without the aid of cement.

BERDMORE'S REFERENCE TO ARTIFICIAL DENTURES

Thomas Berdmore, dentist to George III of England in 1768, makes this statement in regard to artificial teeth: "Although artificial teeth are evidently ornamental, although they give a juvenile air to the countenance, improve the tone of the voice, render pronunciation more agreeable and distinct, help mastication, and preserve the opposite teeth from growing prominent, yet many are prejudiced against them on account of some inconveniences which are often found to attend the use of them. For they are said to become very soon yellow and dirty, to give a stinking breath, not to fit easy on the gums, seldom to stand firm, and to loosen after some time the neighboring teeth to which they are fastened, or the hard ligature, which is commonly used, is often seen to cut very deep into the sound teeth.'' He lays these difficulties to the fault of the ''artist,'' the negligence of the patient, or the want of proper instructions. He recommended the frequent use of the brush with suitable powders, and to avoid the use of red wines and staining liquors, and the use of silk twist instead of wire ligatures.

''A whole set of artificial teeth may be made for one or both jaws, so well fitted to admit of the necessary motions, and so conveniently retained in the proper situation by the help of springs of a new and peculiar construction that they will answer every purpose of natural teeth, and can be taken

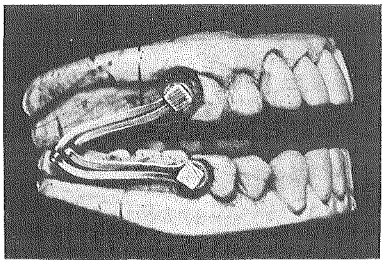


Fig. 1000.— Carved Ivory Dentures Fitted with " Grasshopper Springs "

out, cleaned and replaced by the patient himself, with the greatest ease. I say springs of a peculiar construction, because they are totally different in shape and action from those which have been used by my predecessors, because they follow all the various motions of the jaw very freely, and because the pressure which they give is always equal and gentle, whether the mouth be shut or not.'' He further states that dentures made from soft bone or ivory discolor readily, but may be made of more durable materials which will retain their polish and whiteness for a long time. Further, that the gum portion may be stained so perfectly that ''nobody in common conversation can distinguish the artificial from the natural gums.''

Jourdain, in 1784, described a full upper and lower denture sustained in position by means of four springs, the idea of which, he states, was conceived, but probably not developed, by Massez in 1772. Because this means of retention was complicated and difficult to adapt, it did not come into general use.

PRINCIPAL MATERIALS USED AS DENTURE BASES

The principal materials so far mentioned and used as substitutes for natural teeth were bone, ivory, hippopotamus tusk, wood, gold, silver, white wax, mother of pearl, human teeth and those of animals, all more or less perishable except the metals mentioned.

The effort of Guillemeau, mentioned by Dionis, in 1690, was the first of record to compound a substance which would more nearly fulfill the requirements of durability, appearance and ease of application, for prosthetic substitutes, than did the organic materials in common use.

FIRST SUGGESTION OF PORCELAIN WORK

Fauchard, in 1728, suggested the use of porcelain for teeth and dentures, but did not follow up and develop what has since proven to be one of the most important as well as esthetic phases of prosthetic science. It seems that he made use of enamels for staining both teeth and gums to resemble those of nature. Bourdet, in 1756, stated that he "had used the pink enamel of Fauchard." This enamel must have been in the nature of a paint or varnish, and so applied, since, if of porcelain, the heat necessary to fuse the latter would have destroyed both teeth and base of bone or ivory.

DUCHATEAU'S EFFORTS IN PORCELAIN WORK

In 1774, Duchateau, a French chemist, near Paris, who was wearing a denture made from hippopotamus tusk, and which had acquired a disagreeable odor, conceived the idea that a porcelain denture would be free from the objection mentioned. He presented his idea to Guerhard, a porcelain manufacturer in Paris, and together they proceeded to experiment. The first denture, on account of the contraction of the porcelain in baking, was too small. A number of others were constructed, none of which for various reasons proved satisfactory.

THE WORK OF DUBOIS DE CHEMANT

Discouraged by the many failures encountered, Duchateau applied to Dubois de Chemant, a well-known dentist of Paris, for advice and assistance. By modifying the porcelain of Duchateau with pipe clay and coloring earth, its fusing point was reduced, the color improved, and contraction was lessened. Finally, after a number of efforts, a denture was produced that Duchateau was able to use. Although he endeavored to construct dentures for others, Duchateau's efforts resulted only in failure, his general knowledge of prosthesis being insufficient to accomplish the required results.

He received a vote of thanks and an honorable mention from the Royal Academy of Surgeons of Paris in 1776, before whom his process was laid. The failures mentioned discouraged Duchateau from further efforts in this field, nor does it appear that he again renewed them.

De Chemant, to whom the success of Duchateau's efforts was largely due, continued his experiments, and, after a number of years, succeeded in compounding a porcelain, the contraction of which could be determined to a fairly accurate degree, of modifying the shade to a considerable extent as desired, and of improving the springs and other means of attachment.

Desirabode, writing in 1848, says in reference to the introduction of porcelain: "Fauchard seems to be the inventor of porcelain teeth, then Duchateau improves the manufacture; De Chemant, by accident, gets hold of the secret, which he further improves and gives as his own in 1788 when he published the first edition of his work. De Chemant carried the art to England, where he obtained the exclusive right to work the invention for twelve years."

In the work alluded to, De Chemant shows by means of engravings the various types of prosthetic substitutes he could produce in porcelain. Among these were included a crown, a bridge, full dentures and an obturator.

With few exceptions, Fauchard being a notable example to the contrary, the writer on dentistry in those days published a book, not so much to enlighten his professional brethren, as to impress the public with his superior attainments. De Chemant was one of the latter class. His work was largely made up of eulogistic effusions of himself and the new process of which he claimed to be the sole inventor, thus denying to Duchateau any credit whatever, in either the conception or development of the porcelain idea.

Furthermore, he studiously avoided giving to the profession so much as a hint of the composition or manner of working the paste for the making of "indestructible teeth," which, as appears, still lacked many desirable qualities. Indirectly his selfish, commercial attitude resulted in benefit to the profession by instigating others to enter the field in an effort to find something as good or better than that which he had discovered.

Dubois Foucou, dentist to the King, was one of the jury appointed by the French Academy of Surgeons to examine into the merits of De Chemant's discovery. He was at first opposed to the idea, but later on began experimenting and succeeded in improving both the quality and color of the porcelain over that used by De Chemant. While this was indeed laudable, the greatest benefit resulting from Foucou's researches consisted in publishing to the profession all of the formulas and methods he had discovered. His dentures were produced in three shades, bluish white, grayish white and yellowish white, in varying gradations.

INTRODUCTION OF SINGLE TEETH AND BLOCKS OF PORCELAIN

Fonzi, an Italian, practicing in Paris, in 1808, introduced for the first time single teeth and blocks of teeth, having baked within and projecting from them small pins or hooks of platinum, by means of which they could be attached to bases of various kinds. This was a decided and valuable improvement in itself, for it encouraged the production of bases of more permanent character, such as gold, silver, and platinum, and the consequent development of technic in metallurgical lines. The porcelain of which these teeth were composed was somewhat translucent and much more nearly resembled the natural teeth than did that of either De Chemant or Foucou. Still further credit should be given Fonzi from the fact that these teeth were, to a limited extent, manufactured and rendered available to other members of the profession, and, further, were capable of comparative ease of application.

Thus when the facts are known Fonzi stands out as a prominent character in the advancement of prosthetic science, for it is apparent that from his time on progress in the porcelain field shows gradual but marked improvement.

The production of dentures carved from bone, ivory and similar substances continued for many years after Fonzi's time, largely because of imperfect technical methods, and the difficulties encountered of fusing porcelain in the cumbersome furnaces in use in those days, some of this material requiring a temperature of 3,000 degrees F. to vitrify.

FIRST INTRODUCTION OF PORCELAIN IN THE UNITED STATES

In 1817, Plantou of Paris came to Philadelphia, bringing with him a stock of porcelain teeth made in France. These have been described as being inferior in both quality and color, somewhat resembling a split bean, having a half-round groove in the back, in the sides of which were inserted small

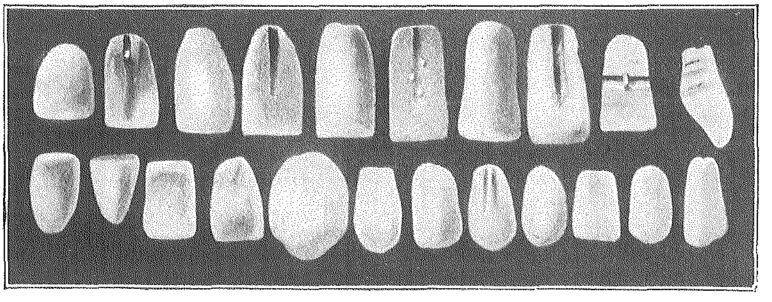


Fig. 1001.— Grooved Porcelain Facings Used Both for Crown and Denture Work About 1820

strips of platinum for bending over and soldering to a gold wire post attached to the denture base.

The arrival of Plantou proved an incentive to members of the profession in this country to enter the porcelain field in an endeavor to improve the quality and forms of the teeth then available.

THE FIRST MANUFACTURE OF PORCELAIN TEETH IN AMERICA

In 1822, Chas. W. Peale began the manufacture of porcelain teeth, in the backs of which platinum pins were inserted and baked for attachment purposes.

In 1825 S. W. Stockton began the manufacture of porcelain teeth with such success that in a few years his business had grown to quite extensive proportions. In reality he was the first in this country to engage extensively in the production of porcelain teeth for the profession.

It was customary, about this time and for many years later, with a number of men in the profession to manufacture teeth, both single and in blocks or sections, to meet the requirements of individual cases in practice.

These teeth and blocks were attached to bases of various kinds, being mounted on ivory or hippopotamus tusk by means of screws or rivets, passing through holes drilled through both base and porcelain, while to metal bases they were attached in the same manner and by soldering a backing to pins baked in the porcelain.

Ambler states that "among those who made teeth for their own use were Doctors McIlhenny (1826), Ambler and Spooner (1828), Flagg (1830), S. Spooner (1831), Harwood and Tucker (1833), Alcock and Allen (1835), and Wildman, who began his experiments in 1837. The latter made painstaking investigations and achieved notable results. 'His work was so important and far-reaching that he has been accorded

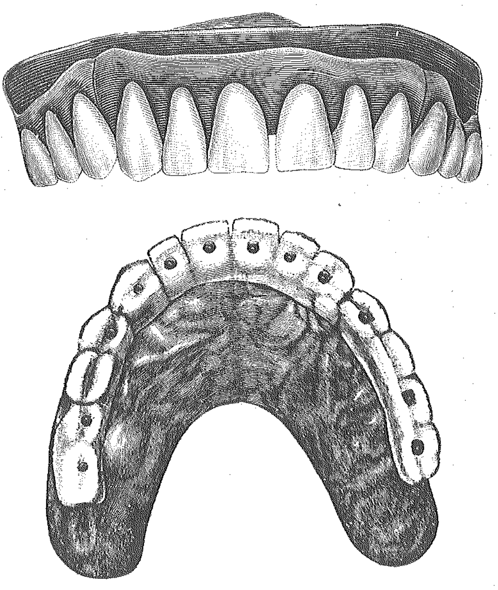


Fig. 1002.— Labial and Lingual Views of Denture Constructed by Dr. McIlhenny in 1835. Tooth Blocks Were Carved by Hand

the honor of having been first to place the manufacture of teeth on a scientific basis.' "

In 1844, Samuel S. White of Philadelphia began the manufacture of teeth, in a small way at first, but his products were of such excellent quality that the business soon grew to large proportions. Upon the foundation which he laid was established the S. S. White Dental Manufacturing Company, which to-day is one of the most extensive, if not the largest, concern of its kind in the world.

For many years the quality of porcelain teeth, both foreign and domestic, has been reasonably satisfactory in color and texture, but few, if any, have fulfilled anatomic requirements. The bicuspids and molars are usually too small and are relatively disproportioned to each other as well. Labial and buccal surfaces, while falling short of perfection in form, presented a much better appearance than did the incisal edges of the anterior or the occlusal surfaces of bicuspids and molars, particularly the latter, the planes and surface markings of which oftentimes in no way resembled in form the surfaces they were supposed to represent.

Within recent years, since mandibular movements are better understood, the demands of the profession for better forms

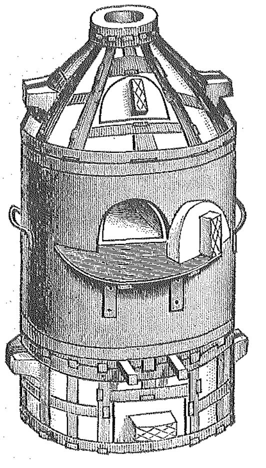


Fig. 1003.—Type of Coke Furnace Commonly Used in the Early Days for Fusing Block Teeth and Contiguous Gum Dentures

of artificial teeth have been and are being met by the manufacturers with commendable and in many instances extremely gratifying results.

INTRODUCTION OF GOLD FOR DENTURE BASES

As previously stated, Bourdet, in 1757, mentions the use of gold for denture bases. It was not introduced into the United States until 1780, when Dr. James Gardette of Philadelphia described and used it for this purpose.

Silver and platinum were also employed for baseplates, but the use of all of these metals was limited, because of the difficulty met with in securing adaptation to the oral tissues.

DIES FOR SWAGING METAL BASES

Dies were frequently made of brass, the model being sent to a brass foundry for casting, no laboratory being equipped with furnaces suitable for fusing this alloy.

Later on zinc was employed for dies because of its comparatively low fusibility and hardness. Still later, about 1860, Babbitt's metal was made use of for the same purpose, it being almost as hard as zinc, fused lower and contracted less

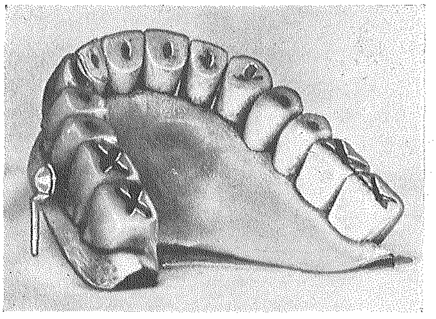


Fig. 1004.— English Tube Teeth Mounted on Swaged Gold Base. Constructed About 1844 (Loaned by C. R. Sykes, of C. Ash & Sons)

than the latter metal. Dr. L. P. Haskell is largely responsible for the introduction of and improvement in Babbitt metal, which, without doubt, is the best alloy available for die purposes.

As late as 1840, De Loude of London, in writing of his methods of technic, says: "The impression is poured with

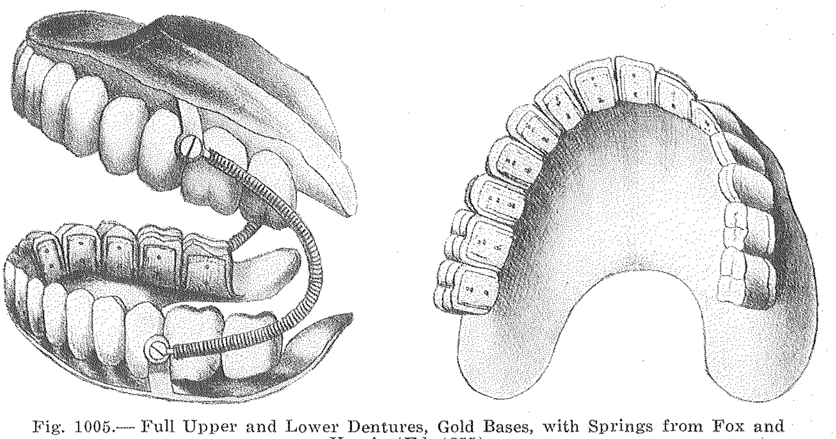


Fig. 1005.— Full Upper and Lower Dentures, Gold Bases, with Springs from Fox and Harris (Ed. 1855)

plaster and the model sent to a brass founder to have a similar one made of brass; after which a *she-mold* of lead is made on the one of brass, then plates of gold, silver or platina are swaged." (Ambler.)

FIRST USE OF CAST BASES

Tin bases made by casting the molten metal into a matrix containing the teeth, and directly to them, was introduced by Dr. Edward Hudson of Philadelphia in 1820. Further work along similar lines was carried on by Dr. W. A. Royce of Newburgh, N. Y., in 1836, and by Dr. George E. Hawes of New York in 1850, but with more or less indifferent success.

Dr. A. A. Blandy of Baltimore, in 1856, greatly improved the then existing methods of technic, and introduced an alloy for denture bases which cast more sharply than tin. The process was termed "Cheoplasty," and dentures so con-

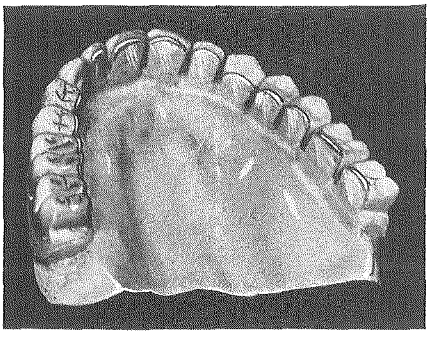


Fig. 1007

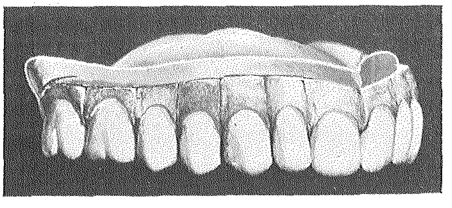


Fig. 1008.—Gold Base Denture, Single Gum Section Teeth, Backed and Soldered, with Peripheral Rim. Constructed by Dr. W. N. Morrison About 1869

structed were called *cheoplastic dentures*. Harris' Edition, 1873, states that "the name chosen by him (Blandy), signifying the making of plates by *pouring* a metal, made *plastic* by heat, is equally applicable to all alloys of tin *now* used. Blandy's alloy of cheoplastic metal was silver, with some bismuth and a trace of antimony." Tin, combined with bismuth or cadmium, was introduced shortly afterward, and these alloys are used, more or less, for lower weighted dentures at the present time.

Hard vulcanite, although discovered in 1851, had not come into general use as a denture base, and the teeth used in metal base denture construction were not suited, because of their form and type of pins, for firm attachment in the cast bases, therefore teeth of modified forms were designed and used for this purpose.

SPECIAL FORMS OF TEETH FOR USE WITH CAST BASES

In 1856, W. G. Oliver and Thomas Harrison introduced teeth with grooves and holes for anchorage purposes, to be

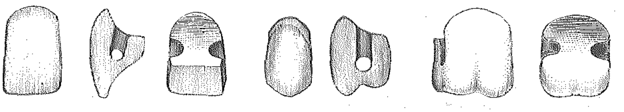


Fig. 1009

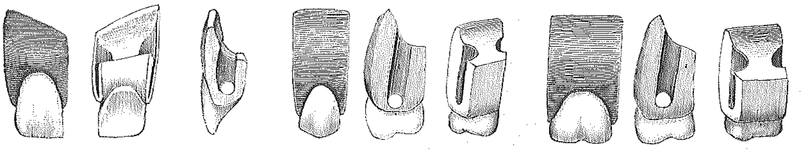


Fig. 1010

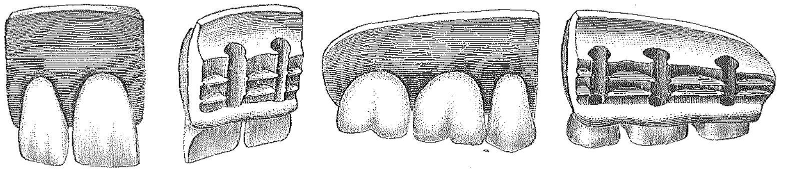


Fig. 1011.— Various Forms of Teeth Designed for Cheoplastic Work by Oliver and Marshall About 1855

used in the casting process. These teeth were planned somewhat on the order of the present diatoric teeth.

DENTAL VULCANITE LITIGATION

In 1852 John A. Cummings of Boston filed a caveat, and in 1855 applied for a patent for the method and use of rubber in denture construction in practically the same manner as it is used to-day. This patent was granted in 1864, and thereupon began a long and drastic siege of litigation, on the part of Cummings and others, to enforce upon the members of the profession who were using vulcanite the payment of *office rights* or *royalty* for the privilege of using rubber for this purpose.

The final summing up and outcome of this now famous legal battle can be found in the Dental Cosmos, April, 1873, the entire issue of that month being devoted to the court transactions in the final case.

The following paragraphs briefly explain the principal points of history of the vulcanite litigation:

"Letters patent were granted to John A. Cummings on June 7, 1864, for an 'improvement in artificial gums and palates,' and on account of a defect were reissued January 10, 1865, to the Dental Vulcanite Company, and later on account of a defect were again reissued March 21, 1865, to said company.

"The Goodyear Company, by assignment, became the legal owners and issued to dentists, for various sums, 'licenses and agreements' to use its process only in their own business, the license not to be assigned, sold, transferred or otherwise disposed of, and the licensee not to encourage infringements, and if he found any one infringing he was to report it to the company and they were to bring suit against the infringer. These licenses were generally given for one year, and were signed by the licensee, the agent and Josiah Bacon, treasurer, who, on account of his arbitrary methods and meanness in dealing with the dental profession, was shot and killed in San Francisco.

"The contest as to the validity of the patent between the Goodyear Company and the whole dental profession of the United States was long and bitter. Finally S. S. White took up the cause for the profession and spent much time and money and in the end won the case and wiped out the abomination." (Dr. H. T. Ambler, in History of Dental Surgery.)

COLLODION AND CELLULOID AS DENTURE BASES.

The refusal of many to use rubber, on account of pending claims of the patentee, led to the introduction of collodion as a denture base in 1859, by John Mackintosh of England.

Dr. J. A. McClelland of Louisville, Ky., in 1860, improved the collodion base and introduced it under the name of "Rose Pearl," but this, as well as Mackintosh's product, proved unsatisfactory on account of contraction, warpage and lack of permanent quality.

Celluloid, having collodion as a base, was invented by Isaiah S. and John W. Hyatt of Albany, N. Y., in 1870, and for many years was used extensively, and is to a limited extent to-day employed in denture construction.

Although any of the existing forms of vulcanite teeth can be used in conjunction with celluloid as a base, a special form of tooth having a constricted cervix and of more natural form generally was designed for this purpose. The countersunk pin tooth followed closely on the introduction of improved teeth for celluloid work.

Some of the most notable attempts to reproduce natural tooth forms were made by Dr. E. T. Starr in 1869. A few of the molds he produced are scarcely equaled by the best efforts of present-day tooth designers.

Ash & Sons of London have long been noted for the production of teeth which, in both form and color, closely resemble the natural organs of mastication. Their tube teeth, which were introduced about 1840, are capable of varied application, both for dentures and single crowns. These teeth can be reshaped by grinding and the glaze restored by polishing so perfectly that the modification cannot be detected. Because of the materials employed and the mode of manufacturing, the finished product is very dense and free from porosity.

Most of the manufacturers of teeth have, within recent years, improved the quality of materials in their products, and practically all of the present-day teeth can be modified and repolished as described.

VULCANIZING RUBBER BETWEEN METAL SURFACES

The process of vulcanizing rubber between two polished metal surfaces was introduced by Dr. Stuck in 1868. His method consisted in forming a cast of the mouth in tin, developing the base plate in wax or securing the required thickness and form of the model denture base with several layers of tinfoil, investing the case in the flask, and on opening removing all but the outermost layer of tinfoil from the matrix side. This resulted in the formation of a metal matrix in which the rubber was packed and vulcanized. The product was much denser than when vulcanized in a plaster matrix, and in addition required no polishing except where the surplus margins were trimmed away. A similar method is sometimes resorted to at present, except that instead of the tin cast of the mouth a plaster cast as ordinarily constructed is used, to which a thin sheet of tinfoil is carefully adapted, cemented to the cast with a thin film of sandarac varnish or Le Page's glue, which thus affords a metallic surface against which the vulcanite is molded.

DENTURE BASES PRODUCED BY ELECTRO-DEPOSITION OF GOLD AND SILVER

Denture bases formed by electro-deposition of gold, and also of gold combined with silver, have at various times been tried, but with indifferent success. Metal deposited by this process lacks the cohesiveness of either cast or rolled plate, and although beautiful results and good adaptation may be secured, unless the base is formed very heavy, so thick, in fact, as to be objectionable, it will fracture readily under stress.

ARTICULATORS

The progress of improvement in articulators, or, more correctly, *occluding frames,* is extremely interesting. The development of this appliance, which is practically indispensable in the correct occlusion of teeth, has been retarded because of lack of accurate knowledge of mandibular movements, or, more exactly, those movements of the mandible concerned in the frictional contact of the lower against the upper teeth. Without a fundamental and exact knowledge of these movements, it is impossible to construct an appliance which will reproduce them.

Even with present established data, there is no appliance yet devised that will reproduce all of the varied essential movements discerned in every individual with exactness, but some approach very closely the desired requirements. Only a brief outline of those appliances most familiarly known can be given here.

A method of building a distal extension to each cast, the first having notches or depressions into which the plaster of

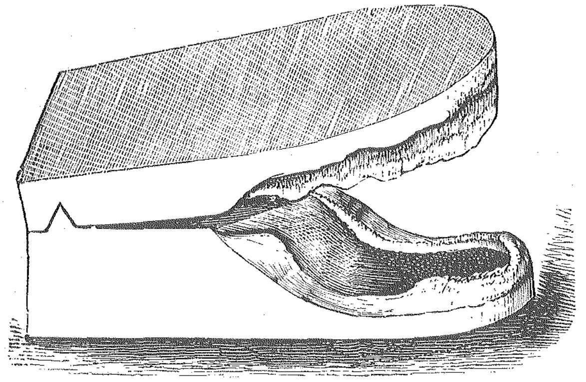


Fig. 1012.— Casts Extended Distally to Form Articulating Surfaces

the opposite side was filled, to serve as guides, constituted the first articulator.

J. B. Gariot is credited with having invented the first dental articulator in 1805. An extended search through dental literature by the writer has failed to disclose more than a mere mention of the fact as stated.

In 1840, Dr. Daniel T. Evans of Philadelphia patented an articulator in which an effort was made to reproduce the lateral movements of the mandible.

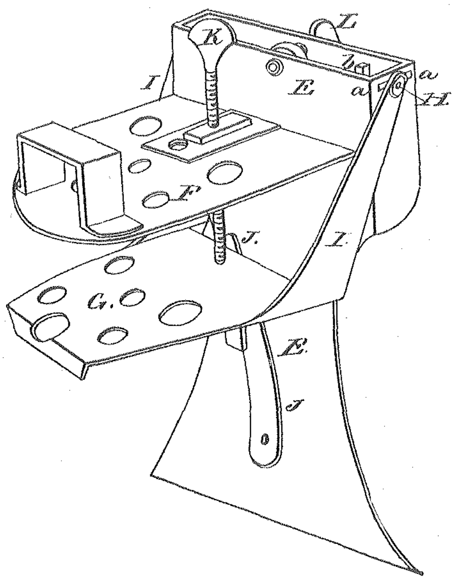


Fig. 1013.— The Evans Anatomical Articulator

The distance between the condyle slots of the frame was less than the average, while the center of rotation in lateral movements was located in the center of the frame.

In 1858, Dr. W. G. Bonwill introduced his "Anatomical Articulator," and presented his theory of the equilateral triangular relation of the mandibular condyles and the lower central incisors. He claimed that by such an arrangement it was clearly Nature's plan to thus provide a more perfect balance for the masticatory apparatus in lateral movements; that these movements were most effective in the reduction of food, and that dentures should be so constructed that the mandibular muscles could perform their functions in the same manner as when the natural teeth were present.

His theories, although in the main correct, aroused considerable antagonism, because, in many cases, the results he claimed could be derived from the use of his articulator were not realized.

This was largely due to ignoring the variation in pitch of condyle paths of different individuals, and in an inaccurate method of mounting casts on the articulator.

Dr. Bonwill was a natural born prosthetist and in the anatomic field overcame, by intuition, the obstacles resulting from his imperfect appliance. In his enthusiasm he failed

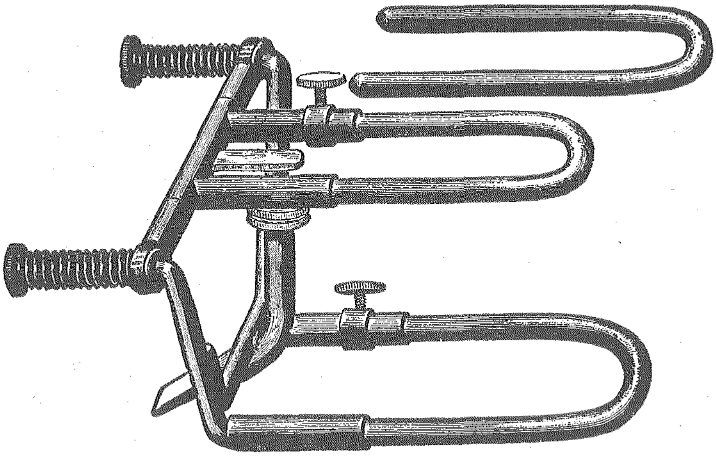


Fig. 1014.— The Bonwill Articulator

to recognize the limitations of the articulator, or to realize that it was his intuitive skill and not the appliance that was responsible for much of his success.

His persistent effort in this field for more than forty years finally aroused the interest of various investigators, with

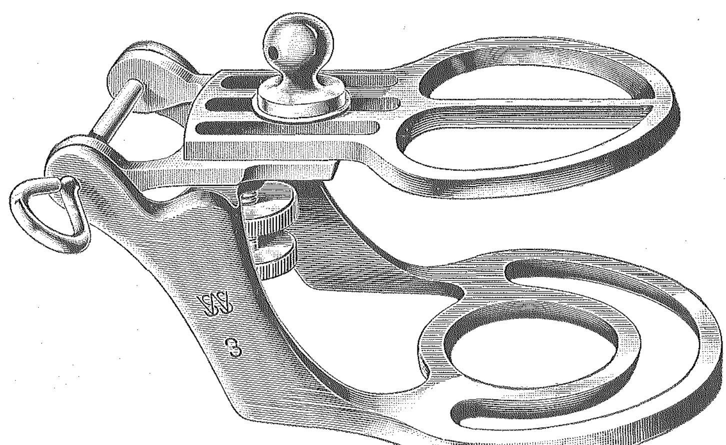


Fig. 1015.— Plain Line or Common Hinge Articulator Used for Many Years

the result that to-day the problem of anatomic occlusion has almost reached solution. The anatomic method of denture construction is a reality, established on a practical working basis, and its great importance and value are gradually becoming recognized by the profession in general.

In 1868, Dr. E. T. Starr devised an articulator, having a lateral movement, with horizontal condyle paths.

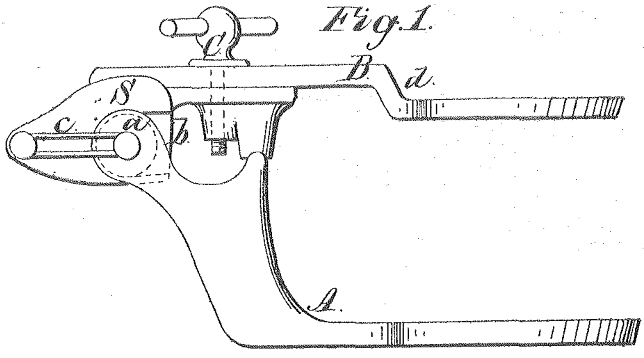


Fig. 1016.— The Starr Articulator

In 1889, Dr. Richmond S. Hayes introduced an articulator having a lateral movement and with inclined condyle paths. From the Patent Office drawings of this appliance it appears that the condyle paths inclined too steeply and were not capable of adjustment.

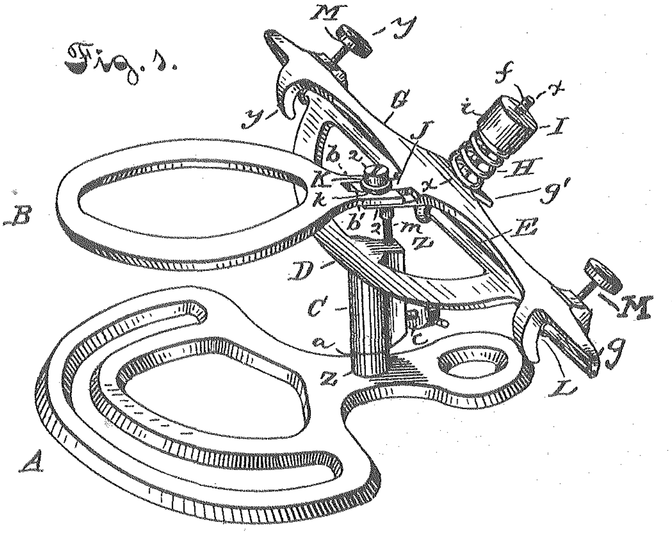


Fig. 1017.— The Hayes Articulator

As a matter of fact, a practical method of registering the human condyle paths had not yet been discovered, nor had the importance of such registration been recognized, so that adjustable condyle paths were not even considered. Dr. Hayes also devised a crude sort of face bow for establishing the correct distance of casts from the frame hinges.

FIRST SUGGESTION OF THE FACE BOW

Previous to this time, Dr. T. L. Gilmer, in a paper presented before the Illinois State Dental Society, in 1882, suggested measurement of the distance from condyles to the middle of the upper jaw so that casts might be mounted a corresponding distance from the articulator hinges, thus avoiding disturbance of occlusion in fracture cases. This in reality was equivalent to the use of a face bow.

STUDY OF CONDYLAR MOVEMENTS

In 1889, Drs. Bowditch and Luce of Harvard, Conn., conducted a series of experiments to determine definitely the condylar movements of the mandible. The results of these experiments were published in the Boston Medical and Surgical Journal of that year, but not being reprinted in any of the dental journals, were not brought prominently to the attention of the profession.

WALKER'S RESEARCH WORK

In 1895, Dr. W. E. Walker, without knowing of the work of Bowditch and Luce, carried out a similar line of investigation, and arrived at practically the same results. Just what he strove to and did accomplish can best be stated by quoting from one of his papers, published the following year:

"Up to that time I had not been able to find mention of the facts which I had observed that, in the movements of mastication, the mandibular condyle moves 'not only forward, but downward also, causing the ramus to drop in the anterior and lateral excursions of the mandible,' and that the condyle on the side toward which the jaw is advancing, in the lateral excursions, does not merely 'rotate on its axis,' otherwise 'remaining stationary,' as we are taught, but that it also moves both upward and backward, very slightly, it is true, in many subjects, and not at all in some, but quite considerably in others."

The discovery of this fact led to another hitherto unrecognized fact, viz., that the lateral rotation centers of the mandible may or may not be located in the condyle centers.

WALKER'S ANATOMICAL ARTICULATOR

Walker designed an anatomical articulator, having both adjustable condyle paths and variable rotation centers which could be set in accordance with records obtained in each individual case.

These records were secured by means of another appliance he devised and called a "facial clinometer." In the light of our present knowledge, a prosthetist familiar with the present-day appliances, if given the Walker articulator and

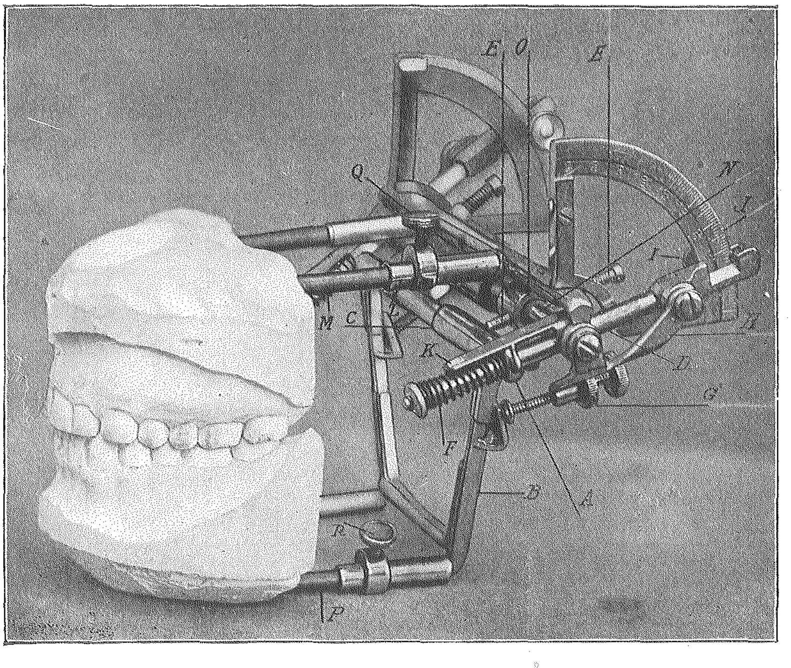


Fig. 1018.— Walker's Anatomical Articulator

clinometer and a Snow face bow, could construct anatomic dentures equal to those constructed by any other system.

Practically the only essential point which Walker overlooked was the importance of and necessity for setting the casts on the occluding frame so that their alveolar planes sustained a similar relation to the frame hinges that the natural alveolar planes did to the condyles. Although he does not explain how he mounted the casts on the frame, it is more than likely that he followed Bonwill's method of calipering—setting them so that the calipers registered four inches from each rotation center, to the position to be occupied by the mesio-incisal angles of the lower central incisors, when occluded. This method, although decidedly better than the usual plan of *guessing* the proper position of the casts, provided for neither perpendicular nor horizontal plane relationship and, therefore, led to errors.

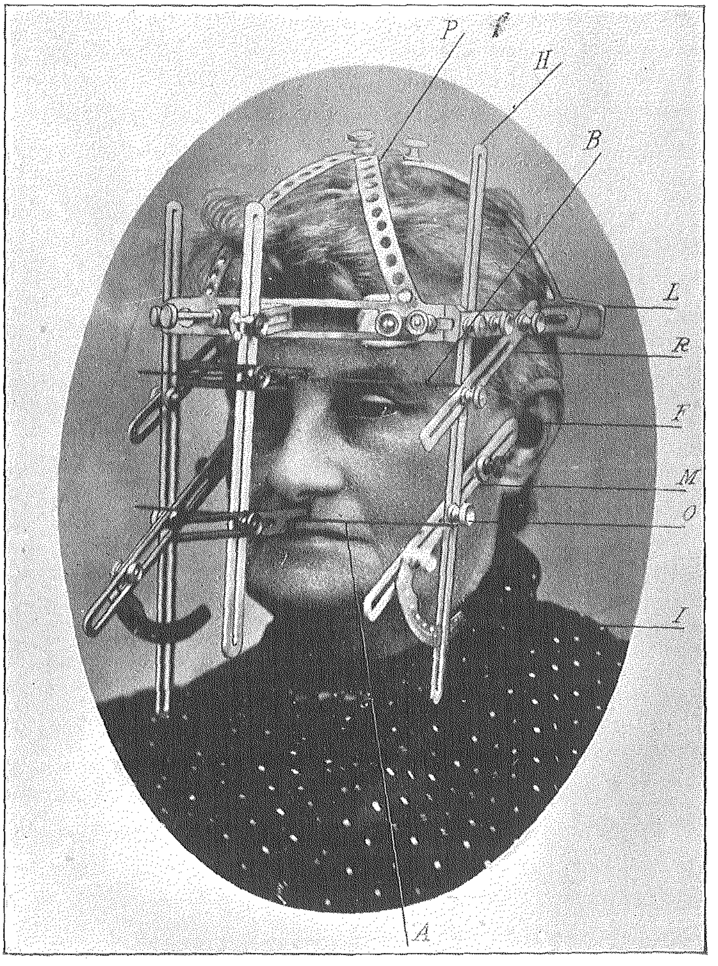


Fig. 1019.— Walker's Facial Clinometer

Walker's efforts were more far-reaching and valuable than he himself or the profession realized at the time, but on the foundation which Bonwill laid, and he strengthened and added to, the present system of anatomic occlusion of artificial dentures rests. Three valuable papers by Walker on mandibular movements and methods of registering them appeared in the Dental Cosmos, in 1896-7.

In 1894 Dr. C. E. Bixby designed an attachment for mounting casts on a plain line articulator.

This device regulated the correct antero-posterior position, but provided no means for establishing the horizontal

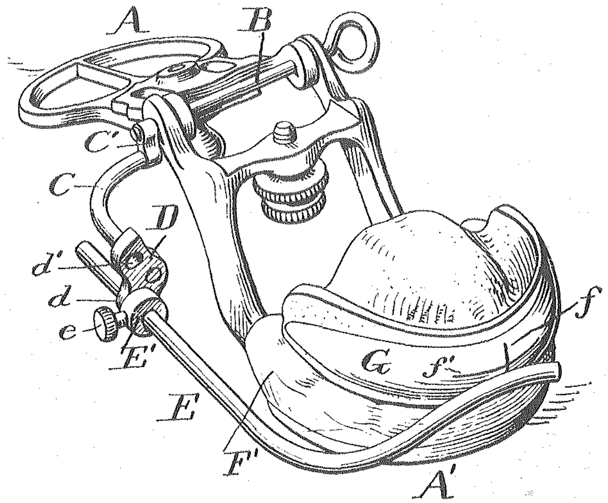


Fig. 1020.— The Bixby Attachment

plane relationship. It, however, was a forerunner of the face bow.

GRITMAN'S ARTICULATOR

In 1899, Dr. A. D. Gritman introduced an improved form of articulator, having the same general proportions as the Bonwill, but more rigid, and with condyle slots set at an angle

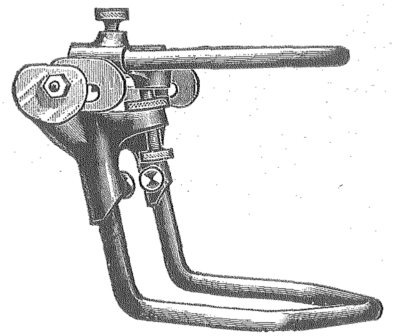


Fig. 1021.— The Gritman Articulator

of about 15 degrees slant. In this, as in all articulators having fixed condyle paths, the pitch of the path of the frame was often increased or decreased in mounting the casts on the frame, depending on the thickness of the cast and the care used in mounting them.

SNOW'S FACE BOW

In the same year, Dr. George B. Snow of the University of Buffalo introduced the *face bow,* a caliper-like device used

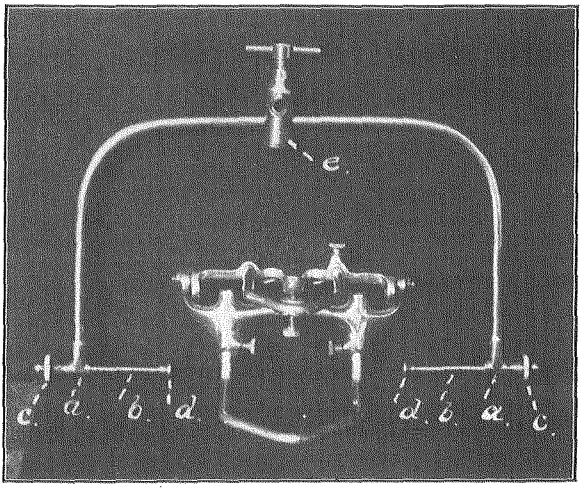


Fig. 1022.— The Snow Face Bow and Gritman Articulator

in mounting casts on the occluding frame. This device is one of the most valuable acquisitions in the anatomic field. By means of this appliance, correct antero-posterior, as well as

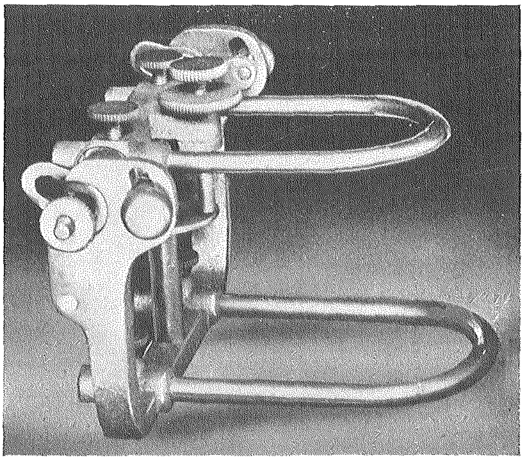


Fig. 1023.—The Kerr Anatomical Articulator

perpendicular and horizontal plane, relationship of casts to frame hinges can be established. As a result, when teeth are arranged on occlusion models, clearance paths for the cusps of the lower bicuspids and molars between those of the upper teeth can be developed, so that in lateral excursions there is no marked interference.

THE KERR ANATOMICAL ARTICULATOR

In 1902 the Kerr Brothers of Detroit introduced an anatomical articulator having adjustable condyle paths and a lateral movement. The first frame was arranged with hinges about on the same plane as the occlusal plane of upper cast when mounted, the idea being to copy the center of rotation of the mandible in wide open movements.

For obvious reasons this was found incorrect, and the design of the frame changed to the form shown on page 1144.

CHRISTENSEN'S WORK

In 1902, Dr. Carl Christensen of Copenhagen, Denmark, discovered a simple method of recording the condyle paths in

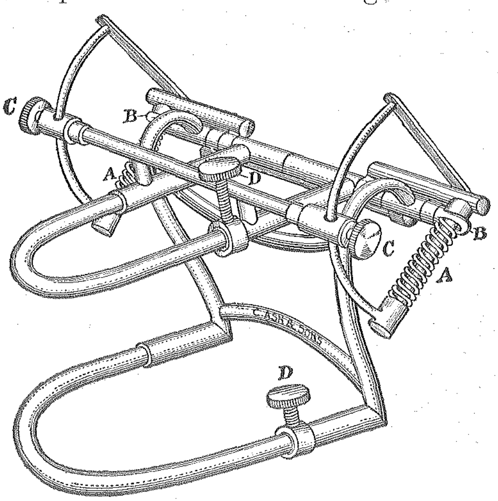


Fig. 1024.— The Christensen Anatomical Articulator

the living subject, and devised an articulator having adjustable condyle paths which could be set according to such registration. (See page 337.)

SNOW'S ANATOMICAL ARTICULATOR

In 1906, Dr. Snow improved the Gritman articulator by converting the fixed into adjustable condyle paths, and applying a tension spring which permitted a greater range of movement without impairing the stability of the frame.

Christensen's method of registering the condyle paths in conjunction with the use of the Snow "New Century Articulator," and the face bow, supply the means for constructing dentures anatomically and is to a great extent the system most generally practiced and taught in this country.

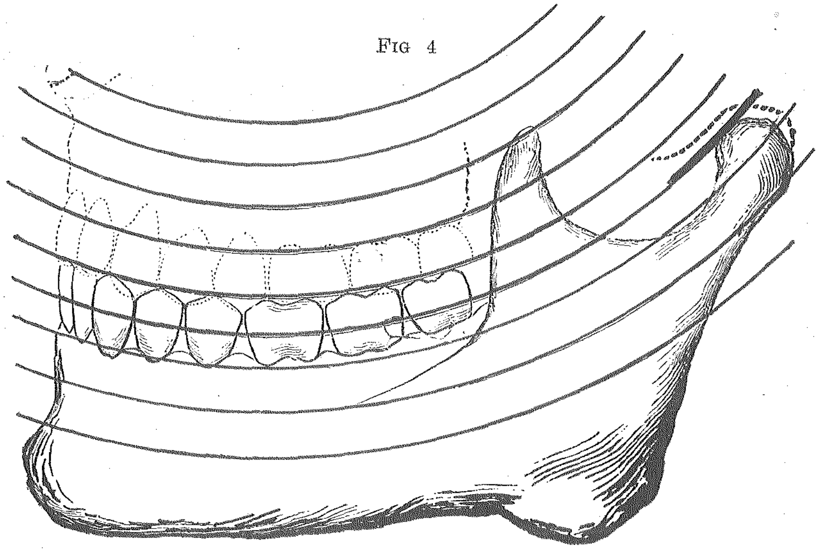


Fig. 1025.— Cut Showing Compensating Curve (Christensen)

Dentures constructed by this method, when introduced in the mouth, will perform essentially the same functions as the natural teeth, and are capable of reducing food with less effort than are those in which hinge action alone is possible. Furthermore, they are much less liable to displacement when

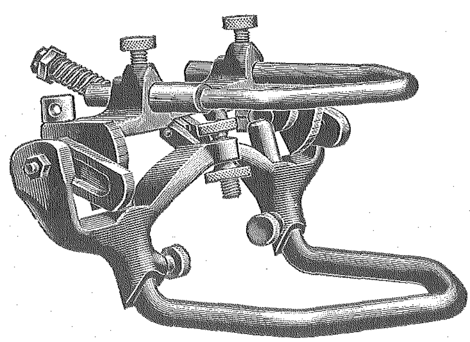


Fig. 1026.— The New Century Articulator (Snow)

in use, as *balancing contact* is one of the essential features that in practically all cases can be attained.

The Snow Articulator, like the Christensen, Walker and Bonwill appliances, has its rotation centers placed four inches apart, which, according to Bonwill's measurements, corresponds with the average distance from center to center of the human condyles.

Walker clearly proved that the lateral rotation centers of the mandible, in some individuals at least, were located, not in, but between the condyles at varying distances in different cases. Others have since proven the truth of Walker's findings, and in addition have shown that the rotation centers may lay outside of the condyle centers as well.

Excepting the efforts of Christensen, as noted, this description has been confined to what has been accomplished by men in this country. It will now be in order to mention some of the contributions to this subject by the members of the profession in Europe, whose interest was aroused by Bonwill's work.

In 1890, Graf von Spee, a German anatomist, called attention to the curved arrangement of the occlusal planes of the natural teeth and of corresponding curves in the condyle paths. (See page 302.)

SCHWARZE'S ARTICULATOR

In 1900, Dr. Paul Schwarze of Leipsic constructed an articulator somewhat on the order of the Bonwill appliance,

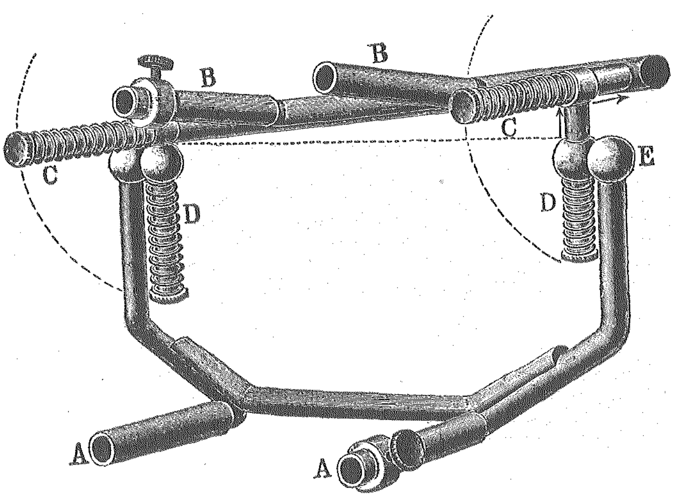


Fig. 1027.— The Schwarze Anatomical Articulator

but having both a forward and downward movement to the condyles.

In 1901, Tomes and Dolamore made a series of records of condyle paths as disclosed by the hinge action, or opening and closing mandibular movements. These were of no special value in a practical way, further than to verify the research work of Walker and others in reference to the downward pitch as well as variations in the condyle paths. (See page 275.)

Parfitt, Constant, Campion, Warnekros, Peckert and others have contributed in various ways and at different times to this most interesting subject.

Recently Bennett has shown that there is an actual bodily side movement to the mandible, which, although caused by the muscles that induce lateral rotation, cannot be classed as rotary. This is a most important recent discovery in mandibular movements, and one which, in some cases, might, with profit, be reckoned with in denture construction.

GYSI'S WORK

In 1910, there appeared in the Dental Cosmos a series of articles by Dr. Alfred Gysi of Zurich, Switzerland, describing

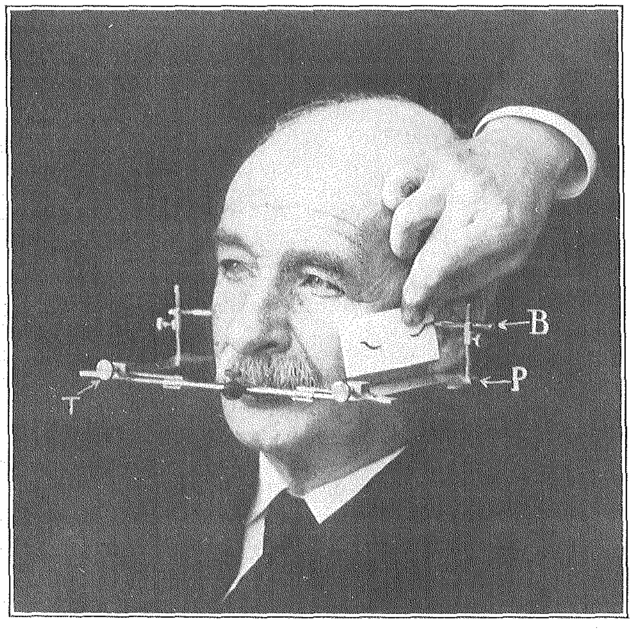


Fig. 1028.— The Gysi Condyle Register

in detail various registering devices for recording mandibular movements, together with many records, secured by means of them.

The principal appliances shown are an *articulator*, a *condyle path register*, and an *incisor path register*.

The articulator has adjustable condyle paths, and also adjustable rotation centers, the maximum distance between which is five and one-fourth inches, while the minimum distance is about two and three-fourths inches.

The condyle register, as its name indicates, records the inclination and curvature, if any exists, of the condyle paths, on cardboard, in such manner that the angular inclination

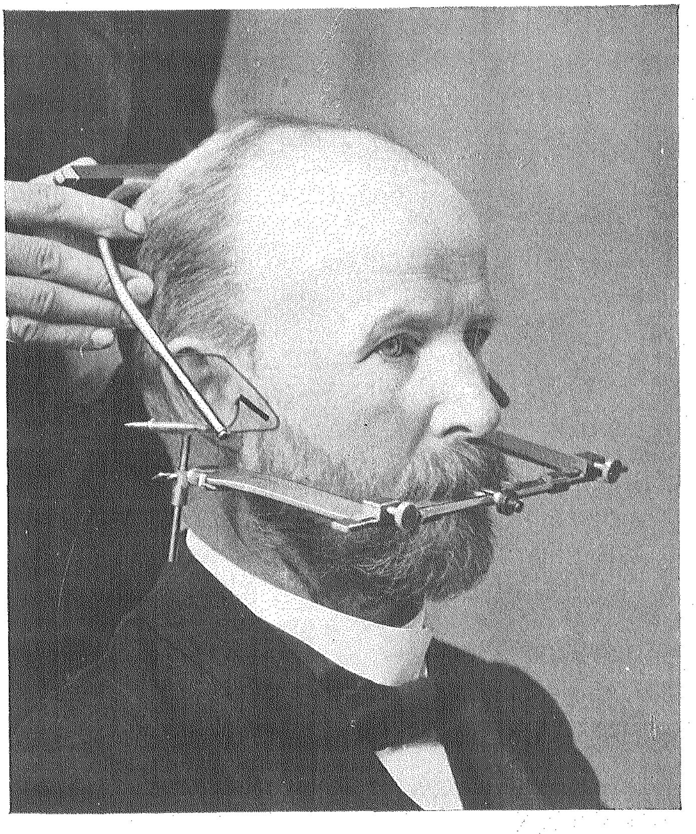


Fig. 1029.— The Gysi Lateral Path Register

may be read and the condyle paths of the articulator set accordingly.

The condyle register also fulfills the same purpose as a face bow in mounting casts on the occluding frame.

The incisor path register consists of a metal plate, attached to the occlusal surface of the lower occlusion model, the upper surface of which is covered with a thin film of carbonized wax. A small steel point, backed by a fine spring within a socket, and attached to a small plate, is fixed to the labial surface of the upper occlusion model in such manner that when the mouth is closed the point rests upon the waxed surface of the incisor path register, which extends somewhat forward of the labial surface of the baseplate. In lateral and protrusive movements of the mandible the point marks upon the waxed surface the lines of travel of the mandible in the incisal region. Later on, when the occlusion models are returned to the casts on the articulator, the rotation centers of the frame are moved to such position that the marker on the upper occlusion model will follow the same lines it marked on the waxed register during mandibular movements. By this means the lateral rotation centers of the mandible are determined and the centers of the articulator set accordingly.

Since 1910, Dr. Gysi has devised a *lateral condyle path register,* which records the bodily side movement of the mandible. The articulator condyle paths are so arranged that they may be set to reproduce this movement to a fairly accurate degree. (See page 465.)

The Gysi Adaptable Articulator, with accessory appliances enable the careful prosthetist to register more of the essential mandibular movements than can be accomplished by any other available means.

Consequently, with such registration possible, and with the generally improved methods in denture construction that have recently been and are being developed, prosthetic dentistry is rapidly advancing into the field of an exact scientific specialty.

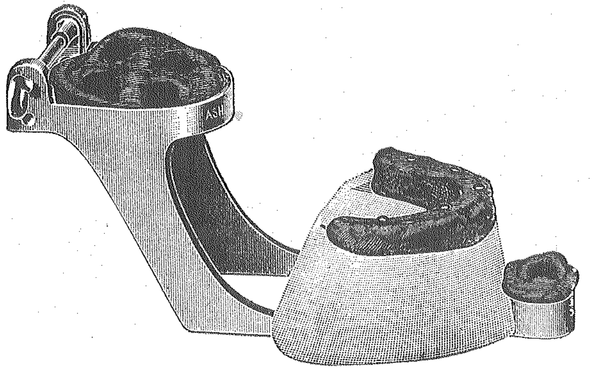


Fig. 1030.—Lower Section of Luce Articulator, Showing "Tracing Knobs" in Position on Lower Occlusion Model

Dr. C. E. Luce has designed an articulator in which certain anatomic movements may be reproduced as follows:

Round head tacks, or "tracing knobs," are pressed into the lower occlusion model, the wax rim of the upper model softened, and introduced in the mouth and the mandible subjected to lateral movements. The round heads of the projecting tacks mark lateral paths in the upper wax rim.

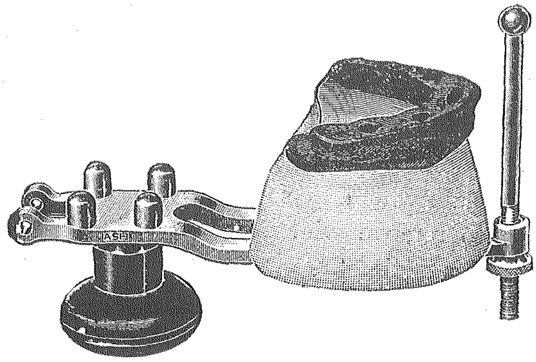


Fig. 1031.— Upper Section of Frame, Showing Paths Traced in Upper Occlusion Model

To use this appliance successfully, the casts should be mounted on it by means of a face bow.

When so mounted, the hinge pin of the articulator is removed, the cup situated immediately in front and between

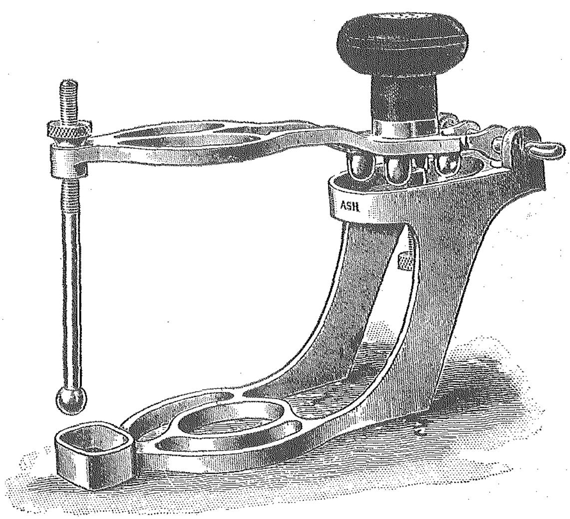


Fig. 1032.— General View of Luce Frame

the hinges filled with softened modeling compound, the upper bow of the frame carrying the cast and occlusion model is set in position and subjected to lateral movements, the round-head tacks guiding the direction of movement. During this lateral movement, projections on the underside of the upper bow, immediately over the hinge cup, form paths in the modeling compound.

These paths in the cup represent shorter arcs of circles than those in the occlusion rims. They have, however, common centers, viz., the centers of rotation of the mandible.

On removing the tacks from the occlusion rim the pins of the frame, resting and moving in the grooves in the compound,

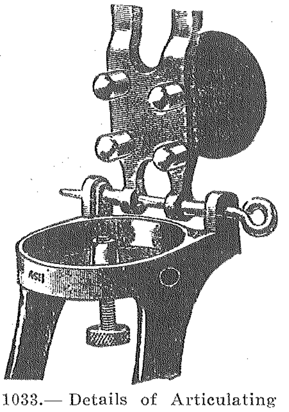


Fig. 1033.— Details of Articulating Cup

within the hinge cup guide and control the lateral movements of the lower against the upper occlusion model on much the same principle as a pantagraph works.

Crown Work

The placing of artificial crowns on the roots of natural teeth has been practiced for hundreds of years, yet it is only within the last half century that much advancement has been made over the primitive methods of Fauchard's time.

PIVOT TEETH OF DE CHEMANT

Pivot teeth of porcelain were mentioned by De Chemant in 1802, although for many years after his time, teeth carved

Fig. 1034.— Porcelain Crown (De Chemant)

from bone, ivory and various substances were used in single crown replacements. Frequently, sound natural tooth crowns were also used for this purpose.

THE GROOVED FLAT-BACK FACING

In the early part of the last century, a porcelain facing, grooved on the back, and with small strips of platinum baked

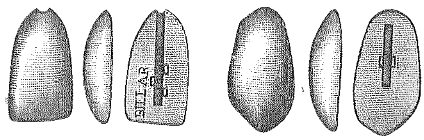


Fig. 1035.— Grooved Facings Formerly Employed in Crown and Denture Construction

in the porcelain along the sides of the groove for attachment to the wire pivot, was used both in Europe and this country in crown work.

THE ASH TUBE TOOTH

The Ash Tube tooth, introduced about 1840, was used in both denture construction and, to a limited extent, in crown replacements. (See page 529.)

The recent articles, within the last two years, by Dr. Girdwood, have shown the modern application of this type of tooth to prosthetic restorations. (Dental Cosmos, 1914-1915.)

THE WOOD PIVOT TOOTH

A full contoured porcelain crown, with a circular opening in the base for the reception of a wood pivot, was introduced, probably between 1850 and 1860. This crown was attached to the root by means of a wood pivot which fitted tightly into both crown base and root canal. The pivot was forced to

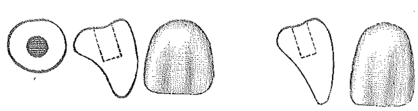


Fig. 1036.— Porcelain Crowns Designed for Use with Wood Dowels

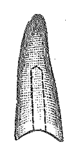


Fig. 1037.— Preparation of Root for Reception of Crown and Dowel. Labial View

place while dry, and on absorbing moisture swelled and firmly held the crown in position. The writer a number of years ago removed two central incisors which had been set in this manner eighteen years previously, neither of which, in that time, had required resetting.

THE SMITH CROWN

In 1844, Dr. J. Smith Dodge devised a crown which was of similar form to the one just described, but in which a wood

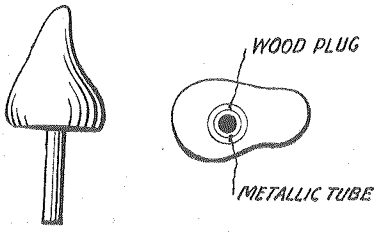


Fig. 1038.—Dr. J. Dodge Smith's Crown

pivot containing a metallic tube for a core to strengthen it was used.

THE CLARK CROWN

In 1849, Dr. F. H. Clark devised a removable crown, which was attached to the root by means of a metal dowel, split to

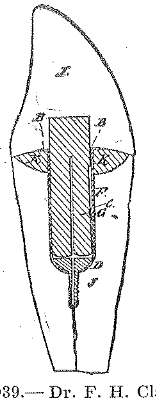


Fig. 1039.—Dr. F. H. Clark's Crown

form a spring, for bearing against a metal tube firmly fixed in the root canal. It was so formed as to afford drainage for pus or vent for gas which might accumulate in the pulp chamber.

THE LAWRENCE-FOSTER CROWN

In 1849, Dr. Henry Lawrence invented a porcelain crown having an opening extending through from base to lingual

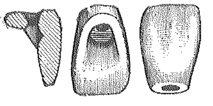


Fig. 1040.—Dr. Henry Lawrence's Crown. Afterward Called the "Foster" Crown

surface. It was held in place by means of a screw anchored within the root canal.

This crown was afterward known as the "Foster" Crown.

THE DWINELLE CROWN

In 1855, the American Journal of Dental Science contained a description by Dr. W. H. Dwinelle of a gold band with floor, fitted to a tooth with vital pulp, and held in place

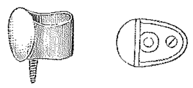


Fig. 1041.— The Dwinelle Crown for Vital Teeth and Non-Vital Teeth

by means of two screws passing through the floor and into the dentin. The "tubbing," or gold-bound cavity, was filled with crystal gold, while to the labial or buccal surface of the band a porcelain facing was affixed.

This same principle was also applied in the crowning of pulpless teeth, the crown being held in position by means of

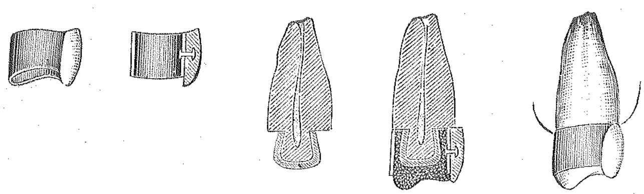


Fig. 1042.— The Dwinelle Crown for Vital Teeth

a screw anchored within the pulp chamber. The five cuts show the Dwinelle method of attaching a porcelain-faced ferrule crown to the stub of a vital tooth with crystal gold.

This work of Dr. Dwinelle is about the first reference found of combining gold and porcelain in the restoration of lost natural crowns.

THE WOOD CROWNS

In 1862, Dr. B. Wood describes the restoration of defective teeth by the application of enamel caps. These were

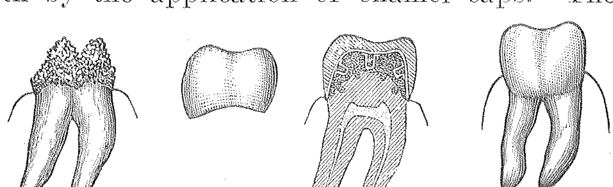


Fig. 1043.— B. Wood's "Enameled Cap" Crowns

formed by fusing to platinum caps, previously fitted to the teeth, some form of enamel, probably such as jewelers used.

These caps were cemented in place with oxychlorid of zinc or attached with gutta percha.

Dr. Wood also constructed thin gold crowns with interior staples by means of which anchorage to the teeth was secured

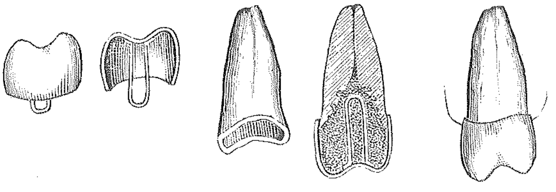


Fig. 1044.— Thin Gold Crowns Described by Dr. B. Wood

with cement. These crowns, because of their thin walls, were more or less unstable.

THE MORRISON CROWN

In 1869, Dr. W. N. Morrison described in the May number of Missouri Dental Journal a gold shell, two-piece crown.

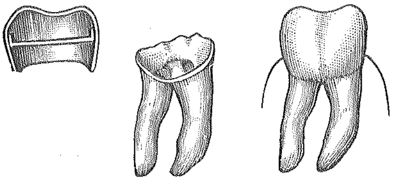


Fig. 1045.— Gold Shell Crown Constructed and Described by Dr. W. N. Morrison in 1869

This crown was substantially the same as is constructed to-day and is quite generally known as the "Morrison Crown."

THE BLACK CROWN

In the June number of the same journal, Dr. G. V. Black described and illustrated the construction of a porcelain-faced

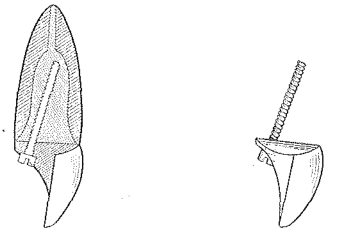


Fig. 1046.— Crown Constructed and Described by Dr. G. V. Black in 1869

crown for an anterior tooth, held in place by means of a screw passing into a gold-lined root canal.

The similarity between this and the crown Dr. Richmond patented years afterward is obvious.

THE BEAN CROWN

In the July number, 1869, of the American Journal of Dental Science, Dr. J. B. Bean described a porcelain-faced

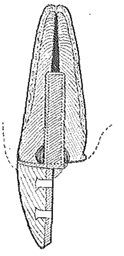


Fig. 1047.— Crown Constructed and Described by Dr. J. B. Bean in 1869

removable crown the dowel of which was split and received within a permanently fixed tube in the root canal.

THE MACK CROWN

In 1872, Dr. Chas. H. Mack designed a pivot tooth having a dovetailed depression in the base of the crown

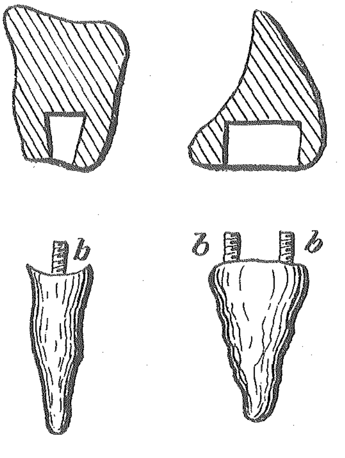


Fig. 1048.— The Mack Crown

Metal pins, roughened, were first fixed in the root of the tooth and the crown attached with cement or amalgam.

THE BEERS CROWN

In 1873, Dr. J. B. Beers of California patented a gold cap crown practically the same as described some four years previously by Dr. Morrison.

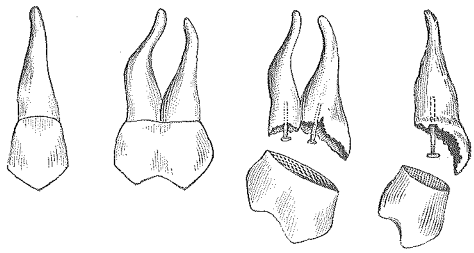


Fig. 1049.— The Beers Crown

THE GATES CROWN

In 1875, Dr. W. H. Gates devised a "vertically open contour crown," composed of metal and porcelain, designed to be held in place with cement. In this, as in the Mack crown,

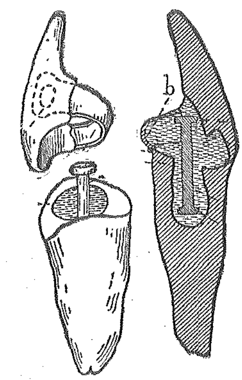


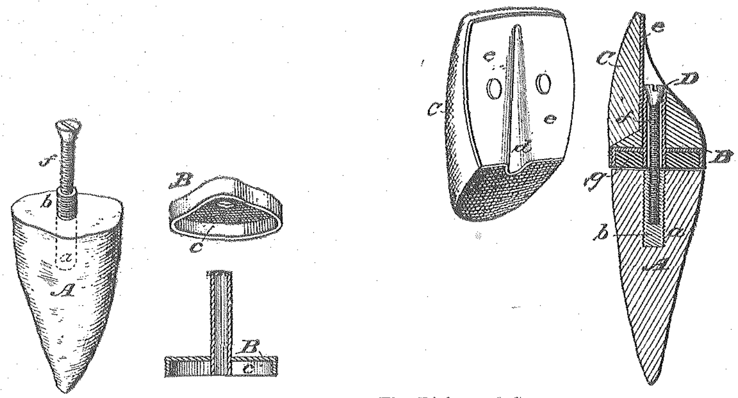
Fig. 1050.— The Gates Crown

the dowel was first permanently set in the root canal and the crown adjusted and attached later. Manufacturing difficulties, however, prevented its introduction and use.

THE RICHMOND CROWN

In 1880, Dr. C. M. Richmond designed a porcelain-faced crown backed with metal and held in place on the root by means of a screw similar to the crown designed by Dr. Black.

An internally and externally threaded tube was fixed in the root canal, the crown formed with a groove in its lingual surface for the passage of a screw which entered the tube within the root, and by means of which it was held in place.



Figs. 1051 and 1052.— The Richmond Crown

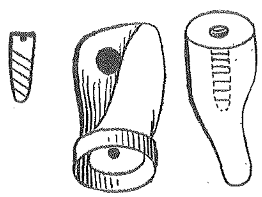


Fig. 1053.— Sketch of One of Dr. Richmond's Earlier Crowns

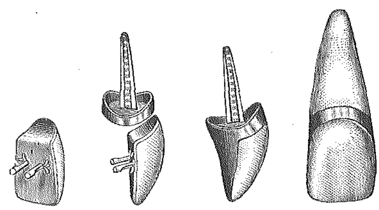


Fig. 1054.— The Improved Richmond Crown

A cap diaphragm rested upon the root end and over this the crown base, also of cap form, telescoped.

THE GATES-BONWILL CROWN

In 1881, Dr. W. G. A. Bonwill designed a crown wholly of porcelain having a central opening slightly enlarged at either end for the reception of metal dowel.

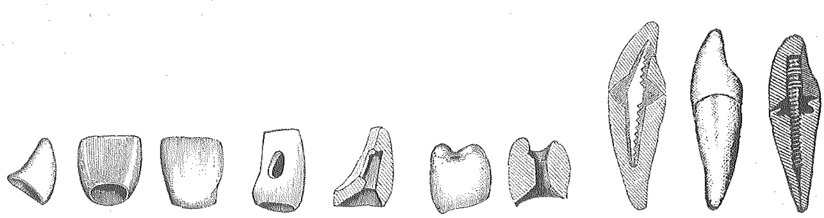


Fig. 1055.— The Gates-Bonwill Crown

These crowns were set with an amalgam specially prepared by Dr. Bonwill. Both three-sided and triangular metal dowels were used.

The specifications of the Mack patents, issued six years previously, were so broad that they covered the principle of this crown. Therefore, when placed upon the market it was given the name of the "Gates-Bonwill Crown."

THE BÜTTNER CROWN

In 1881, Dr. W. H. Büttner patented a set of appliances for reducing the root periphery of a tooth to a uniform cylin-

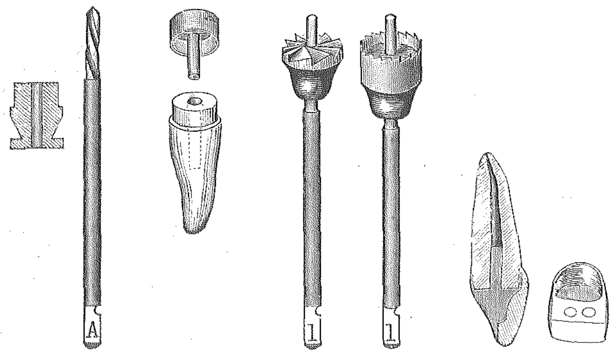


Fig. 1056.— The Büttner System of Crown Construction

der, fitting a deep-sided dowel cap to same and root canal and attaching a porcelain facing to the base so formed.

THE HOW CROWN

In 1883, Dr. W. S. How designed what was called the "four-pin crown." These pins, set within a depression on the lingual surface of the facing, were folded around a threaded

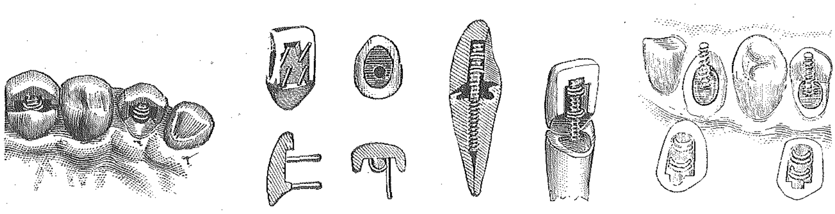


Fig. 1057.— The How Four-Pin Crown

dowel fixed in the root canal and the lingual contour of the tooth developed in amalgam.

Dr. How also designed the Dovetail Crown in 1889.

THE WESTON CROWN

In 1883, Dr. Henry Weston designed a "porcelain pivot crown" having two pins located in a depression on its lingual surface for the reception of a cross-head dowel. The dowel and facing were attached with solder and the crown attached to the root by gold, cement or amalgam.

Another form of crown devised by Dr. Weston consisted in a more fully contoured porcelain facing, in which the dowel

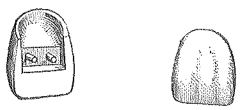


Fig. 1058.— Weston's Cross-Head Dowel Crown

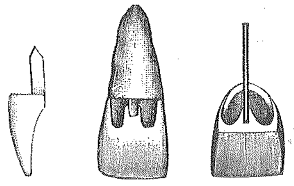


Fig. 1059.— Weston's Fixed Dowel Crown

was baked. This crown was secured to the root in the same manner as was the preceding crown.

THE LOGAN CROWN

In 1885, Dr. M. L. Logan devised a full contoured porcelain crown having a platinum dowel permanently fixed within its base.

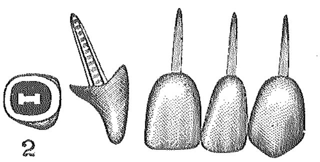


Fig. 1060.— The Logan Crown

This crown has, almost from its introduction, been extensively employed and has proven most serviceable as a substitute of the fixed dowel type.

THE BROWN CROWN

In 1890, Dr. E. Parmly Brown designed a crown very similar to the "Logan," but with a convex instead of a concave base.

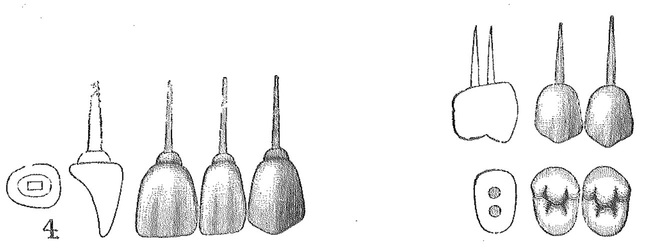


Fig. 1061.— The E. Parmly Brown Crown

Within recent years many forms of detached dowel crowns have been introduced, which, because of comparative ease of adaptation, are fast coming into favor, both as crown replacements and for use in bridge and denture work as well.

Among these may be mentioned the Davis, S. S. White, Justi, Brewster Twentieth Century, illustrations of which are found elsewhere.

An analysis of the various means by which crowns, both ancient and modern, are fixed to natural teeth and roots shows but two general principles of attachment, viz., with dowels, the telescoping principle, or a combination of the two methods.

Much of the material contained in the foregoing history of crowns has been obtained from a monograph published by the S. S. White Dental Manufacturing Company, entitled "Origin and Development of Porcelain Teeeth," and from various articles which have appeared from time to time in the Dental Cosmos.

Bridgework

Modern bridgework, of a practical character, is of very recent origin as compared with dental procedures in general.

Dental literature of modern times contains scarcely any reference to bridgework previous to 1869.

In addition to the three greatly improved crowns presented by Drs. Morrison, Black and Bean in that year, Dr. Bennett described, in the Dental Cosmos of October, 1869, a method of bridging in the space of a single missing tooth as suggested by Dr. B. J. Bing of Paris.

THE BING BRIDGE

This method consisted in preparing cavities in the teeth proximating the space, fitting a square bar across the space, its ends resting within the cavities, and by suitable steps

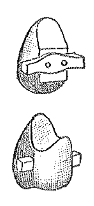


Fig. 1062.— The Bing Bridge Tooth, 1869

adapting and soldering a facing to the bar. The appliance was fixed by packing gold foil into the cavities and around the bar ends.

DR. WEBB'S WORK

In 1873, Dr. Marshall H. Webb suggested a modification of the Bing method, consisting of a flattened "two stop backing and saddle," and in 1879 a "stop post," consisting of a

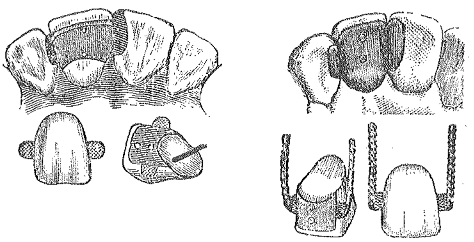


Fig. 1063.— Modification of the Bing Bridge (Webb)

facing attached to a rigid wire staple, the ends of which are anchored within the root canals of the proximating teeth.

In both cases the stops were surrounded by and anchored within gold foil filling in the cavities of the adjoining teeth.

DR. WEBB'S WORK

In 1880, Dr. Wilbur F. Litch suggested two modifications of the Bing bridge. The first was called a "wing plate," in which the backing was extended beyond the dummy so as to rest upon the lingual surfaces of the proximating teeth. Perforations were then made in the wings and corresponding

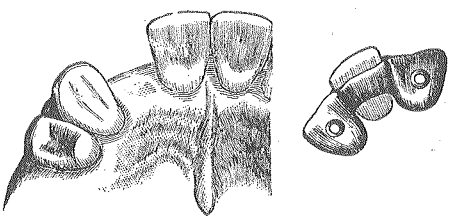


Fig. 1064.— Dr. Litch's First Modification of the Bing Bridge

holes in the teeth, through the enamel, and as deeply in the dentine as practicable, without endangering the pulp.

Headed platinum pins were passed through the plate into the holes, the relation between backing and pins secured, the case invested and the pins soldered to the wings. The substitute was set with cement.

The second modification consisted in devitalizing either one or both teeth and extending dowels through the wings into the root canals. It will be noticed that both Drs. Webb a Litch increased the anchorages of the dummies by root do

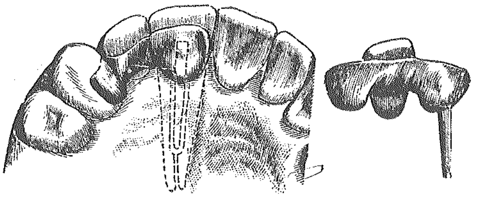


Fig. 1065.— Dr. Litch's Second Modification of the Bing Bridge

els, being impelled to do so because of failures in their first attempts.

DR. WILLIAMS' WORK

In 1884, Dr. J. Leon Williams, in the Dental Cosmos, called attention to the necessity for more stable anchorage for

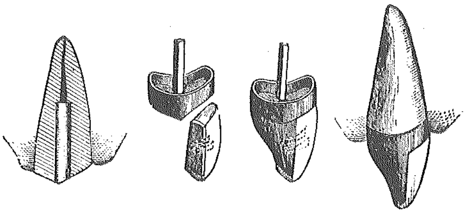


Fig. 1066.— Modified Richardson Crown (Williams)

bridges and suggested the use of a modified, so-called, Richmond crown, which, in a general way, represents a common type of porcelain-faced crown of to-day.

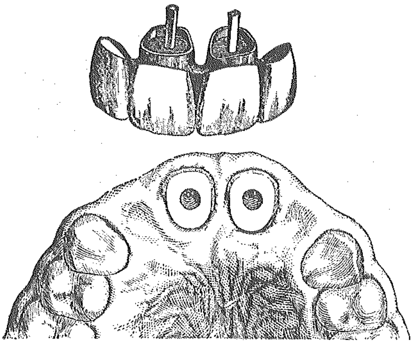


Fig. 1067.— Four-Tooth Anterior Bridge (Williams)

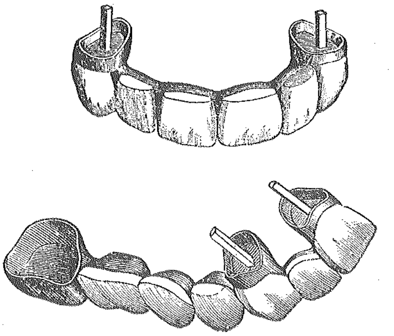


Fig. 1068.— Two Bridges Described by Dr. Williams in 1884

This article was followed, the next year, with illustrations and descriptions of two very practical bridges by the same writer.

Dr. Williams remarks, in January Cosmos, 1884: "As the single crown is the beginning and the end of all bridgework, a description of that particular form, which is of the greatest practical value, will be necessary. This is known as the Richmond crown, though not the crown he claims as his invention. It consists essentially of three parts — a pin [post?] which enters the root canal; a root cap of gold; and a porcelain face, which is the ordinary plate tooth."

It is evident that our modern system of bridgework could not have been possible without the evolution of suitable crowns for supporting the same.

DR. STARR'S WORK

In the Dental Cosmos, 1886, Dr. R. Walter Starr described a difficult case of restoration in which two removable bridges were successfully applied. The telescoping crown principle is here mentioned for the first time.

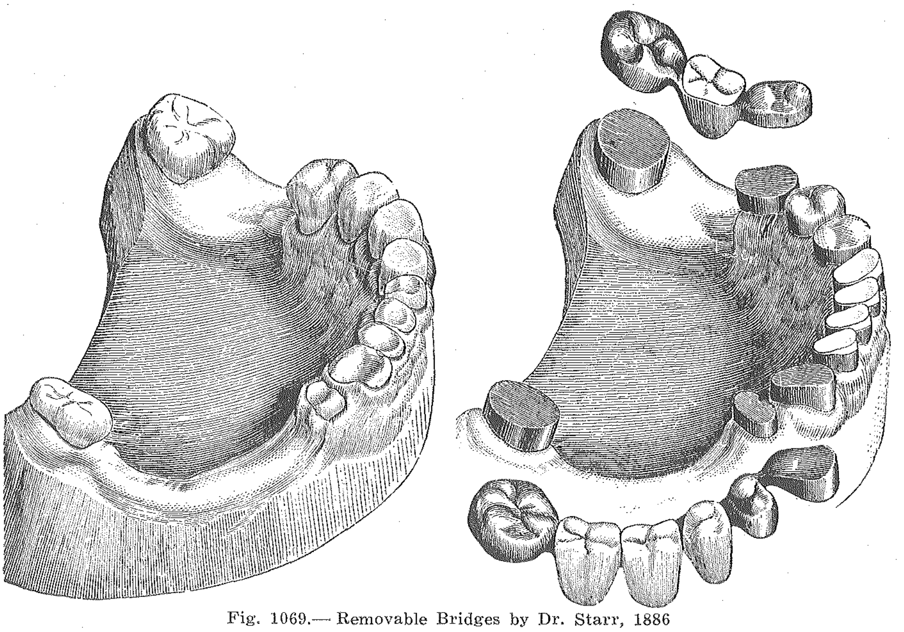


Fig. 1069.— Removable Bridges by Dr. Starr, 1886

In 1887, Dr. Starr suggested a modification of the Bing bridge tooth, consisting of a porcelain tooth with two parallel bars extending through it by means of which the projecting ends of the substitute were anchored within fillings placed in the proximating teeth.

The names of Drs. Cryer, Starr, Hodgkin, E. Parmly Brown, Rollo Knapp, Stowell, and Rhein are associated with the early history of recent bridge methods, nearly all of whom presented modifications of the Bing bridge.

Drs. Williams, Richmond and Knapp seem to have been among the first to recognize the necessity for the use of

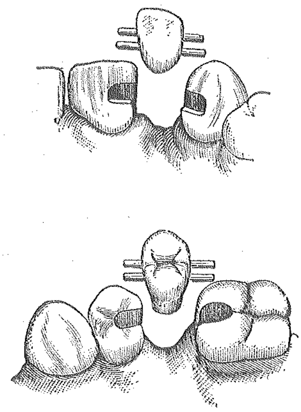


Fig. 1071.— Starr's Modification of the Bing Bridge, 1887

stronger and more hygienic abutments in bridge appliance, although no doubt many others were coming to recognize the same fact.

In 1888, Dr. Sidney S. Stowell described an extension stop-supported bridge, similar to those frequently constructed to-

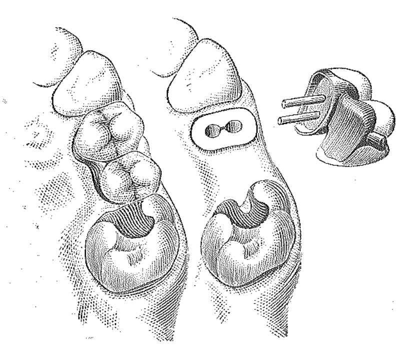


Fig. 1072.— Two-Tooth Stop and Saddle Bridge

day, except that with present methods the stop rests in a depression within an inlay instead of being enclosed within a filling, as described by Dr. Stowell.

BASIS OF OUR PRESENT SYSTEM OF BRIDGEWORK

The crowns of Wood and Dwinelle in the "50's" formed the basis. The great improvements by Morrison, Black and

Bean, in crowns, and the appearance of the Bing bridge tooth, all of which were presented in 1869, although crude, furnished the necessary elements which had previously been lacking.

Further improvements in crowns, the development of various forms of dummies, together with simplified technical procedure, gradually followed, but only after many failures and a considerable lapse of time.

It is singular to note that practically all of the pioneers in bridgework failed to recognize the heavy stress in masticatory effort delivered against bridge replacements. Neither were the limitations in regard to resistance of stress of the materials employed well understood.

This lack of knowledge of the strength of materials used, together with an indefinite or exaggerated idea of the capacity of natural teeth or roots for performing their own work and carrying the additional burden imposed by the replaced teeth were some of the discouraging features.

Peridental troubles, the splitting of roots and recurrent decay of the abutment and pier teeth and roots were of frequent occurrence.

A recognition of these facts, which could only be gained by experience, led to further improvements in crowns of greater strength and of more hygienic form and in more judicious selection of cases for substitutes of this type.

PORCELAIN BRIDGE

Baked porcelain crown and bridge work went through a similar process of trial, failure and development before the limitations in this field were finally determined. The principal

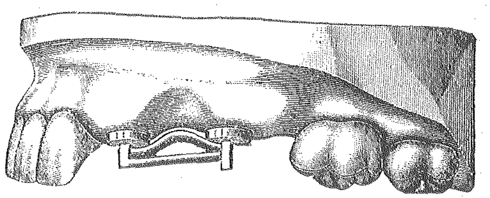


Fig. 1073.— Platinum Framework for Porcelain Bridge (Schwartz, 1902)

failures were due to insufficient strength to the metal substructure and deficient bulk of porcelain. One of the pioneers in this field was Dr. G. W. Schwartz of Chicago, who was engaged in the production of porcelain crowns, bridges and inlays as early as 1893.

While to-day, the application of fixed bridgework is not as extensive, the results of such application at the present time are generally far more satisfactory than in the past.

REMOVABLE BRIDGES

Bridges of the removable type, and partial dentures supported by saddles resting upon the alveolar process, retained in position by some of the various forms of fractional appliances, are now introduced in many cases where formerly bridges of the fixed type were applied.

INLAYS

An inlay, in its dental meaning, refers to a filling composed of some dense material, constructed outside the tooth cavity, and which is held in position in the cavity by some adhesive medium.

FIRST RECORDED ATTEMPTS IN FILLING TEETH

The first attempts at filling teeth must naturally have been extremely crude, and the results of the pioneer efforts in this field have proved but temporary in character. Because of the difficulty in adapting dense materials, the first fillings were undoubtedly of the pasty, plastic or pitchy class.

Mastic and alum, a substance of this class, was recommended for filling carious cavities, by Rhazes, a Persian physician, about 850 A. D. (Guerini). Frequently medicinal agents were incorporated with the mastic base for the purpose of arresting the progress of decay, myrrh, sulphur and turpentine being mentioned in this connection. The comfort derived from the use of such stoppings, although only of temporary nature, gradually led to the general practice of filling, and the use of more permanent materials.

Mesu, an Arab surgeon, in the latter part of the eighth century recommended the use of gold foil for filling teeth, while from the thirteenth century on various writers mention the use of both gold and lead for this purpose.

FIRST MENTION OF INLAYS IN DENTAL LITERATURE

In 1690, Pierre Dionis, a surgeon of Paris, in discussing the filling of teeth, says: "For this purpose, gold or silver leaf is made use of; but this method of stopping is not durable, because gold or silver leaf is apt to become loosened and fall out. It is therefore preferable to make a stopping with a piece of gold or silver corresponding in size and shape to the cavity. Many prefer lead on account of its softness, while others simply use wax." (Guerini.) This is the first definite reference to the inlay method of filling teeth, so far as the writer knows, in any of the old-time treatises on dental procedures.

In 1718, Lorenz Heister, a German surgeon recommended the filling of teeth with various substances. In reference to crown cavities in molar teeth he recommends gold or lead leaf, or a *piece* of the later fitting into the cavity. (Guerini.)

Unfortunately, few specimens of ancient inlay work are in existence, and the genuineness of such as are preserved is questionable.

PREHISTORIC INLAY WORK

In the Peabody Museum of Harvard University is a prehistoric skull, in the central incisors of which are inlays of green stone. This specimen was found a few years ago among the Aztec or Toltec ruins, near Copan, Honduras, by Professor Owen. Whether these inlays were placed in the teeth to correct the ravages of decay or merely for ornamental purposes cannot, of course, be determined.

THE BEGINNING OF MODERN INLAY METHODS

Authentic records of inlay work in modern times date back only about one hundred years. At the beginning of this period, tin, lead and gold, in the form of foil, were the only metallic fillings in use. Amalgam had not yet been introduced. It came into vogue as a filling material, under the name of "silver paste," about 1825, but for years was looked upon with disfavor and used to a very limited extent. Cohesive gold was not introduced until 1855, and therefore, since none of the foils were cohesive, extensive contour restorations were impossible. Added to these difficulties, the general dislike on the part of patients to the display of metals in the mouth, rendered the filling of teeth a discouraging, and oftentimes unsatisfactory, procedure.

It is not surprising, therefore, that efforts were early made to find a material for filling operations less objectionable in appearance, and easier to manipulate than the metals. The records of these attempts are scattering and difficult to find.

Many efforts in inlay work, and probably some reasonably successful results, were without doubt never disclosed, because, as a rule, the pioneer practitioner kept his methods a secret.

Such early records as are available are usually found in little handbooks, published in the early days by the practitioner, and intended for circulation among prospective patients. Later on, the dental journals from time to time contained descriptions of inlay methods, as they developed.

BRIEF SUMMARY OF INLAY WORK, BEGINNING WITH 1820

In 1902, Dr. Walter W. Bruck of Breslau, Germany, in the Items of Interest, presented an outline of the history of inlay work, gathered from common and obscure sources. A portion of the following brief description of the progress of this work is based upon the article mentioned.

In 1820, C. J. Linderer filled teeth by the "fournieren" (inlaying) method and the "plattieren" (veneering) method. The first procedure consisted in preparing a cavity in circular form, and from the tooth of some animal shaping a cylindrical rod to fit. This was driven into the cavity, the projecting portion cut off and polished even with the tooth surface. The expansion of the inlay, due to absorption of the oral fluids, caused it to swell and thereby furnish retention. Sometimes both inlay rod and cavity walls were threaded to furnish positive mechanical retention.

The plattieren method was adapted to shallow cavities and consisted in shaping small, flat pieces of rhinoceros teeth to fit the prepared cavity. These veneers were usually held in place with dowels of the same material. Difficulty in matching the shades of the natural teeth, discoloration from use and general lack of permanency, were the principal objections to the Linderer inlays.

In 1837, Dr. Murphy of London conformed a platinum matrix to the prepared cavity, and in this matrix a glass inlay was fused, which was held in place with amalgam.

In 1857, Dr. A. J. Volck recommended the use of porcelain for filling cavities in the front teeth. The inlays so formed were held in place by packing ropes of gold foil around their peripheries.

In 1862, Dr. B. Wood shaped porcelain blocks to tooth cavities by grinding to form.

In 1870, Dr. Hickman formed inlays from sections of porcelain teeth, shaping the pieces to fit the cavities by grinding.

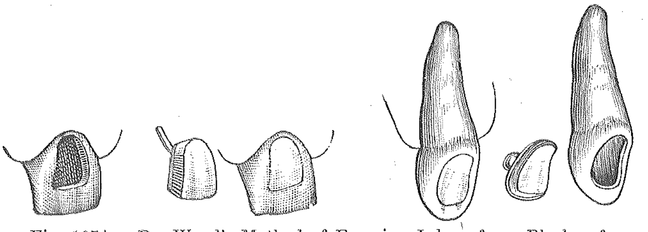


Fig. 1074.— Dr. Wood's Method of Forming Inlays from Blocks of Porcelain by Grinding

In 1870, Dr. Starr designed "cavity stoppers," small pieces of porcelain of various shapes and sizes, which were fitted to cavities by grinding. The pieces were provided with platinum pins for retention purposes.

DR. C. H. LAND'S METHOD OF PORCELAIN INLAY WORK

In 1870, Dr. C. H. Land constructed inlays by "fusing pieces of artificial teeth in a platinum impression of the outer borders of the cavity." This method, as he later on modified it by pulverizing the teeth before fusing, represents the basic principle of our porcelain inlay system of to-day.

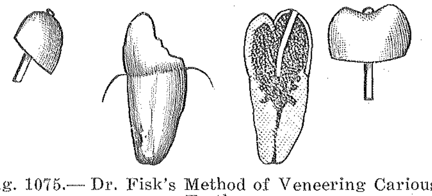


Fig. 1075.— Dr. Fisk's Method of Veneering Carious Teeth

In 1876, Dr. Bogue described a method suggested by Dr. Fisk of veneering a carious tooth with small gold caps, which he likened to "little gold toadstools, set with gutta percha, somewhat resembling an umbrella."

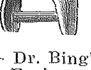


Fig. 1076.— Dr. Bing's Metallic Facing

DR. BING'S METALLIC FACING

In 1877, Dr. B. J. Bing recommended the use of "metallic facings" for protecting fillings of cement or gutta-percha. These facings were usually made of pure gold or platinum, and when set very much resembled in appearance the metallic inlays of the present time.

Dr. Wilber F. Litch describes these facings quite fully in the American System of Dentistry, p. 949. Of their practicability, he says: "In large crown cavities they have an indefinite durability, and in the writer's practice large numbers of proximal facings have been in use for three and four years and still give no sign of failure." This system, although crude, proved an incentive to many to attempt the restoration of badly decayed bicuspids and molars by these or similar means. The writer constructed and placed a number of facings of this type for patients in the clinic of Washington University Dental School in 1891. (Mo. Dental College.)

ROLLINS' METHOD OF INLAY WORK

In 1885, Dr. W. Rollins, in the Archives of Dentistry, described as follows a method of inlay work employed by himself for a number of years previous to the date mentioned. An impression of the tooth with cavity prepared is taken in a material composed of two parts mastic, one part paraffin, and one part graphite. The tooth and cavity surfaces should be previously oiled with vaseline. When secured, the impression should be placed in a bath of copper sulphate, and a film of copper deposited by electrolysis, the process usually requiring from two to three days to develop a sheet about 1½ m.m. thick, or sufficiently rigid to obviate distortion in handling. The impression was then removed, and a hole bored in the bottom of the cavity in the copper reproduction of the tooth, to facilitate the removal of the matrix. Into the cavity a piece of No. 30 gold foil was adapted with pellets of cotton. The matrix thus formed was filled with enamel powder and fused in a gas muffle furnace. Before the mass hardened it was pressed into the copper mold with a platinum instrument. After cooling, the enamel was removed from the mold by pressure through the opening in the base of the copper pattern, and the gold matrix peeled off. It was set with a mixture of zinc oxide and gutta-percha, the excess being removed with chloroform.

DR. DUNN'S METHOD OF INLAY WORK

In 1885, Dr. C. W. Dunn, in the British Journal of Dental Science, described a method practiced by himself since 1868, of taking a wax impression of the tooth and cavity, from which a model in plaster was secured. This was painted with a mixture of wax and rosin, to prevent friability of the cavity margins. Into the cavity a filling was fitted by repeated grinding and trial, until satisfactory adaptation had been secured, after which it was set with cement. Various substances were used by him for inlays, such as mineral and natural teeth, as well as the teeth of cattle and lambs.

DR. STOKES' METHOD

In 1887, Dr. J. L. Stokes, in the Southern Dental Journal, described a method of first making the inlay, and shaping the cavity to receive it. After setting, he removed the hardened cement from the joint to a slight depth, and filled between the cavity walls and inlay with gold. A similar method of retention had been previously introduced by Dr. Essig of Philadelphia some time in the seventies.

DR. AMES' METHOD OF GOLD INLAY WORK

In 1888, Dr. W. V. B. Ames of Chicago constructed gold inlays by adapting a foil matrix of platinum to the tooth cavity, and fusing in it gold plate or solder to the required contour. The inlay was then cemented in position. Shortly after this he demonstrated the method at a meeting of the Illinois State Dental Society, a description of which is found in the Proceedings of 1890.

So far as the writer is able to learn, this was the beginning of the gold inlay methods by the matrix system. It demonstrated the practicability of fillings of this type.

VARIOUS METHODS OF INLAY PRODUCTION IN RECENT YEARS

In 1889, Dr. W. Storer-How, in the Dental Cosmos, described in detail the method of constructing inlays by grinding sections of porcelain teeth of suitable shade, to the desired form.

In 1889, Dr. Herbst described a method of making glass inlays. An impression of the tooth with cavity prepared was secured in Stent's Compound, from which a plaster model was formed. To make the base of the inlay rough, for retention purposes, grains of sand were placed in the bottom of the cavity of the plaster tooth, and the latter, while moist, was filled about two-thirds full of powdered glass. The moisture was then absorbed and the glass fused. This was then repeated until the inlay was of the desired contour.

In 1890, Prof. Sachs recommended making a matrix of Williams' gold foil No. 60, or of platinum foil, and fusing the glass directly into this reproduction of the cavity. Sachs also described an excellent method of making inlays from porcelain teeth of suitable shade. From a porcelain tooth a piece nearly cylindrical in form and slightly larger than the cavity was cut. This cylindrical section was mounted with melted shellac on the end of an engine mandrel. The mandrel was revolved in the engine and the porcelain held against the face of a lathe stone revolving in the opposite direction. The mandrel was held at a slight angle to the face of the lathe wheel, so as to form the mounted block into a slightly tapering cone. The cavity was prepared in circular form by means of suitable wheel burs. The inlay, still mounted on the mandrel, was introduced into the cavity with emery powder or pumice stone, and revolved rapidly to secure close adaptation at the margins. When closely adapted a groove was cut near the peripheral base of the inlay for retention purposes. After setting, the surplus, or projecting end, was reduced to a level with the tooth surface with stones and discs. Copper trephines charged with diamond dust were also used for cutting the section from the porcelain tooth, while cylindrical burs corresponding in size to the section cut by the trephine were used for forming the cavity.

In recent years the supply houses have introduced rods of porcelain for inlay work, of varying sizes and tints, with trephines of corresponding sizes for cavity preparation. This system obviates grinding the periphery of the inlay. A section of rod, slightly longer than the depth of the cavity, is cut and cemented to place, and the surplus reduced with stones and discs.

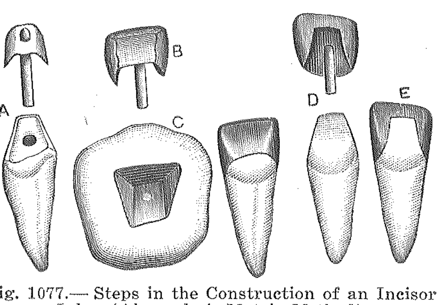


Fig. 1077.—Steps in the Construction of an Incisor Inlay (Alexander's Matrix Method)

DR. ALEXANDER'S INLAY METHODS

In 1896, Dr. C. L. Alexander described a method of inlay construction, the substance of which is as follows: Prepare cavity with definite margins. Make holes for retaining pits in dentin. Adapt platinum foil to tooth surface. Insert retaining posts through matrix. Take impression of posts and

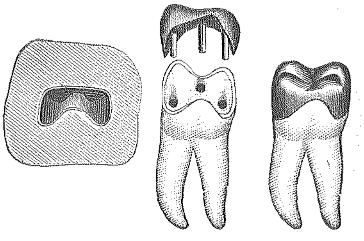


Fig. 1078.— Pin Inlay for Molar Tooth

foil; remove, invest and unite with pure gold. Return to tooth for final adaptation and trimming.

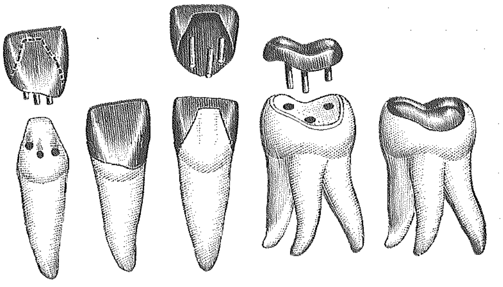


Fig. 1079.— Various Views of Incisor and Molar Inlays

When fitted, a wax or modeling compound bite is taken, occlusion casts are formed, the bite removed, and the desired restoration developed in wax.

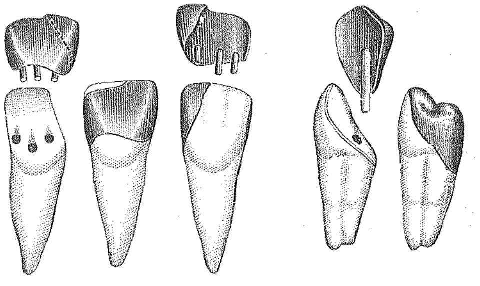


Fig. 1080.— Restorations for the Anterior Teeth

Over this restoration in wax, gold or platinum foil is burnished.

Invest, leaving one side open for removal of wax with hot water and into the metal-lined matrix thus formed gold is fused. The various illustrations here shown are from the Dental Cosmos.

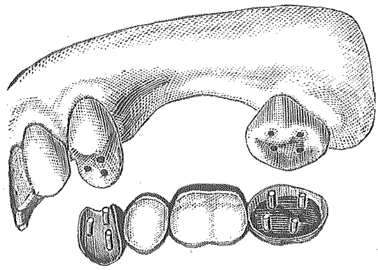


Fig. 1081.— Bridge with Pin Inlay Attachments

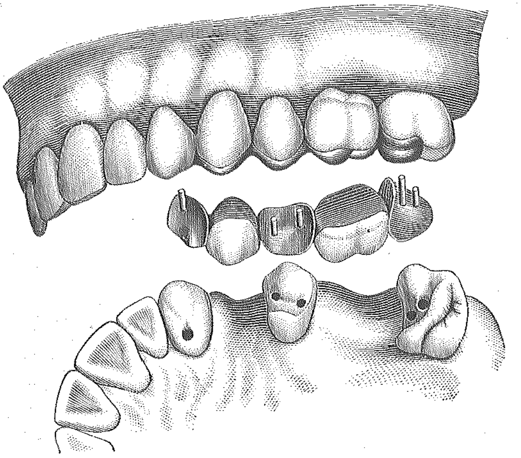


Fig. 1082.— Upper Bridge Supported by Three Pin Inlays

In 1897, Dr. M. S. Finley described a similar method of restoring the occlusal surfaces of bicuspid and molar teeth.

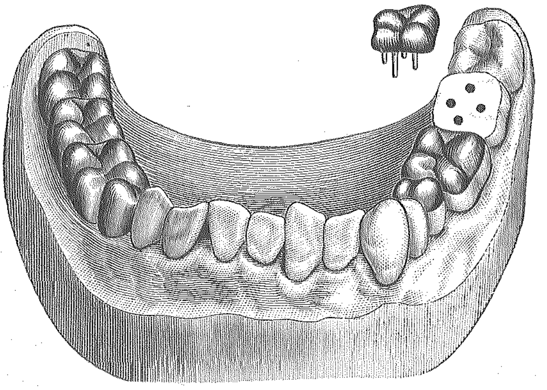


Fig. 1083.— Pin Inlay (Finley)

Heavy gold, however, instead of foil, was used for adaptation to tooth surfaces. When swaged on a die and adapted to the tooth, the cusp forms were developed on this rigid foundation.

Gold inlays were made by preparing the cavity without under cuts, and into this Watts' crystal gold was moderately condensed, the filling being built to general contour by this means. It was then removed and the cavity surfaces of the inlay were painted with rouge and alcohol to prevent the solder, which was afterward flowed into the interstices, from spreading and modifying the form of the inlay. The originator of this method is not known to the writer. Dr. W. M. Griswold of Hamburg, Germany, described it a number of years ago, and stated that he had been using it since 1898.

SLOW PROGRESS OF INLAY WORK

Inlay work advanced slowly because of the prejudice existing in regard to the use of cement as a retention medium for fillings of this class. The objections urged against inlays in general, both porcelain and metallic, were, first, the liability of the cement to solution by the oral fluids, and second, the tendency of such fillings to become displaced under stress.

Three factors contributed largely to the production of both classes of inlays under consideration: First, the introduction of the Custer electric furnace in 1894, and of improved porcelain bodies, revolutionized and simplified the making of porcelain inlays; second, the methods of cavity preparation in general, suggested by Dr. Black, of opening up cavities in order to gain access to all parts, and of developing flat seats and parallel walls so as to furnish resistance form, largely overcame the liability to displacement, of inlays of both gold and porcelain, when set and subjected to stress; third, observation of cases where properly adapted and correctly set inlays had been subjected to stress and the action of the oral fluids for a considerable length of time, disclosed the fact that cement, although not ideal, was a reasonably good retaining medium, not liable to solution as rapidly as was at first deemed probable, and that under favorable conditions there was no recurrence of decay.

The improvements mentioned in porcelain bodies, and means of fusing the same, together with the beautiful results accomplished by experts in this field, developed a widespread wave of enthusiasm in ceramic dental art. Like all new things which promise reasonably good results, porcelain became a fad and was grossly misapplied, not only in the construction of inlays, but in crown and bridge work as well. In limited bulk, porcelain is inherently weak, friable and extremely liable to fracture under stress. These facts were overlooked, or not recognized by many, with the result that many discouraging failures occurred. Warpage of the matrix, resulting in imperfect adaptation of inlays to cavities, difficulty in matching the tints of natural teeth, with fracture and displacement of the fillings under stress, were some of the discouraging features of porcelain inlay work.

From flood to ebb tide, the wave of enthusiasm in ceramic work lasted about ten years, beginning about 1895, just following the advent of the Custer electric furnace. It reached its highest level in 1903-4. Since the latter date mentioned, as time and service disclosed the limitations of porcelain as a filling material, its use has gradually declined. Its value in favorable locations is unquestioned.

PROGRESS OF GOLD INLAY METHODS

Meanwhile, although less desirable from an esthetic standpoint than porcelain, the production of gold inlays rapidly increased, because of their great inherent strength and wide range of application. During the period from 1900 to 1907, the method of gold inlay production by means of a matrix gained in favor, technical steps improved, and the value and permanence of this system of filling teeth was practically established.

One of the greatest difficulties met with in the making of gold inlays by the methods then in vogue was in warpage of the matrix while fusing the gold in it to the desired contour. In 1905, Dr. Barnes of Cleveland, Ohio, demonstrated that by substituting 1-500 platinum foil for the 1-1000 gold or platinum foil then in use, warpage could be practically elminated.

While the matrix method of inlay production had approached a stage bordering on perfection, the technical steps involved were at times tedious and sometimes complicated, depending on the form and location of the cavity to be filled. The production of the matrix itself, although much less trying on both patient and operator than tedious filling operations, required time and skill to secure the desired results. Some easier method, therefore, was sought.

INCEPTION OF THE WAX MODEL METHOD

The idea presented of making a model of the filling by pressing wax into the tooth cavity, or a reproduction of it.

This model, when properly carved and contoured, was invested and cast in metal. Where or when this idea originated, or to whom credit for it belongs, cannot now, and probably never will, be determined.

An Analysis of the Casting Process

By analysis, the casting process, as applied to dental operations, may be set forth as follows:

First, forming in a plastic material as wax, or in wax and metal, a model or pattern of the object it is desired to reproduce by casting.

Attaching to the model, before investment, a wax or metal sprue former to form a *pouring gaine,* or sprue, for the injection of the metal into the mold.

Enclosing the pattern with sprue former attached, in a single mass, or a sectional mass of refractory material, capable of setting in a short time and of withstanding heat without material change.

Eliminating the wax from the investment by some form of applied heat, thus freeing the mold for the introduction of the metal.

Fusing the metal in a crucible-like depression in the investment, which is connected with the mold, through the sprue; or melting the metal in a crucible and pouring it directly into the enlarged outer extremity of the sprue, through which it is conducted into the mold.

Applying pressure to the molten metal to force it into all parts of the mold, to insure the production of a sharp casting.

Some of these various processes will now be considered in detail, after which their application in the production of prosthetic restorations of different kinds will be presented somewhat in chronological order.

FORMING MODELS IN WAX OF THE CASTING TO BE PRODUCED

The construction of a plastic model, usually wax, of the object it is desired to reproduce in metal.

This principle is centuries old among artizans, and even among uncivilized people, with some of whom it was customary to form in wax a model of an implement and enclose it in a clay investment. On heating the clay, the latter was hardened and the wax dissipated, thus leaving a matrix or mold into which the molten metal, usually copper, was cast.

METHODS OF FORMING A SPRUE OR POURING GATE

A sprue is defined as follows: "In casting metal, one of the passages leading from the 'skimming gate' to the mold; also, the metal which fills the sprue or sprue-gate after solidification, same as dead-head." (Century Dictionary.) "A piece of metal or wood used by a molder in making the ingate through the sand." (E. H. Knight.)

For many years, in prosthetic procedures it was customary, and is, even at the present time, in two-piece molds, to cut the sprue after investment of the model. More often, however, a piece of wax is attached to the pattern leading externally to the outside of the investment flask, so as to form a groove in both parts of the investment. When the matrix is separated and the wax removed, the groove thus formed may be enlarged if necessary for the injection of the metal. In single investments, a piece of wax, metal or wood, of suitable size for the sprue is attached to the model before investing, and removed after the investment has hardened. When wax is used, its removal is effected by heat.

In Harris, Ed. 1873, the first suggestion of "small cylindrical wax gates" are mentioned in connection with the Bean process of casting. These were enclosed in a single investment to serve as sprue formers through which the metal was cast in attaching the teeth to the aluminum base.

In Richardson, Ed. 1880, mention is made of a tapering sprue former of wax, in connection with Reese's cast base dentures. The name *pouring-gaine* is there applied to it. In the final investment of a pattern, the wax sprue former was entirely enclosed, and subsequently dissipated in heating the case.

ENCLOSING THE WAX MODEL IN A SINGLE INVESTMENT

The object in enclosing a wax model in a single investment rather than in a sectional matrix is to prevent fracture of the margins of the mold, which nearly always occurs in opening a matrix formed in two or more pieces.

Rough margins of the mold result in rough castings, while oftentimes, even though the margins may not be fractured, slight contraction in the investment material, or failure of the several sections of the matrix to register correctly, will permit the fused metal to escape into the joint areas.

This fact has been recognized by many and for the past twenty years or more the single investment has been gradually coming into favor.

ELIMINATING THE PATTERN BY HEAT

This is a logical outcome of the use of wax for a pattern and of its enclosure in a single investment.

FUSING THE METAL IN CLOSE PROXIMITY TO THE MOLD

The principal cause of failure in casting operations is due to the metal when fused becoming chilled and more or less sluggish in injecting it into the mold. This difficulty is specially noticeable when the metal is melted in a separate receptacle from which it is poured into the mold.

To cast sharply, a metal or alloy must be superheated sufficiently so that after injection into the mold it will be in a liquid, conformable condition, in order to become adapted to irregular surfaces.

APPLYING PRESSURE TO THE FUSED METAL TO INDUCE SHARPNESS OF DETAIL IN THE CASTING

The necessity for applying pressure in some manner to the fused metal to insure sharpness of detail in castings was recognized by Blandy in 1855, and many others since his time.

The manner of applying pressure to eliminate the air in the mold and permit the metal to fill it perfectly varies greatly, as will subsequently be seen.

Briefly summed up, some of these methods are as follows: Gravity, vibration, mechanical pressure, compressed air or gas, partial vacuum, centrifugal force and steam.

PIONEERS IN THE PRODUCTION OF CAST WORK

The casting of denture bases of tin, as stated on page 1132, was first attempted by Dr. Edward Hudson of Philadelphia in 1820, by Dr. W. A. Royce of Newburgh, N. Y., in 1836, and by Dr. George E. Hawes of New York in 1850.

Tin does not cast sharply by the ordinary or crude methods employed in those days and therefore the production of dentures by this method was not very satisfactory.

The introduction by Dr. A. A. Blandy of an improved tin alloy gave a decided impetus to casting methods since his time.

THE BLANDY CAST BASE DENTURE

The Blandy Process of casting metal base dentures, which was presented in 1856, was described in Harris, Ed. 1873, in substance as follows:

A wax model of the required denture was formed in which the teeth were arranged, much as for vulcanite cases, a special tooth being used for this purpose.

The waxed case was enclosed in a two-piece investment composed of plaster and feldspar. On separating, the larger

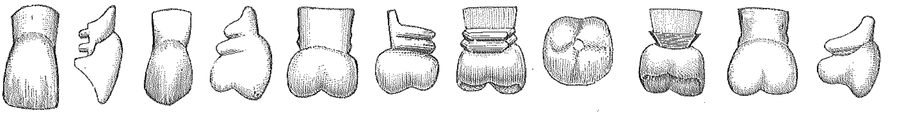


Fig. 1084.— Teeth Designed for Use with the Blandy Process, 1855

portion of wax was removed, but the smaller portions between the teeth were allowed to remain, being subsequently dissipated in the heating process.

A channel was cut in the back of the case, at least two inches long, to serve as a sprue, and on either side vents for the escape of the air were formed. A deep sprue was suggested so that when filled, the weight of the metal therein contained would insure density in the casting. In addition to this means, it was suggested that jarring the flask as soon as the metal was poured would aid in the production of a sharp casting.

BEAN'S METHOD OF CASTING ALUMINUM

In 1867, Dr. J. B. Bean of Baltimore formed denture bases in wax, arranged gum section teeth in occlusion and alignment and carved the denture to required form. The gum sections were then removed and a recess of dovetailed form was carved in the wax baseplate to the lingual of the pins to afford anchorage for the gum sections in final attachment.

The wax model, minus the teeth, was then enclosed in a special flask, in an investment composed of plaster and pumice stone previously boiled, so treated to form a denser mass than would result from an ordinary mix.

When the investment was hardened, the flask was opened, the wax removed, the flask again closed and thoroughly heated to evaporate the moisture.

The flask was supplied with three openings, one centrally located to serve as a sprue for the introduction of the fused metal, and a smaller one on either side for the admission and exit of hydrogen gas at the moment of casting. At the time of clearing the matrix of wax, grooves were cut from these openings to the interior of the mold.

The terminal end of the sprue on the flask was cone-shaped to receive an extension sprue, some six inches long, which was heated and set in position just before pouring the metal.

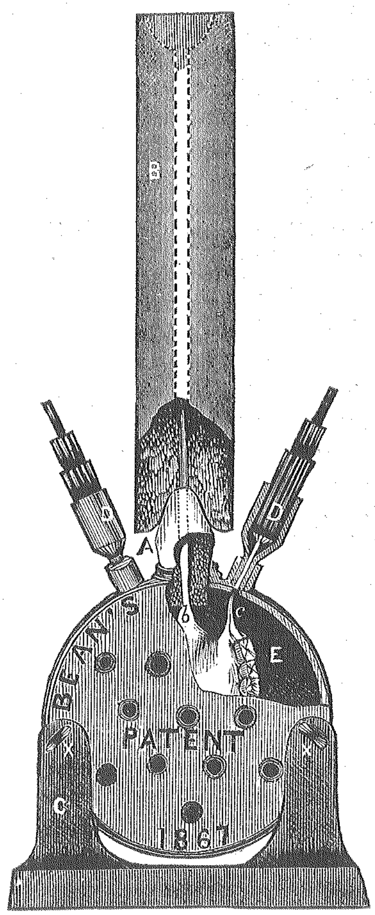


Fig. 1085.— The Bean Appliance for Casting Aluminum (Reproduced from Harris, Ed. 1873)

When the aluminum was fused, hydrogen gas was introduced in the mold through one of the lateral openings in the flask, to expel the air and thus prevent oxidation of the heated metal, the extension sprue set in position and the metal cast into the hydrogen filled mold.

As the metal filled the mold, the hydrogen escaped through the other lateral opening. Both lateral openings were partially obstructed by fine wire which, although permitting the introduction of gas in one and the escape of gas and air through the other, prevented the escape of the metal under pressure of that contained within the long sprue.

When cast, the baseplate was finished, the porcelain blocks adjusted in position and attached by a second casting process in which a more fusible alloy was injected into the dovetailed groove previously mentioned, and around the pins of the teeth.

In this second step the use of "small cylindrical wax gates" was mentioned. These served the purpose of sprue formers, were enclosed with the baseplate and teeth in a single investment, subsequently dissipated by heat, and through them the low fusing alloy was cast under gravity pressure into the groove and around the pins of the teeth.

In these two operations described by Dr. Bean are presented several of the fundamental processes of casting, viz., in the first steps are mentioned a wax pattern; its investment in a sectional matrix of refractory material; injection of the molten metal into the mold under gravity pressure; in the second steps are mentioned "cylindrical wax gates," or sprue formers, a single investment, or one piece matrix, and dissipation of the wax by heat.

SAUER'S METHOD OF CASTING ALUMINUM

On page 630 of the Dental Cosmos, 1873, is illustrated an apparatus designed by C. Sauer of Berlin, for casting aluminum denture bases. This appliance resembles in many respects the Bean apparatus which had been introduced a few years previously.

The points of interest in this article are the use of an alloy of aluminum, recommended because it cast more sharply than the pure metal, the application of a deep sprue to the flask to increase the pressure on the metal within the mold, and the casting of the fused metal directly against the teeth.

REESE'S METHOD OF CASTING TIN ALLOYS

In 1879, Dr. G. F. Reese introduced a new alloy of greater hardness than that previously in use, which was designed for upper denture bases. A special flask of his own design was recommended for the investment of the case.

HAYFORD'S METHODS AND APPLIANCES

In 1884, Dr. J. W. Hayford of Xenia, O., patented an appliance for casting Watt's, Weston's and other fusible alloys then in use. This appliance consisted of a press and a flask having an opening in its upper side through which the fused metal was poured into the sprue and mold.

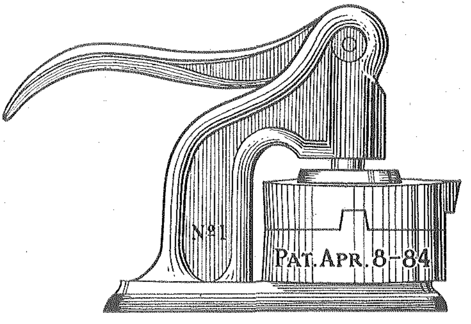


Fig. 1086.—Dr. Hayford's Casting Appliance

By means of a lever a plunger was pressed downward into the flask and against the fused metal and in this manner it was forced into all parts of the mold by mechanical pressure.

THE WATT'S FLASK

In the latter part of the 80's, Dr. Geo. E. Watt designed a flask having two extensions in which the sprues were formed. When the cast metal was injected into the mold the weight of that contained within the sprues condensed that within the mold by gravity pressure. (See page 224.)

DR. MARTIN'S METHOD OF CASTING

Beginning about 1889, and for a number of years following, Dr. G. M. Martin of Indiana demonstrated and taught the method of casting inlays, crowns and bridges in the Indiana Dental College, and in post-graduate work in Indianapolis.

The method was substantially as follows:

Formation of the pattern in wax, investment in refractory material within a cuplike receptacle, eliminating the wax with heat, melting the metal in a crucible-like depression, which was connected with the mold by a sprue, and casting the fused metal by mechanical and later by centrifugal force. No matrix was used in forming the pattern in wax for an inlay.

The crucible and sprue were formed by attaching a piece of wire in case of inlays, or a strip of metal plate in bridgework, to the curved side of a section of cork, mounting the pattern at the outer extremity of the sprue former and applying the investment around the pattern and over the curved cork base.

THE CARROLL METHOD OF CASTING ALUMINUM

In 1888, Dr. C. C. Carroll patented an apparatus for casting aluminum denture bases, bridges and crowns. The principal improvement of the method over those preceding it was

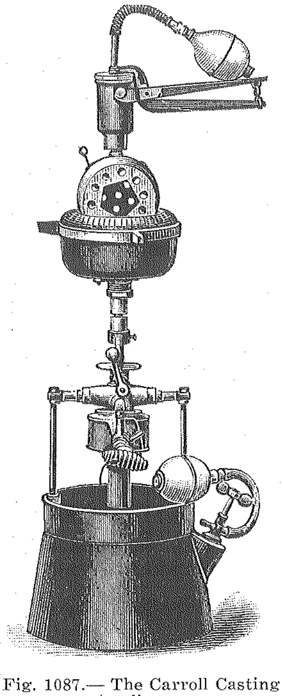


Fig. 1087.— The Carroll Casting Appliances

in the use of a sealing cap for closing the crucible, and casting the metal by means of compressed air.

Dr. Carroll demonstrated his appliances and method of casting aluminum at the World's Columbian Dental Congress in Chicago, in 1893, as well as at previous times.

THE ZELLER CASTING APPLIANCES

In 1891, the Zeller appliances were introduced These consisted of a flask for investment of the case, burners for heating the flask and fusing the aluminum, and a suction tube by means of which a partial vacuum could be created in the mold.

When the case was heated and the metal fused, it was drawn into the mold by mouth suction or a suction bulb.

THE FENNER CASTING APPLIANCES

In 1893, the Fenner appliances were introduced. These consisted of a flask with attached crucible for investment of the case and holding the metal while fusing, of a stove and jacket for heating the case, a sealing cap fitted with a packing by means of which the metal could be forced into the mold by compressed air. The writer used and demonstrated both wax and metal sprue formers with this appliance as early as 1895.

DR. HARPER'S CAST CROWNS AND BRIDGES

In 1894, Dr. W. E. Harper of Chicago constructed cast aluminum bridges by the following method, one special type of abutment of which will be outlined:

A molar tooth having a proximo-occlusal cavity was prepared by reducing its occlusal and axial surfaces in the usual manner required for the reception of a shell crown.

The cavity in the tooth was prepared as for the reception of a filling, but without undercuts, the axial walls flaring outward slightly.

An axial band of aluminum was then fitted to the tooth, being carried slightly under the gingiva, the occlusal end being left open.

Wax was pressed into the open end of the band, directly into the cavity against its various walls, and over the reduced occlusal areas of the tooth, without the interposition of a matrix.

The patient was instructed to bite into the wax to develop occlusion, after which the cusps were carved to required form.

This wax-metal abutment was then united to the dummies, which were of wax, or, in some cases, of wax and porcelain combined, a wax sprue former attached, the whole piece invested in a Zeller flask, and heated to dissipate the moisture and wax.

The aluminum was then fused in the attached crucible and drawn through the sprue into the mold by partial vacuum force.

In specimens shown the writer in 1896 and subsequently, there appeared to be perfect union between the cast metal and the band.

This abutment might appropriately be termed a *crown inlay,* since it constituted not only a crown, but an accurately fitting inlay as well.

Dr. Harper frequently demonstrated and described this method of crown-inlay construction at various clinics and to different individuals as well. He stated to the writer as early as 1896 that he had been successfully following this plan of bridge construction in his practice.

By analysis this method embodies the pressing of wax directly into the tooth cavity, and against various tooth surfaces, in the formation of the crown-inlay pattern, without the interposition of a matrix, the use of a sprue former of wax, investment of the pattern in refractory material, dissipating the wax by heat, casting the fused metal into the matrix by vacuum force.

THE ALEXANDER METHOD OF CASTING INLAYS

Reference has previously been made to Dr. C. L. Alexander's method of forming inlays. His first paper on "Casting Fillings and Abutments for Bridges" was reported at a meeting of the Southern Dental Association, held at Asheville, N. C., in July, 1896. The discussion which followed clearly brought out the fact that the durability of the cement by which inlays were held in place was still a point not yet determined by experience, and many in the profession opposed the application of inlays on this ground.

The "casting of fillings," however, was "in the air," and the possibilities in this field were beginning to be recognized.

THE HOLLINGSWORTH METHOD OF CASTING

In the American Text Book of Prosthetic Dentistry, pages 669-70, Ed. 1896, is described the Hollingsworth method of casting bridge dummies, the patterns of which were composed of wax, wax and paraffin, or wax and gutta percha.

The pattern after being carved to correct occlusion and form between the two abutments, was removed. To one end was attached a cylindrical piece of wax about one-eighth of an inch in diameter, to serve as a gate or sprue former.

A shallow, oblong, sheet iron pan, to which a handle was attached, was used as a table on which to invest the case.

The investment, composed of a mixture of plaster and marble dust, was mixed to medium thin consistency, the pan filled with it and the wax pattern with sprue former attached, laid on it near one end, and covered over to the depth of about one-half inch.

The investment in the other end of the pan was not contoured but left flat, and when hardened a depression or shallow crucible was formed in this surface and connected by a groove with the exposed end of the sprue former, the investment around which was removed to form a funnel-shaped opening for the ready entrance of the gold into the mold.

All surfaces were cleared of debris and the case heated to dissipate the moisture and wax.

In the crucible depression, gold scrap or plate was placed and with a blowpipe, brought to a thoroughly liquid condition,

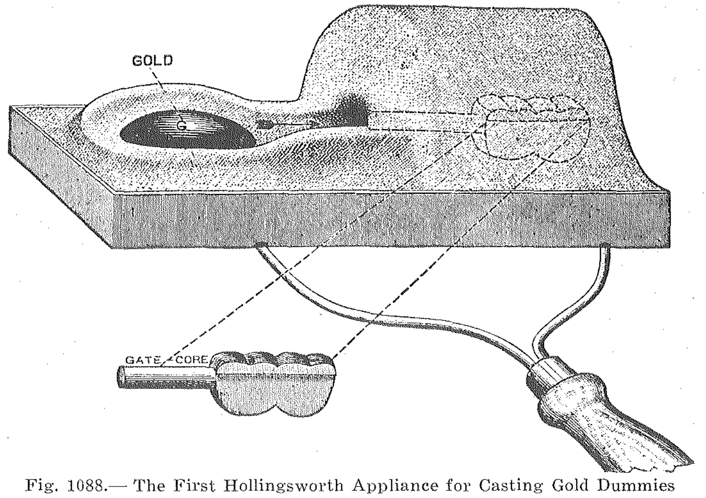


Fig. 1088.— The First Hollingsworth Appliance for Casting Gold Dummies

when, by tipping the pan in an upright position, the gold was cast into the mold by gravity.

In 1902, Patent No. 708,811 was issued to Dr. M. W. Hollingsworth for a machine for forcibly casting dental bridges. The fundamental principle of this machine resembled somewhat his first crude appliance, previously described.

This appliance consisted of a base provided with a hinged table, on which the investment rested. Through the bottom of the table projected a sprue former of brass, having a reduced upper extremity to which the wax model was attached. A metal hood for supporting the sides and outer end of the investment was adjusted to the table, and which, being adjustable, permitted the investment to be closely applied to the pattern and thus exclude the air, after which, while the investment was still soft, the hood was adjusted and filled.

When hardened, the sprue former was removed and a stick of carbon of corresponding size was inserted into the opening.

In investing a case in this appliance, the crucible for melting the gold was formed in one end of the table, being connected with the sprue by a lateral groove and opening.

When the investment was thoroughly dry and heated, and the wax dissipated, gold was placed in the crucible, where it was fused.

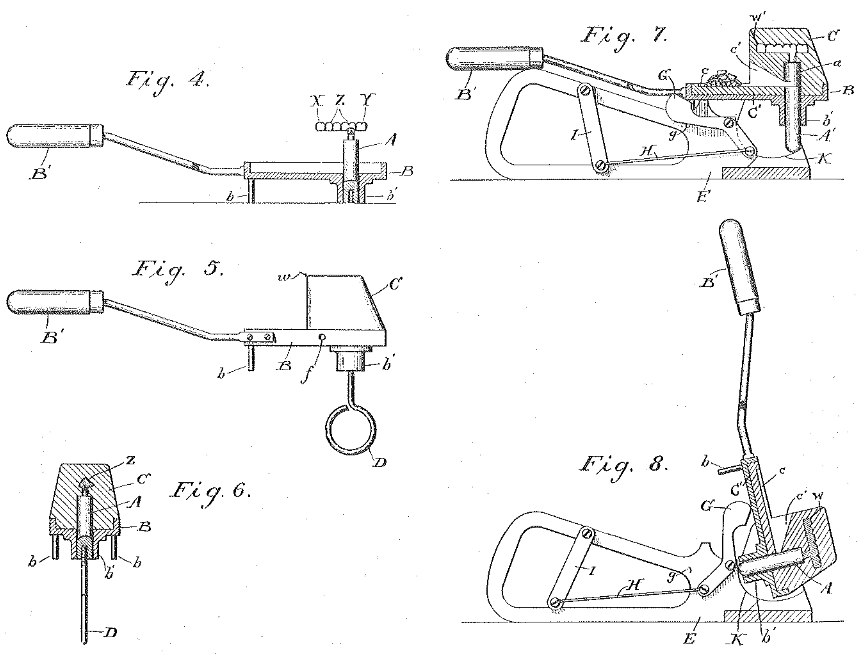


Fig. 1089.— The Hollingsworth Pressure Casting Appliance

By means of a lever device the hinged table was raised to an upright position. This movement cast the gold into the sprue and mold by gravity.

When the table was in nearly an upright position the outer end of the carbon was brought in contact with a cam surface of the base, thus pressing it forward into the sprue and forcing the gold into the mold by mechanical pressure.

These processes involve a wax model, enclosed in a single investment of refractory material, a removable metal sprue, formation of a crucible depression in the investment, dissipation of the wax model by heat, fusing and casting the gold under both gravity and mechanical pressure.

FLASK DESIGNED BY THE WRITER

In 1900, the writer designed a flask for casting aluminum in which a metal sprue former was used in conjunction with a wax model enclosed in a single investment.

The metal was melted in an attached crucible and forced into the mold with a metallic piston which fitted the interior of the crucible. Because of difficulty at times resulting from the piston becoming locked within the crucible chamber, a sealing cap, with tube attached, was substituted and by this means the fused metal was injected into the mold with compressed air, and also steam pressure. These flasks were used for some time in the technic laboratories of the Northwestern University Dental School by Dr. Waldberg, Dr. Methven and the writer.

DR. PHILBROOK'S METHOD OF CASTING INLAYS

Between 1896 and 1905, Dr. B. F. Philbrook, of Dennison, Ia., developed a system of casting inlays which in substance was as follows:

In his first efforts, between the period from 1896 to about 1898, he formed a model of the desired filling by pressing wax into the cavity of a tooth, reproduced in the usual way, in plaster. This is known as the indirect method. From 1898 and thereafter he formed the filling by pressing the wax directly into the natural tooth cavity, without the interposition of a matrix, and carved it to the required form.

To each extremity of the inlay a cylindrical piece of wax was attached, one to serve as a sprue former, the other to form a channel through which to clear out the wax.

The pattern and extensions were then invested in refractory material in a ring in such manner as to exclude the air, the sprue former occupying a central position, the other extension situated near one side.

When the investment had set, it was trimmed out around the sprue former to form a crucible-like depression in which to melt the metal.

With a bulb syringe, hot water was forced into the sprue and mold, and out the side channel, thus freeing the mold and openings leading to it of the greater bulk of wax.

The invested case was heated to expel the moisture and any remaining wax present, the metal placed in the crucible, fused with a blowpipe, and forced into the mold as follows:

A sealing cap consisting of a metallic disc of larger diameter than the investment ring, having attached an asbestos packing for sealing against the escape of air, was pressed firmly and evenly down upon the upper end of the ring.

Through a tube of metal which was attached to the upper central side of the disc, air was forced by mouth pressure into the crucible containing the fused metal, thus injecting it through the sprue into the mold.

By 1904, several important modifications in the above methods were made by Dr. Philbrook, viz., the use of a metallic sprue former, the designing and use of a metallic crucible former, dissipation of the wax by dry heat or flame, a sealing cap containing moist asbestos, the steam from which, when heated and confined, injected the fused metal into the mold.

The methods and appliances employed by Dr. Philbrick, from 1896 to 1905, inclusive, may be briefly summed up as follows:

A model formed without a metal matrix; both by the indirect method of pressing wax into a plaster model of the prepared tooth and cavity, and by the direct method, by pressing the wax directly into the natural tooth cavity; the use of both wax and metal sprue formers; a metallic investment ring; metal as well as wax sprue formers for supporting the pattern and forming the sprue; investment of the wax pattern in a single mass of refractory material; dissipation of the wax by hot water in some cases, dry heat or flame in others; fusing the metal in the crucible depression of the investment in the upper end of the ring; injecting it into the mold by compressed air or by steam pressure.

DR. SCHLOTTER'S CLINIC

In 1904, Dr. Jacob Schotter at Manitowoc, Wis., gave a clinic before the Wisconsin State Dental Society on cast gold inlays, in which successful castings were shown, made by gravity pressure. This clinic demonstrated the method he employed in his practice.

THE LENTZ CASTING PROCESS

In August, 1905, Dr. John A. Lentz of Phœnix, Ariz., applied for a patent for a "process for forming dental structures," which patent was granted in October, 1906. Briefly described, his processes are outlined as follows: "My invention relates to such dental work as making inlays, onlays, crowns, bridges, artificial dentures and other dental structure, or certain parts of the foregoing."

He mentions specifically his method of preparing a molar tooth for a crown in the usual manner, to which was fitted a properly contoured band. A plastic impression material was then placed on the occlusal end of the band, forced between its inner walls and the axial surfaces of the tooth and against its occlusal surface as well, without the interposition of a metal matrix. By closing the jaws in various positions, clearance paths for the opposing cusps were developed, after which the cusps were carved to desired form.

The crown was then removed and inclosed in a suitable investing material in a two-piece ring. On warming and sep-

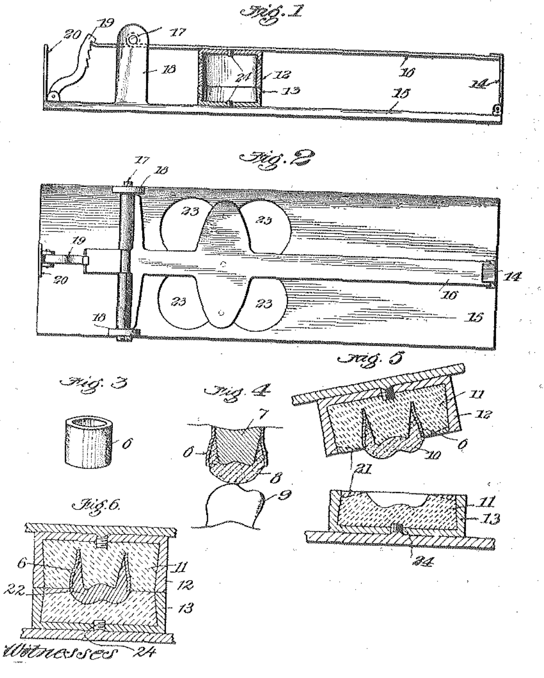


Fig. 1090.— The Lentz Casting Appliance

arating the latter, the plastic material which lined the interior of the band and of which the cusps were formed was removed. In one portion of the ring the root sides and end, reproduced in investment material, were thus exposed within the enclosed gold band, while in the other part of the ring the investment presented the reverse of the carved cusp surfaces.

The casting was accomplished by drying and heating the investment in the two halves of the ring, placing an excess amount of gold in the cusp depressions, where it was fused, while pressure, sufficient to force it into all parts of the mold, was developed by dropping the lever of the molding machine down until the two halves of the ring touched and registered.

By this process the fused gold was adapted to all the inequalities of the root surfaces, as represented in the investment material within the ring, and when properly finished, fitted the root closely. Modeling compound or wax was used as the impression material.

THE OLLENDORF CASTING PROCESS

In 1906, or previously, Dr. Ollendorf, of Breslau, Germany, presented appliances and described a system for casting crowns, bridges and dentures under pressure. He used the disappearing wax model, enclosing it in an investment of silex and plaster. Gravity force for producing pressure on the gold in casting was employed, as in some of the preceding methods mentioned. This method was described by Dr. Sachs in a paper read before the American Dental Society of Europe, August, 1906. (Dental Review, March, 1907.)

SUMMARY OF PROGRESS IN CASTING OPERATIONS

Thus it appears that the five fundamental principles involved in the casting process as practiced to-day were widely known and utilized prior to 1907 in crown, bridge and denture construction, and the casting of inlays was practiced by a considerable number of individuals with greater or less success.

That experiments had been and were being conducted along these lines by a considerable number of individuals is unquestioned. The results of these efforts were frequently gratifying, but sometimes disappointing, due largely to a lack of exact knowledge of the physical properties of materials employed.

CAUSES OF FAILURES IN CASTING OPERATIONS

In the light of present knowledge, the causes of failure in some of the pioneer efforts with cast inlays were due to dimensional changes in the wax model during and after forming it, this material being very susceptible to temperature variations, to impurities present in the wax which remained as a residue in the matrix, and failed to volatilize on heating; to changes in the investment under heat; but principally in failure to render the gold sufficiently plastic to cast sharply.

Although it is possible to superheat gold to a sufficient degree to cast sharply, by means of the ordinary blowpipe, still, under some conditions, it is a difficult task.

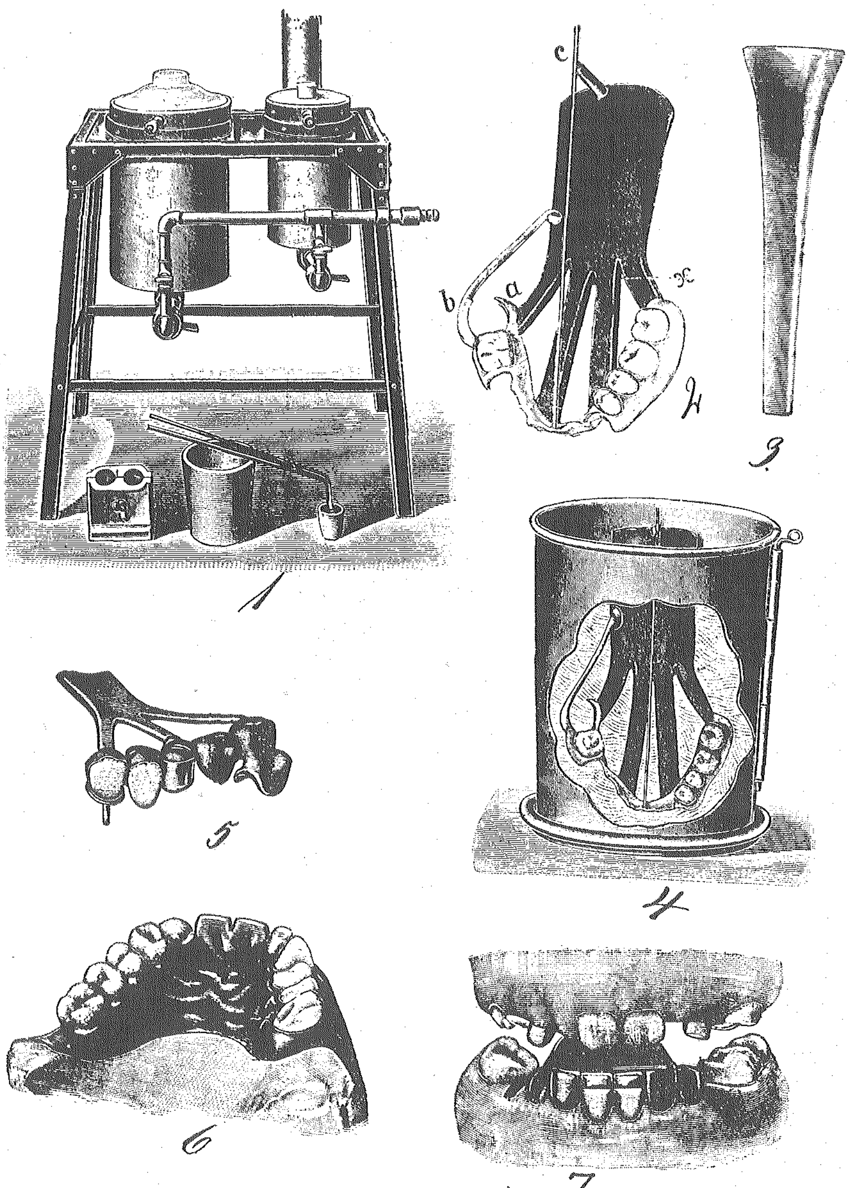


Fig. 1091.—The Ollendorf Casting Appliances

Had the pioneers, in the casting of prosthetic substitutes in gold, recognized the great value and efficiency of the Knapp nitrous oxide and gas blowpipe which was introduced about

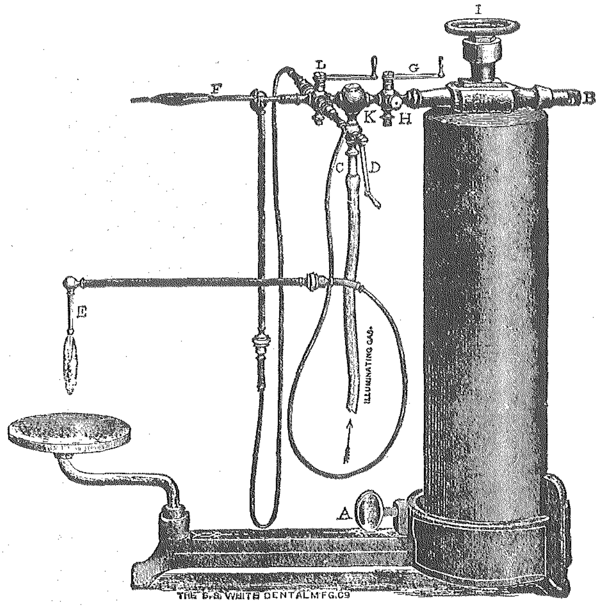


Fig. 1092.— Knapp's Nitrous Oxide and Gas Blowpipe

1890, work in these lines would have progressed rapidly, and the problem of casting inlays and various prosthetic appliances would have been practically solved.

DR. TAGGART'S METHOD OF CASTING INLAYS

In 1907, Dr. W. H. Taggart of Chicago made application for patents on various processes and "Apparatus for making models for the casting of dental inlays and the like," "Method for making models for dental inlays and the like," "Method for making dental inlay fillings and the like," "Apparatus for making castings." The first two patents were granted in 1907, the last two mentioned in 1911.

Briefly, the steps of producing an inlay by the Taggart method are as follows:

A pattern of the desired filling is made by pressing wax directly into the prepared tooth cavity, without the interposition of a matrix, and carved to required form.

The pattern is mounted on a metallic sprue former, which rests in and is supported by a metallic, dome-shaped crucible former.

A mix of refractory investment material is made and carefully applied around the wax model in such manner as to eliminate the air.

The investment ring or flask is then set on the crucible former and its interior filled with investment material, thus surrounding the previously coated model.

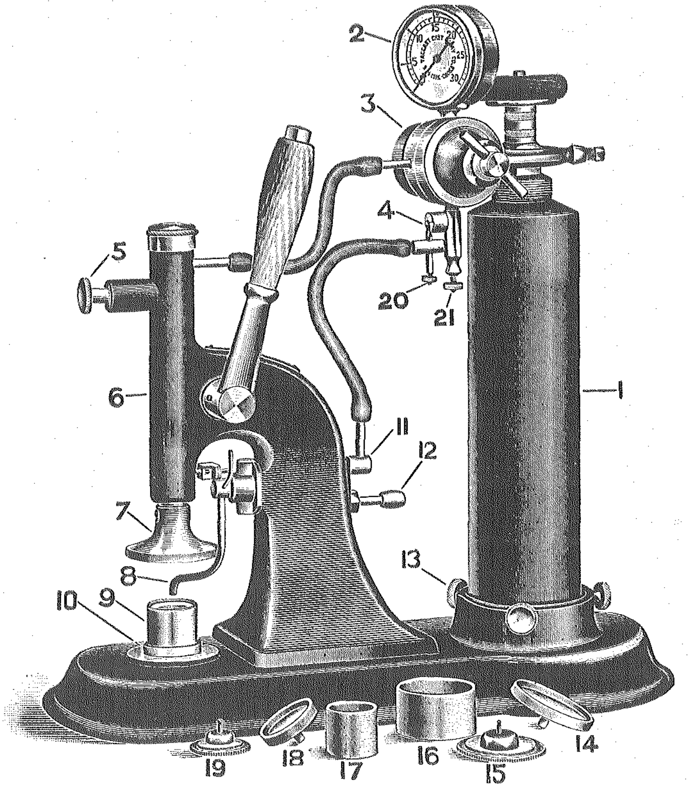


Fig. 1093.— The Taggart Casting Appliances

When the investment has hardened, the crucible former and sprue former are removed.

The invested case is then heated to expel the moisture and dissipate the wax.

The flask or investment ring is then set in the depressed base of the casting machine, the metal placed in the crucible depression of the investment and fused with the flame from an attached blowpipe of the nitrous oxide and gas type.

When fused, the plunger which carries a sealing cap on its lower end is brought forcibly down upon the upper end of the flask, thus preventing escape of the nitrous oxide gas, which is automatically admitted at the time of sealing the crucible space.

Under compression of the gas, the fused metal is forced through the sprue into the mold.

The essential principles involved in this process may be briefly summed up as follows:

A wax model formed with or without a metallic matrix, an investment ring, a metallic sprue former, a metallic crucible former, a sealing cap for confining the compressed gas, a single investment matrix, dissipation of the wax pattern by heat, injecting the fused metal into the mold by compressed gas.

The discovery by Dr. Taggart that in order to cast sharply gold must be superheated, constitutes the most valuable contribution to the casting process introduced within recent years.

This he accomplished and demonstrated by means of his casting appliances to which a blowpipe of the Knapp pattern was adapted. With the Taggart appliance or the Knapp blowpipe, gold in small quantity can be readily heated several hundred degrees above its melting point.

In using either of these appliances, care must be observed not to overheat the gold or *burn it.* When excessively overheated, even pure gold is slowly but gradually dissipated, while if composed of an alloy some of the lower fusing constituents will be oxidized or volatilized, thus impairing the quality of the metal for specific purposes.

Again, in superheating the gold excessively, the investment deteriorates, resulting in rough surfaces in the mold, change in form of the latter, and in some cases intimate union of the investment with the casting.

By means of an ordinary gas blowpipe, with a free inlet for both gas and air, and means for controlling the same, together with a strong pressure of air such as can be developed with a large foot bellows or power pump, equally good results may be accomplished without danger of dissipating the gold or impairing the investment. (See page 1050.)

RECENT APPLIANCES

Within recent years many devices in which some of the older methods of pressure mentioned were employed have been introduced, two of which will be described.

THE SOLBRIG CASTING PLIERS

This device consists of plier handles; to the shorter end of one is attached a pad containing moldine or moist asbestos. The opposite beak contains a depression in which rests the investment ring. When fused, the metal is forced into the

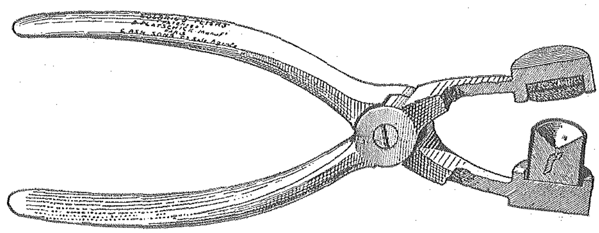


Fig. 1094.— The Solbrig Casting Appliance

mold by closing the plier handles, thus bringing the pad attached to the opposite beak in contact with the ring margins and sealing the crucible chamber. (Ash's Quarterly, 1910.)

THE BIBER CASTING APPLIANCE

This consists of a base for supporting the investment ring, and a cup device containing moldine or clay.

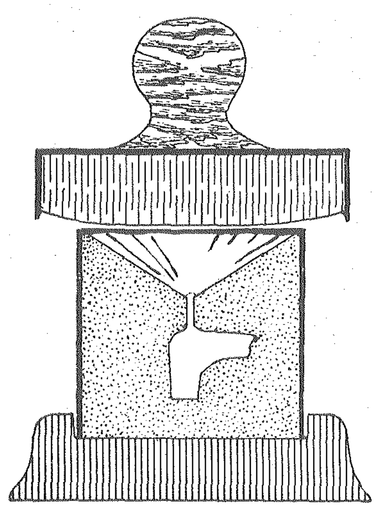


Fig. 1095.— The Biber Casting Appliance (Ash's Quarterly, 1910, Slightly Modified)

When the gold is fused, the cap is applied to the ring and the metal forced into the mold by hand pressure.

From this brief outline of casting operations in the past, the names of a number of men who engaged in this work, together with a description of their methods and appliances, have been omitted for lack of time and space.

The writer has attemped to present in a concise and dispassionate manner those facts which he has been able to carefully gather from reliable sources, pertaining to the inception and growth up to present development of the five fundamental principles of the casting process.

That the science of precision casting is yet imperfect is evident, since the control of dimensional changes in the materials used has not yet been accomplished.

By simplest means and with crudest appliances some are able to secure results equal to the best. Others, equipped with the most convenient and improved apparatus meet with frequent failures. Personal equation in this as in many other fields largely determines the quality of results attained.

From this outline it will also be seen that the development of the five fundamental principles of casting as practiced today is the result of the composite effort of many men, extending over a period of many years. Practically all of the processes had become, and most of them were long ago recognized, as heritages of the profession, since time and use had rendered them more or less common methods of procedure.

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