Modern gnathological concepts

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With deep gratitude, this book is dedicated to Dr. Max Kornfeld, who persuaded me to transform a dream into a reality; to Dr. William Dykins, whose faith and encouragement inspired me to carry on; to Gloria, my wife, without whose patience and understanding these long months this book would not have been possible

Preface

This book was written from a desire to assist the members of the dental profession in learning the principles of gnathology herein described. After witnessing the difficulties which men have encountered in attempting to understand and carry out these principles, I felt that an undertaking of this sort should no longer be postponed.

Heretofore, the paramount handicap to a student of gnathology has been the lack of available organized material. There have been several articles dealing with the philosophy and principles of gnathology but none with its application. Such material as exists is to a great extent somewhat sketchy and incomplete, lacking illustrations, continuity, and detail. Because of this a thorough study of the subject has been extremely difficult.

Circumstances early in my professional career enabled me to study and experiment with various approaches to articulation. In the course of this work attempts were made to uncover the shortcomings of seemingly logical approaches to the problem. After four years of investigation, I became exposed to the work of the Gnathological Society. Almost immediately it seemed to me that here at last was the answer. But caution, born of disillusionment with other approaches, required that many hours be spent in searching for flaws, in trying to refute the principles. Yet, today—fifteen years later and in the light of present knowledge—the fundamentals of gnathology remain basically sound and intact. Only minor details have required correction.

With the passage of time, more and more men have become interested in gnathology. Unfortunately, though, our teaching on a postgraduate level has been inadequate. Some progress has been made on a preceptor level, but few can be trained in this way. Several years ago, the University of Pennsylvania incorporated some of the principles in its undergraduate program, and soon more men were showing a lively interest in the subject. But the stumbling blocks still exist. The time and the effort required to learn gnathology are big hurdles to overcome; hence the real need for a manual—a "do-it-yourself" guide—a handbook that will be helpful when one begins to do this work.

At the start of this undertaking, it was evident that many illustrations would be necessary. Where photography was not feasible, line drawings were used to clarify various points.

Fifteen years of observation and application substantiate the content of this book as the basis for the practice of dentistry for the present and, very probably, the future. Certainly, many details will be improved upon in the years to come to enable us to follow these principles with greater accuracy and less effort. But, as the basis for dental practice, the arrangement herein contained will still be sound.

Victor O. Lucia

Acknowledgments

My sincerest thanks to the many friends who read the manuscript and offered constructive criticism and encouragement. Without their enthusiastic support, this book may never have been realized.

Topping the list of persons to whom I am indebted is Dr. Beverly McCollum, who deserves credit for the greatest contribution to dentistry in the last quarter century; next, Dr. Ernest Granger, who has been responsible for the teaching of gnathological procedures throughout the country; then Dr. Charles Stuart, whose vast experience in articulation has led to newer gnathological concepts and improvements; and Harvey Stallard, whose wisdom, patience, and ability have played a major role in the development of gnathology.

Many thanks to Dr. Peter Thomas, an able, energetic, generous man who has helped many dentists to practice their profession with greater facility and better results.

Dr. Max Kornfeld was responsible for the dream becoming an actuality, for it was he who suggested that this book be written.

I am particularly grateful to Dr. William Dykins for his faith, loyalty, and encouragement, which induced me on several occasions not to abandon writing this book.

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I am also indebted to Dr. Charles Brecker for his sound and generous advice. He has been a valuable friend since undergraduate days, when he was one of my teachers.

Many thanks to Marlene Minett, my hygienist, who in spite of her many duties typed the first draft, and to Charles Cottone, my technician, who was always ready to help prepare material to be photographed and to offer encouragement when things were most difficult.

My greatest indebtedness is to Mary Gardiner for her editing and final typing.

The least evident but most important contribution was that of my wife and children, whose patience and tolerance allowed me to accomplish this task.

Victor O. Lucia

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CHAPTER 1

Philosophy of dental practice

Full-mouth rehabilitation is the performance of all the procedures necessary to produce a healthy, esthetic, well-functioning, self-maintaining masticatory mechanism.

REASONS FOR FULL-MOUTH REHABILITATION

The most common reason for doing a full-mouth rehabilitation is to obtain and maintain the health of the periodontal tissues.

Clinical periodontal findings are correlated with radiographs for a determination of the extent and character of the disease. Having determined the presence of periodontal disease, we attempt to correlate our findings to the function of the mouth.

In examination of the function of the mouth, many factors are to be considered. The most important is the discrepancy known as the premature contact—a contact between an upper and lower tooth which prevents or interferes with the normal path of closure of the mandible. As important and perhaps showing a greater degree of disease is the area that receives the force of closure after the patient skids off the prematurity. This area receives the force in the form of a rebound as the normal path of closure is interfered with by the premature contact. (Figs. 1 to 5.)

The various excursions of the mandible are examined to determine how much harmony exists between the jaw movement and the tooth contacts, and the teeth that receive most of the load in the different positions are noted.

A definite correlation between the malfunction and the clinical periodontal findings is usually possible. This correlation generally precludes all other potential causes of the periodontal condition. Even so, in order that the problem may be attacked from every conceivable angle, each of the other factors must be considered and investigated.

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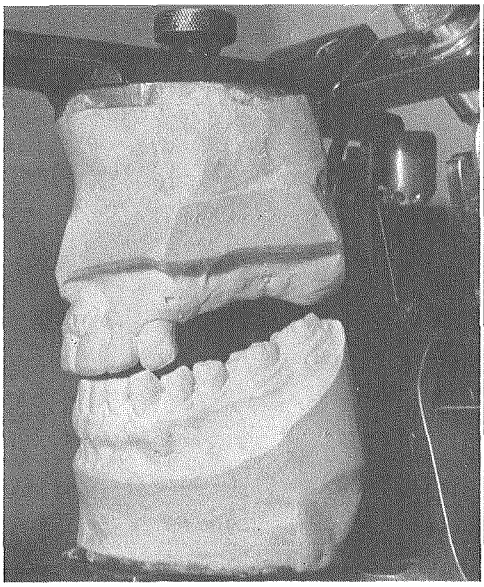

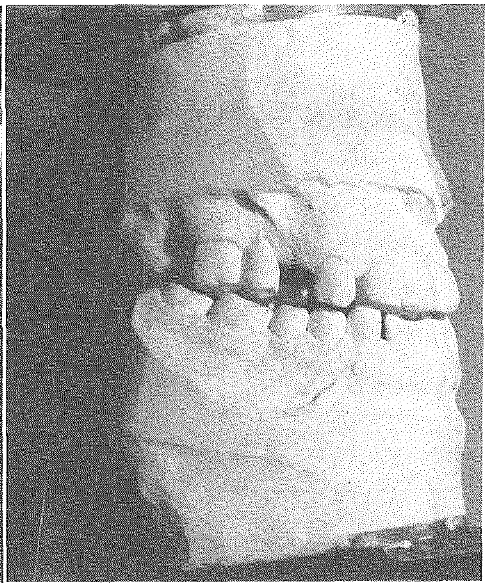

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Fig. 1. Premature contact of upper and lower cuspids prevents normal closure of mandible.
Fig. 2. Opposite side of casts shown in Fig. 1. Contact of opposing teeth prevented by premature cuspid contact on opposite side.

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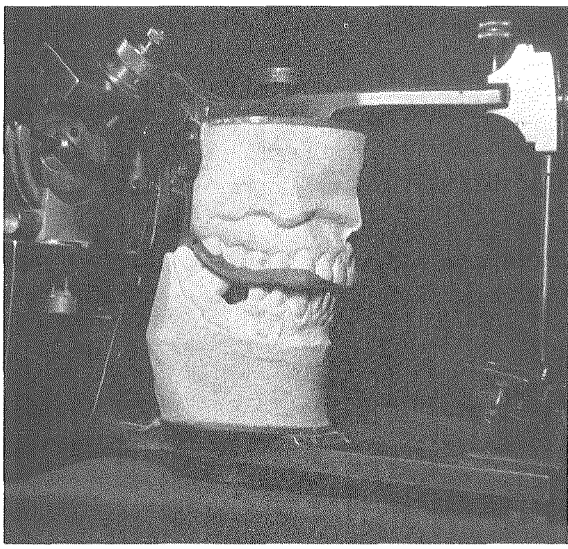

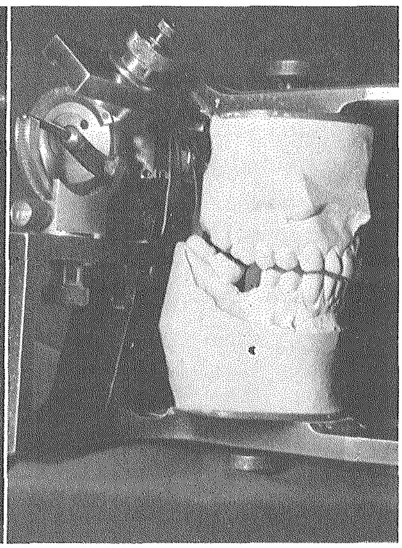

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Fig. 3. Centric interocclusal record used to relate lower cast to upper cast on articulator.
Fig. 4. Centric interocclusal record removed, and teeth allowed to make first contact as mandible closes. Note premature contacts in bicuspid area.

In connection with malfunction, the oral habits which could have a bearing on the condition present must be considered. These may include such things as bruxism, lip-chewing, thread-biting, tongue habits, etc.

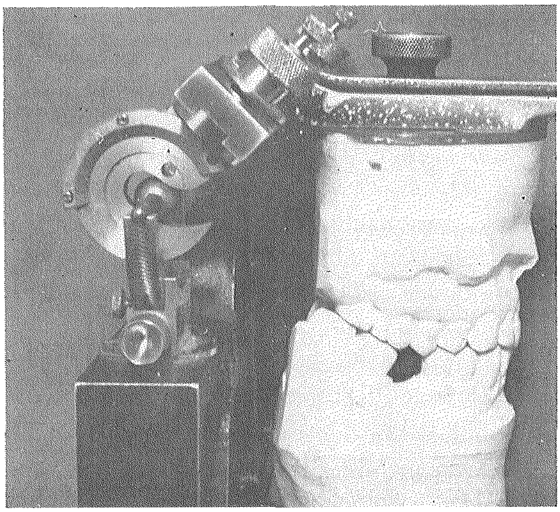

Fig. 5. Teeth of casts shown in Fig. 4 made to contact. Condyle ball on articulator must advance on condyle slope to permit interdigitation of teeth.

A second reason for full-mouth rehabilitation is a temporomandibular joint disturbance. This may be difficult to diagnose, and great care must be taken to determine the etiological factors involved. Frequently there is a malrelationship between the articulation and the movements of the joint—a disharmony of function. Sometimes there is a muscular dysfunction which is caused by some irritant or a nervous affliction. Occasionally this muscular dysfunction is caused by the malarticulation which produces muscle spasms, and these in turn are interpreted as a joint disturbance. Usually in patients with joint disturbances the periodontal condition is very good, which is probably why the joint has been injured instead of the periodontium. When a disharmony exists, it must be ascertained whether the patient is injuring the joint as a result of the malfunction, a bad habit, or an emotional disturbance. Emotional disturbances are very difficult to deal with, and many times the patient requires the assistance of a competent psychiatrist.

A third reason for full-mouth rehabilitation is the need for extensive dentistry. In such patients some teeth are missing and others are worn down, and there are old fillings that need replacing. Usually the patients have little periodontal involvement and no joint symptoms. These are the easiest patients to treat, and the beginner should limit full-mouth rehabilitation to them. As long as extensive dentistry is necessary, why not work on the case as a whole so that all the parts will be related to each other and to the function of the individual?

By far the most difficult patients to treat are the few who have succeeded in developing a severe periodontal condition and have at the same time a malfunctioning joint. Even though the joint be asymptomatic, it may exhibit a behavior pattern that is troublesome to deal with. It may be *mobile,* and the dentistry may require frequent adjustment as the joint begins to function properly with possible healing. In addition, tooth settling and migration will increase the discrepancies. These are the patients that try men's souls. It behooves one to proceed with extreme care and to anticipate the possible contingencies. Sometimes it is impossible to predict the extent of treatment necessary in order to resolve the condition.

The treatment of the emotionally disturbed patient with a joint problem is probably the most exasperating. Although it is possible to treat the condition physiologically, the emotional disturbance is something else again. I have seen patients with beautifully functioning masticatory mechanisms who still were able to produce joint symptoms almost at will. These are the patients who take the joy out of dentistry. It is distasteful and unpleasant to be one to suggest psychiatric treatment, but if the dentist is convinced that this is the problem, then he owes it to the patient and to himself to recommend such a course.

Which patients should not be treated by full-mouth rehabilitation?

Frequently, friends and relatives of one's rehabilitation patients will request similar treatment. There are many malfunctioning mouths that do not need extensive dentistry and have no joint symptoms. These patients are best left alone. Some mouths which have the potential to break down, for some reason, never produce the destruction. We are not justified in prescribing a full-mouth rehabilitation unless there is definite evidence of tissue breakdown. One may argue, as many have, that it should be undertaken as a preventive measure. I do not agree! There are enough malfunctioning mouths which do not break down to rule against predicting something which may never happen. If there is need for extensive dentistry, then by all means it should be carefully correlated to the rest of the mouth by complete rehabilitation. One or two "good" teeth sometimes may have to be operated on to satisfactorily accomplish our objective. The utopia in dentistry would be the directing of dental procedures toward the prevention of such conditions and the application of dental practice to the correction of these conditions when they do exist. In short, no pathology—no treatment!

OBJECTIVE OF TREATMENT

Having decided that a mouth requires the full treatment, what is the objective? All these patients have one problem in common—stress and strain. Usually the stress and strain are due to malfunction or a malrelation of the parts of the oral mechanism. Occasionally undue stress and strain on the oral mechanism are the result of an emotional disturbance. Whatever the cause, whatever the reason, the common denominator seems to be stress. The problem, then, resolves itself into one of minimizing these stresses so that they are not destructive. At least they should fall within the capability of the tissues to withstand them and maintain a state of health.

To accomplish this objective to the fullest degree possible, it is essential to have an intimate knowledge and a very clear understanding of the masticatory mechanism, of certain principles and forces. Just what is involved will be detailed and clarified in the chapters to follow. Briefly, however, it requires a study of the forces of mastication or, rather, the forces encountered in the oral cavity. (They are not necessarily masticatory.) It requires a knowledge of how the oral mechanism is built and how it functions. Because of the structure, design, and function of the mechanism, certain considerations are necessary in studying these stresses. Obviously, if stresses are involved and if they are excessive (at least the implication is that they may be excessive), the concern is how to reduce or minimize them so that they will not be destructive. Granted that the muscles of the oral mechanism can exert a certain amount of force, in order to prevent this stress from being destructive (as long as we have it and must deal with it), the best thing to do is to distribute it simultaneously—over as many teeth as possible—over the temporomandibular joints—over as great an area as possible—over as much tissue as possible—yes, over as many cells as possible. This approach makes sense. A given force distributed over as great an area as possible reduces the stress per unit so that it can be tolerated by the tissues. Aging tissues are often not able to withstand the same stress as younger tissues. This is why a malfunction is frequently tolerated at a younger age.

The problem, then, becomes one of how best to distribute this given force or stress.

The oral mechanism consists primarily of the temporomandibular joints, the teeth and their supporting structures, and the muscles of mastication. We are concerned with the joints and the supporting structures. The teeth are the means by which the stresses are going to be directed or transmitted. We know from anatomy and physiology that the temporomandibular joint is a stress-bearing joint. We know that the supporting structures (bone) of the teeth are designed to withstand stress. The objective is to distribute these stresses equally between the joint tissues and the supporting structures. The teeth will be the means by which the forces are distributed.

HARMONY OF FORM AND FUNCTION

The temporomandibular joint has a definite pattern of function. It can be demonstrated clearly that it is a definite pattern. If, in the execution of this pattern of function, the teeth interfere, there is a clashing of stresses in the mechanism. This will be true whether the stress is used to masticate food or just to punctuate a swallow. If the tooth contact is not in harmony with the temporomandibular joint pattern, then the entire stress or the greatest part of it will be transmitted through the malrelated tooth to its supporting structures. It may be more than those cells can endure. It would be much better to have the tooth contact its antagonist at the same time that the temporomandibular joint is in its best bracing position so that the force could be evenly distributed between the supporting structures of the tooth and the temporomandibular

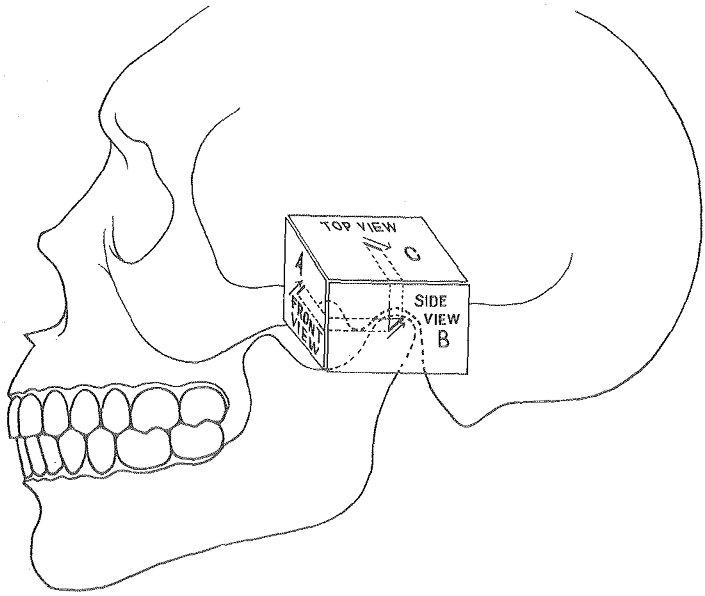

Fig. 6. Working occlusion. Drawing illustrates typical cusps required to maintain equal contact as a result of typical travel of center of rotation.

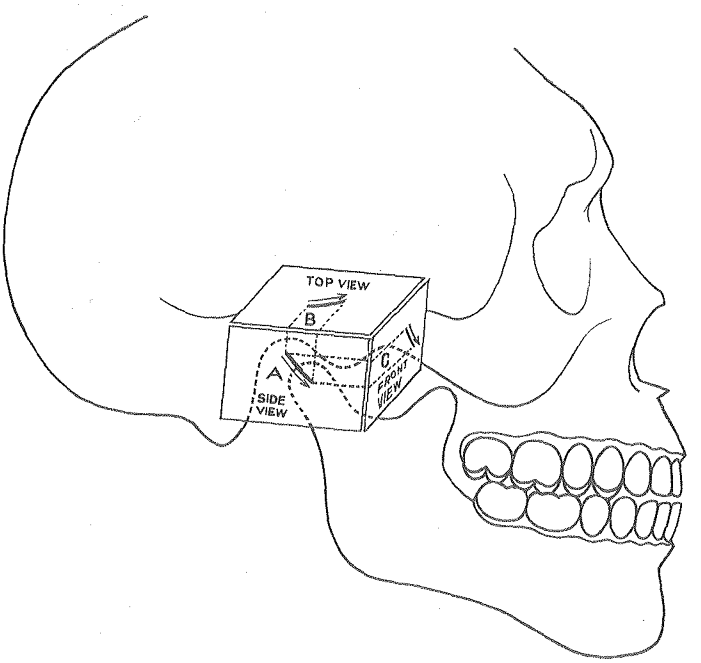

Fig. 7. Balanced occlusion. Cuspal form is dictated in part by path of travel of center of rotation.

joint. Carry this further and have all the teeth functioning equally. The stress per unit would consequently be better distributed. Now of course the patient does not chew in one motion or one closure, but in a very complicated, varied pattern. *The real trick is to make it possible to keep the stress equally divided throughout the whole pattern of movement.* How this task is executed is the substance of this book.

The peculiar movements of the temporomandibular joint make it necessary to have cusps on teeth in order that there be distribution of stress (Figs. 6 and 7). The cusps have to be of a special design. Basically they are similar; yet each mouth has its own peculiarity. It is this peculiarity that makes each articulation as individual as one's fingerprints (Figs. 8 to 13). The factors that make for this individuality will be thoroughly explored in another chapter.

To carry out the ideas of stress distribution, in patients who have no end teeth in the arches and in whom removable restorations have to be used, it is very important that every effort be made to continue to distribute the stress

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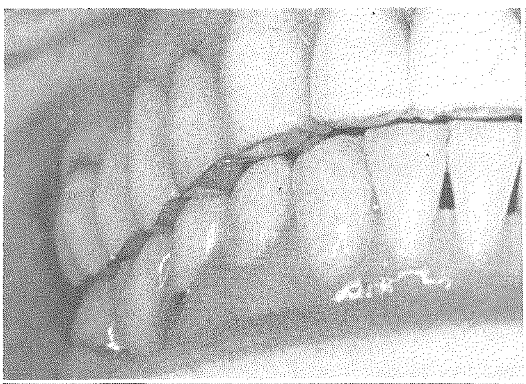

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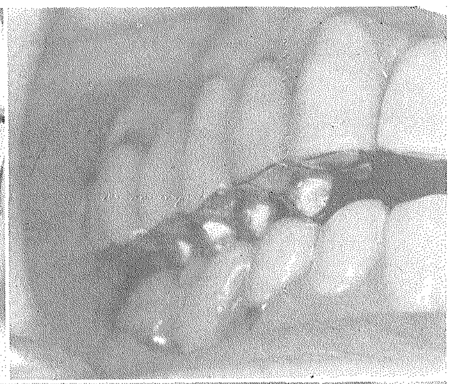

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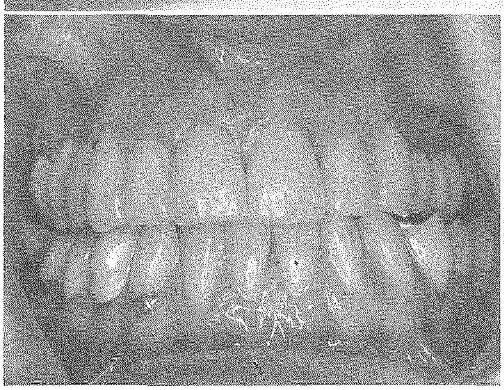

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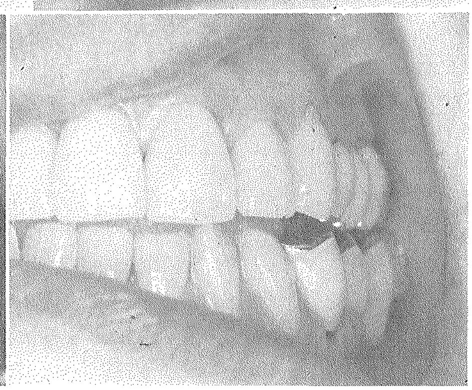

Fig. 8. Centric occlusion in centric relation of a typical practical appliance.
Fig. 9. Cusps required to maintain equal contact in balancing position of typical appliance shown in Fig. 8.
Fig. 10. Centric occlusion in centric relation of a practical appliance with a crossbite relationship on left side.
Fig. 11. Balancing relation of practical appliance shown in Fig. 10 on crossbite side.

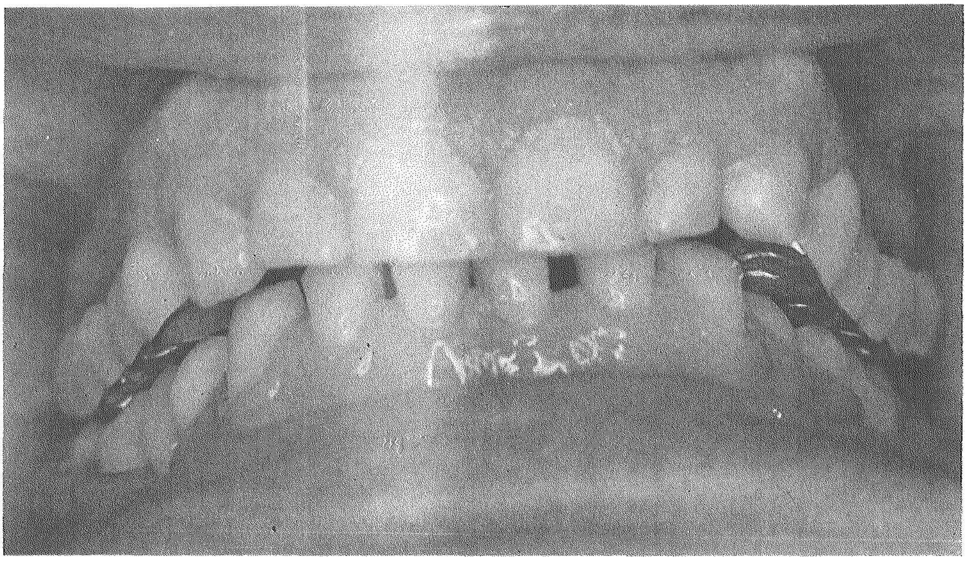

Fig. 12. Centric occlusion in centric relation of a practical prosthesis requiring a slightly different cuspal form.

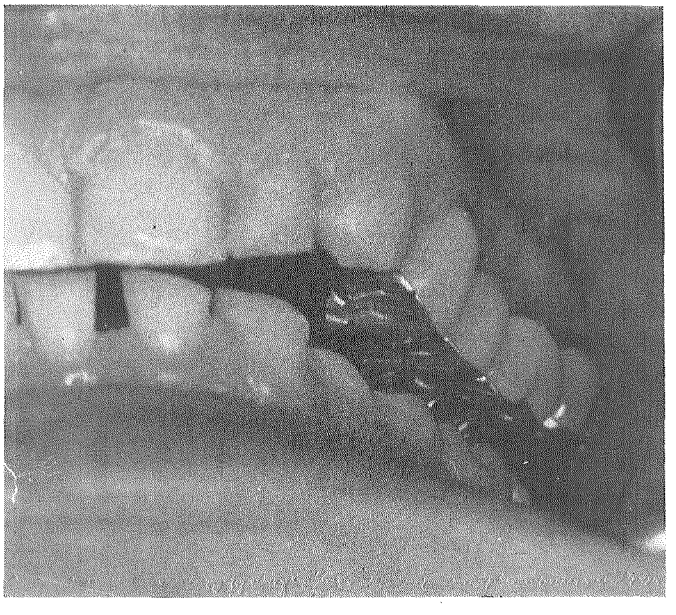

Fig. 13. Balancing relation of appliance shown in Fig. 12. Compare with Figs. 9 and 11.

over as great an area as possible. This is accomplished by means of mucostatic bases and well-articulated chewing surfaces. It is possible to get some stability for weak teeth from a good removable denture instead of putting additional stress on the already endangered abutment teeth. The use of precision attachments helps to minimize the strain on abutment teeth. A mucostatic base is the only means by which a removable restoration can be kept in proper function for any length of time.

Wherever feasible, fixed bridges are preferred to removable ones. The possibility of maintaining an equal distribution of stress is greater with fixed work than with removable bridges. The distribution can be maintained longer with less adjustment.

METHOD OF TREATMENT

What is the method of treatment for accomplishing this?

Several things should be obvious. We must be able to treat the entire mouth at one time so as to manipulate all the chewing surfaces—upper and lower—at the same time in order that they can be the true mates they were intended to be. "The same time" does not mean in an interval of hours, days, or weeks. Rather, it means that, before anything is completed, there must be control of all the surfaces so that they may be adjusted or altered as necessary. This precludes quadrant dentistry as a total treatment.

The second requisite for proper treatment is the accurate recording and duplication of the patient's temporomandibular movements in every minute detail. Actually this is tantamount to having the patient's head to work on in the laboratory without the distracting factors of saliva, cheeks, and tongue. Some men attempt to accomplish this directly in the mouth, but as we shall see, this is almost an impossible task.

Before the preparations are made, it is necessary in the treatment planning to determine which cusps are essential and approximately where they will be located. This is extremely important because it will influence the type of preparations to be used. Depending on how the teeth interdigitate, it will be decided whether full coverage is indicated or whether the problem can be resolved with onlays. Of course, onlays are by far the choice. The veneer materials available today are a poor substitute for nature's enamel and will never take its place. The best-made restorations that are adjacent to gingival tissue can only be irritants. However, sometimes the amount of cusp warpage which is necessary will produce too great a display of gold. In these patients a compromise may have to be made whereby full coverage with its drawbacks is resorted to.

The practical treatment of a patient necessitates the completion of all the preparations of the teeth involved. Usually this cannot be accomplished at one sitting; nor would I want it done that way. Therefore, it is necessary to construct temporary restorations for each quadrant as the treatment proceeds. When all four quadrants are prepared, the master impressions are taken, and these casts are accurately related to the articulator by means of a face-bow and a centric interocclusal record. The prepared teeth will have the exact relation on the articulator that they have in the patient's mouth. Quadrant impressions are taken as each quadrant is prepared, and the quadrant casts made from these impresssions will be used for final margin and contact adaptation of the wax patterns. The temporary restorations are usually made of good scrap gold and in one piece for easy handling during their frequent removal and insertion. Splinted together, they also tend to maintain the status quo in the interim required for laboratory procedures.

The carving of the wax patterns and the factors involved in articulation are covered in two lengthy chapters; therefore, a discussion here of the subject will serve no purpose. It will suffice to say that an articulation is developed in wax on the master casts on the articulator. The characteristics of the articulation will be a harmonious arrangement of the occlusal surfaces that will follow the movements of the temporomandibular joint. The anterior teeth—overbite and overjet—will be in harmony with the posterior occlusal surfaces so that in all the possible movements (within tooth contact) the forces will be distributed over as many teeth as possible. The cusps will be parabolic in shape—a must if they are to work in harmony with the rotary movements of the mandible. Each side will be in balance with the other, and a simultaneous contact will be maintained by all the teeth throughout all the excursions. The wax patterns will be separated and transferred to the quadrant dies, and the margins will be adapted. The patterns will then be cast in a hard gold and prepared for trial in the mouth.

Regardless of how carefully and accurately we work or think we work, these castings are far from the finished product that the patient will wear. The errors incorporated in cutting the wax patterns and transferring them to individual dies, the investing and casting errors, the material errors—all add up to an unbelievable amount. It, therefore, becomes necessary to correct the restorations before they can be worn. Each restoration is carefully fitted to each tooth and to each other. After the restorations have been fitted satisfactorily, a remounting is done. This means that accurate casts containing the restorations are placed on the articulator in the same relation that they had in the mouth. This step is accomplished by means of a face-bow transfer and a centric interocclusal record. The restorations are then very carefully adjusted until they exhibit the same characteristics and relation to each other as the wax patterns on the master casts. When this has been accomplished, the restorations are ready to be worn temporarily by the patient.

There are several reasons for temporary wearing of the restorations. Healing of the supporting structures of periodontally involved teeth will frequently produce a slight change in the position of the teeth (and their restorations). Malfunctioning joints often heal after proper function, with the result that there is a slightly different relationship. Patients, after overcoming long-imposed neuromuscular patterns of malfunction, will more readily give an accurate joint relationship. If the restorations are temporarily cemented, they can be removed without difficulty for slight adjustments to perfect the restoration. One needs but a single experience of having to cut out a permanently cemented restoration to be cured of being hasty in permanently cementing restorations! In patients with very bad periodontal or joint disorders, it is often necessary to have half a dozen remountings over a period of several years before real success can be achieved.

Splinting is a last resort. It was mentioned briefly that temporary restorations are splinted together both for convenience in handling and because this tends to maintain the status quo.

In contrast, permanent restorations are almost never splinted. Experience has shown that splinted teeth never respond to treatment so quickly nor so well as individual restorations do (provided that the articulation is correct). There is just one exception to this rule. Only after repeated efforts at stabilizing the teeth by means of individual restorations have failed, may we, as a last resort, solder these restorations together in a splint. This is recognized as a final recourse and a definite compromise, something to be undertaken when it is the only way to maintain the teeth for a while longer. It is never the treatment of choice. When splinting is a routine procedure, it is only a coverup or a compromise for improper articulation.

PERIODONTAL THERAPY

As was stated at the beginning of the chapter, full-mouth rehabilitation is performed to produce a healthy, esthetic, well-functioning, self-maintaining masticatory mechanism. It is often necessary to institute good periodontal therapy to achieve these ends. Periodontal therapy is always undertaken when it is required to produce the health of the oral mechanism. Quite frequently after a mouth has been properly treated, only routine scaling and curettage is required to accomplish this. Occasionally more extensive therapy is indicated if a particular area does not respond to treatment or is so advanced that periodontal surgery is called for. Only in rare cases is periodontal surgery instituted before any treatment is attempted. Whenever possible, one waits until the mouth is restored to proper function before deciding whether extensive periodontal treatment is necessary.

It is possible by periodontal therapy (conservative and/or surgical) to eliminate pockets. However, unless the function is corrected, pocket-free teeth can still bounce around during function. So, both should be done whenever feasible. Of the two, complete pocket elimination is less important than stability in function. Experience has shown that pockets do not necessarily get worse if not completely eliminated, provided that proper function is established. Nevertheless, pockets should be carefully treated by frequent curettage and adequate home care.

GNATHOLOGY

The philosophy upon which this approach to dental practice is based is that of gnathology. "Gnathology is the sum total knowledge required to successfully treat the complex organ of chewing and includes all the ramifications of dentistry."*

An often heard criticism of this philosophy of dental practice is that it is too accurate, too careful, too complex. The truth is that we do not begin to come even close to accuracy. We think we do; we try to. Some day, though, we will find that what is here advocated will be looked upon as a very crude approach to the ideal.

The advice offered by the late Oscar Hammerstein II could well apply to a philosophy for dental practice:

"Have You a Civilized Mind?"

> "Too many men become certain about too many things too early in their lives. Over-eager to have everything 'settled in their minds,' they lack both the wisdom and the courage to expose their hastily adopted ideas to healthy doubts. They cling with blind passion to their false 'certainties' and too often are ready to kill or be killed for them. In these immature absolutists lies the seed of tragedy. The earth is sick with them.
>
> "The certainties of a strong man are built on a structure of resolved doubts. By the time he reaches a conclusion, he has traveled the hard road of reason. Even then he will be tolerant of another man's beliefs, and willing always to compare them fairly with his own. The man with a civilized mind is neither afraid nor ashamed to change it.
>
> "Your uncritical loyalty to weak ideas cannot make them strong. Be ever ready to let your ideas stand up and fight for themselves. Let them survive or die according to their merit. It is only in ideas honestly and bravely tested that you will find security."†

*From Stallard, Harvey: Personal communication.

†From Hammerstein, Oscar II: "Have You a Civilized Mind?" This Week Magazine, June 22, 1952, sect. 7, p. 2.

CHAPTER 2

Anatomy and physiology of the masticatory mechanism

IMPORTANCE OF UNDERSTANDING ANATOMY AND PHYSIOLOGY OF MASTICATORY MECHANISM

An understanding of the anatomy and physiology of the masticatory mechanism is essential to intelligent diagnosis and adequate treatment. If we know how the normal masticating mechanism functions, we will be able to recognize its malfunction and be in a position to correct it.

A correlation of the anatomy of the parts and the function of the parts will help one to understand the intricacies of the mechanism.

For purposes of this discussion, it seems superfluous to mention that a normal, healthy mechanism is described—not one which has been "condylectomized," partially ankylosed, paralyzed, or in any way prevented from functioning normally. Interesting data, of course, may be gained from studying such abnormalities, and their behavior can be better understood once one becomes familiar with the normal mechanism.

THE OSSEOUS STRUCTURES

The masticating mechanism is made up primarily of three osseous structures—the temporal bones, the maxillae, and the mandible. The maxillae and the body of the mandible house the teeth—the instruments of mastication. The temporal bone and the condyle portion of the mandible form the contact or articulation between the osseous structures of the mechanism. In addition, the muscles which activate the chewing mechanism obtain their anchorage from and are attached to these osseous structures. Continuous contact is made between the mandible and the temporal bones by means of the temporomandibular joints. The glenoid fossa of the temporal bone is concave anteroposteriorly as well as mediolaterally. It is the shape of the anterior slope of the fossa that determines the condyle paths (the lateral, protrusive, and in-between lateral protrusive). The

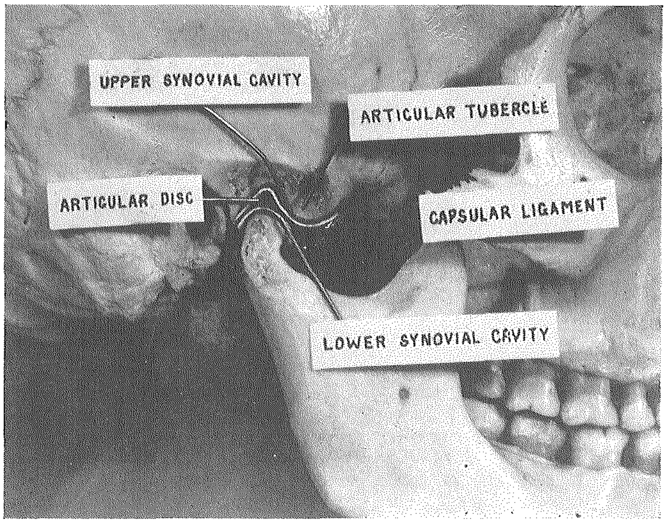

Fig. 14. Photograph of simulated components of the temporomandibular joint. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

head of the condyle is oval in shape, and its long axis is at an oblique angle to the median axis of the skull. The synovial membranes and the meniscus are interposed between the fossa and the condyle (Fig. 14).

In function, the head of the condyle rotates on the undersurface of the meniscus. It is in this compartment of the joint that the hingelike action of the joint takes place. The hingelike action is the center of action of the parts—the disc, the condyle head, and the synovial membranes.

The upper surface of the disc makes contact with the glenoid fossa. It is the simultaneous sliding of the disc and condyle that produces the translatory movement of the temporomandibular joint. In other words, the head of the condyle rotates on the undersurface of the disc; the condyle and the disc together translate across the base of the fossa (anteroposteriorly, mediolaterally, or in-between).

The meniscus, or disc, consists of fibrocartilage, oval in shape, thinner at the center than at the circumference. "The inferior surface is concave and fits on to the condyle of the lower jaw; while its superior surface is concavo-convex from before backward, and is in contact with the articular surface of the temporal bone."*

The stress-bearing character of the disc is evident in the fact that the blood and nerve supplies are in the periphery, the center being devoid of these tissues.

Contact between the head of the condyle and the glenoid fossa is made by

*From Schaeffer, J. Parsons (editor): Morris' Human Anatomy, New York, 1953, Blakiston Division, McGraw-Hill Book Co., Inc.

the center of the disc. Stress of mastication in the joint is absorbed in this relation. The meniscus has its bearing against the articular surface of the temporal bone, which forms the anterior wall of the glenoid fossa. It is in this relationship that the forces of mastication are absorbed by the temporomandibular joint.

Lubrication of the joint is accomplished by the synovial membranes. Each compartment of the joint has its own synovial sac.

The disc and the synovial membranes are not compressible nor variable in the normal course of events, but serve as ball bearings between the skull and the condyle.

FUNCTION OF LIGAMENTS AND MUSCLES

Ligaments and muscles hold the temporomandibular joint and the chewing mechanism together. The ligaments (Fig. 15) limit the amount of movement of the mechanism. They prevent the mechanism and joint from falling apart when the muscles are relaxed. They help to determine the position of the mandible when the muscles relax. Thus, to some extent, physiological rest is governed by these ligaments.

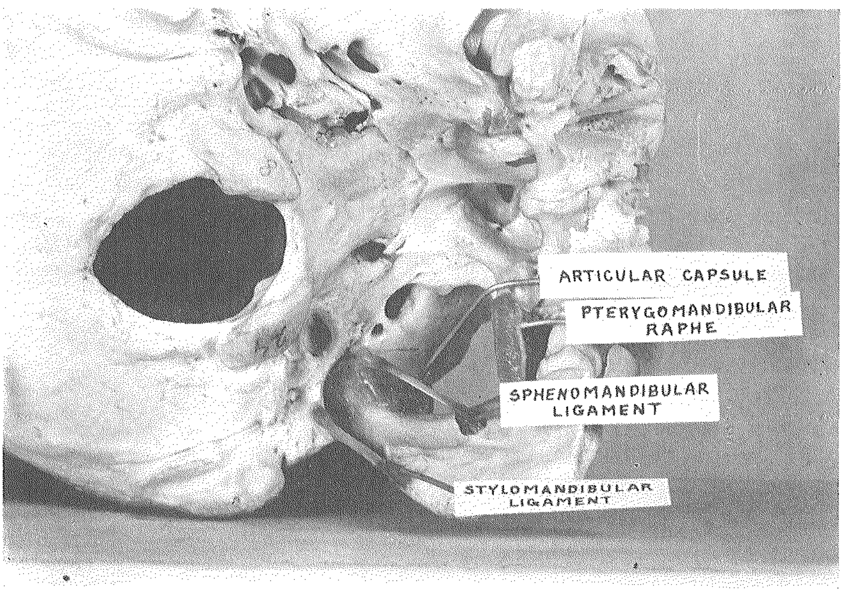

Fig. 15. Photograph of simulated ligaments of the temporomandibular joint. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

Capsular and temporomandibular ligaments

The most important ligaments of the temporomandibular joint are the capsular and the temporomandibular. The temporomandibular ligament forms the lateral

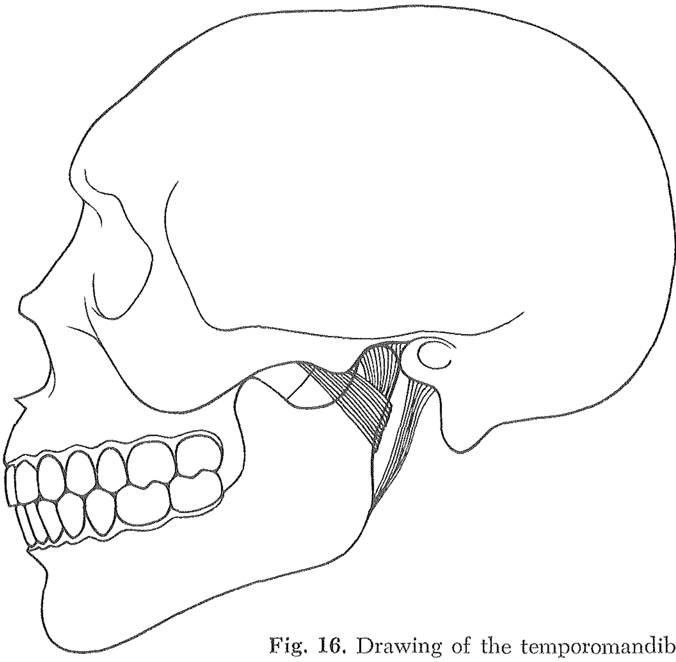

Fig. 16. Drawing of the temporomandibular ligament.

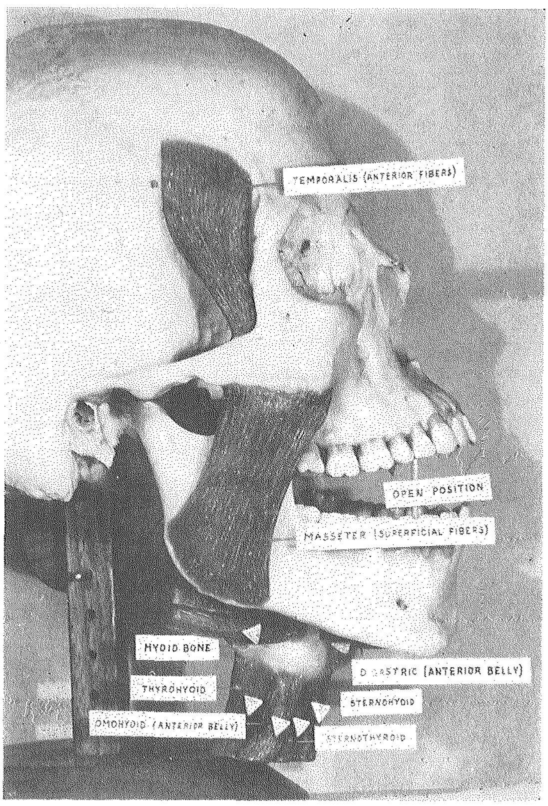

Fig. 17. Photograph of simulated muscles as they act in kinematic chains. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

part of the capsule and reinforces it. Broad above, it is attached to the zygoma and to the tubercle (articular eminence of the zygoma). It is inclined downward and backward and is inserted into the condyle and neck of the mandible laterally. The fibers coming from the tubercle are short and nearly vertical (Fig. 16). Together, the capsular and temporomandibular ligaments enclose the structures of the joint and tend to limit its movements. These ligaments are loosely attached in the upper compartment of the joint to permit translatory movements. They are more firmly attached in the lower compartment where the hingelike action takes place.

The temporomandibular joints are movable fulcrums activated by the muscles of mastication. These joints have some of the elements of a ball and socket. They glide forward and backward as well as sideways. Actually they can glide and rotate at the same time in the manner of a movable ball and socket.

In a discussion of the muscles of mastication, there is a tendency to speak of individual muscles and to describe their separate actions. Yet, muscles function in groups as kinematic chains (Fig. 17).

Temporalis muscle

The temporalis muscle (Fig. 18) is a large, strong muscle of mastication. It has its origin in the temporal fossa on the side of the skull. Its origin covers a considerable area and, by means of an aponeurosis, connects with its mate on the other side of the skull very much in the manner of a saddlebag. Its insertion is in the coronoid process of the mandible and reaches down to the ramus

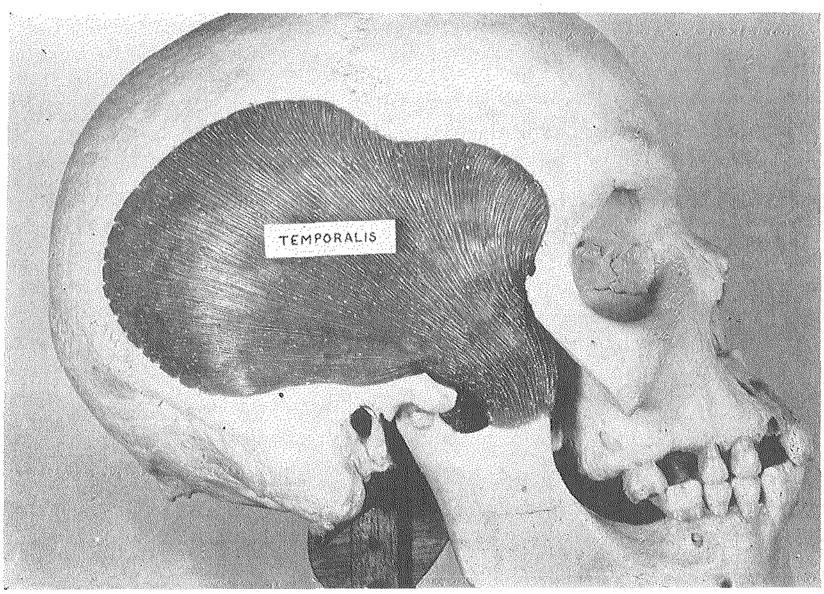

Fig. 18. Photograph of simulated temporalis muscle showing its broad origin and narrow insertion. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

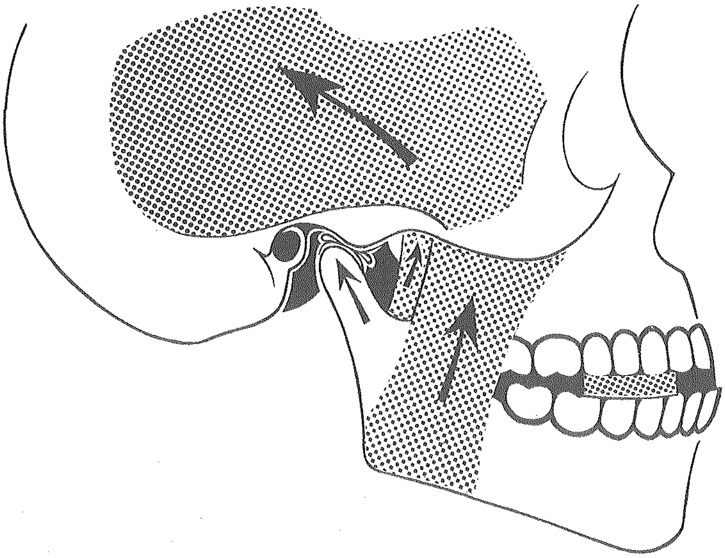

Fig. 19. Drawing of the elevator muscles of the mandible. The resultant force of their contraction causes the upward and backward seating of the condyle.

of the mandible. It should be noted that the insertion is anterior to the temporomandibular joint. Although the fibers of the temporalis muscle are described as vertical, oblique, and horizontal, contraction of any or all of these fibers has a definite tendency to elevate and retrude the mandible. This is understandable if we recall that the temporomandibular joint is made up of the glenoid fossa, the anterior surface of which slopes upward and backward, and that the meniscus is interposed between the head of the condyle and this slope. Any contraction of a muscle attached in front of this upward slanting guide must have a tendency to brace the condyle head in a posterior and superior position (Fig. 19). There will be more about this later in the discussion of centric relation and its importance in dentistry.

Masseter muscle

The masseter muscle (Fig. 20) has its origin in the zygomatic arch. It arises in two heads—a superficial one from the outer border of the arch and a deeper one from the inner and more posterior portion of the arch. Its insertion is in the outer angular region of the mandible. Fibers of the masseter muscle are almost at right angles to the occlusal surfaces.

The masseter is a very powerful muscle of mastication. Its contraction elevates the jaw and forcibly brings the teeth together. Like the temporalis muscle, its contractions tend to seat the condyle in a posterosuperior position in the glenoid fossa. Neither the temporalis nor the masseter has anything to do with lateral movements of the jaw. Their contractions primarily elevate the jaw and bring

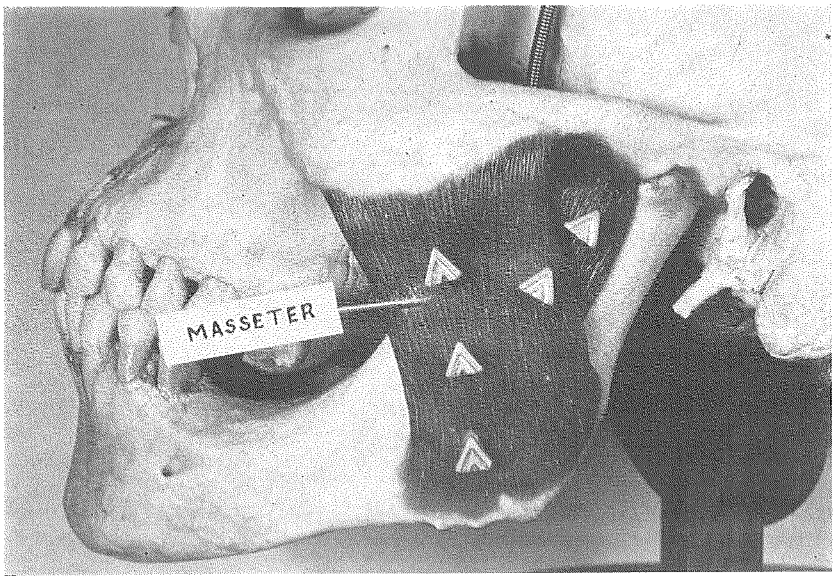

Fig. 20. Photograph of simulated masseter muscle. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

the teeth together. It is because of this action that the occlusal surfaces of the teeth must harmonize with the hingelike action of the mandible. The masseter can snap the teeth together in any position from centric to protrusive. Having the occlusal surfaces of the teeth in harmony with this action permits a better dissipation of the forces of this muscle to the periodontal tissues of the teeth as they come together through a bolus of food.

External and internal pterygoid muscles

The external and internal pterygoid muscles are responsible for the lateral movements of the mandible.

The external pterygoid (Fig. 21) has its origin, by means of two heads, in the great wing of the sphenoid bone and the outer surface of the pterygoid plate. The uppermost fibers of this muscle are inserted in the articular disc through the articular capsule. The majority of the remaining fibers are inserted in the anterior surface of the neck of the mandible.

The fibers of the external pterygoid muscle are in a horizontal and medial direction, and their contraction pulls the head of the condyle and the meniscus forward and medially (Fig. 22). This action sets the mandible into position for chewing. If the external pterygoid on one side relaxes while the one on the other side contracts, the mandible will be moved into a lateral position. It guides the mandible into lateral position and steadies it while the subject bites (contraction of the temporal and masseter) in the lateral position. Contraction of the fibers of the external pterygoid also tends to act as a brake against the

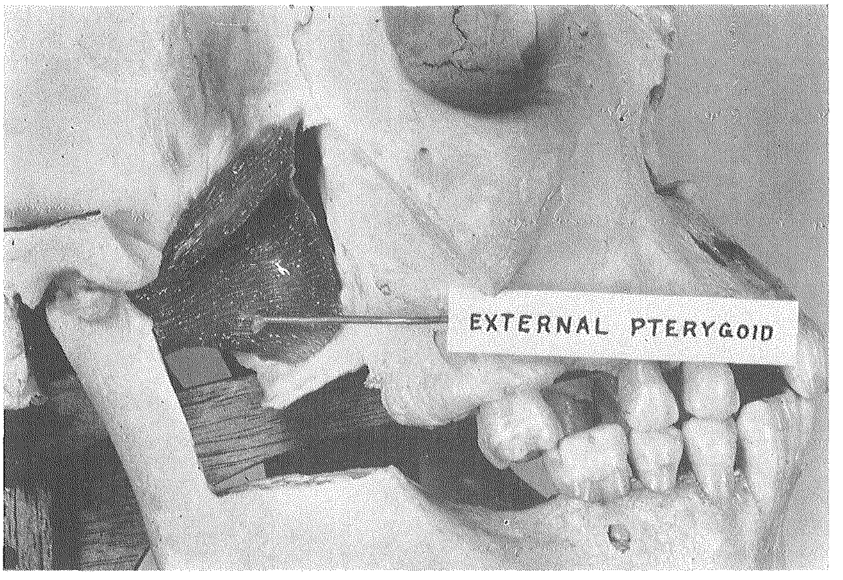

Fig. 21. Photograph of simulated external pterygoid muscle. A section of the mandible has been removed to show muscle origin and insertion. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

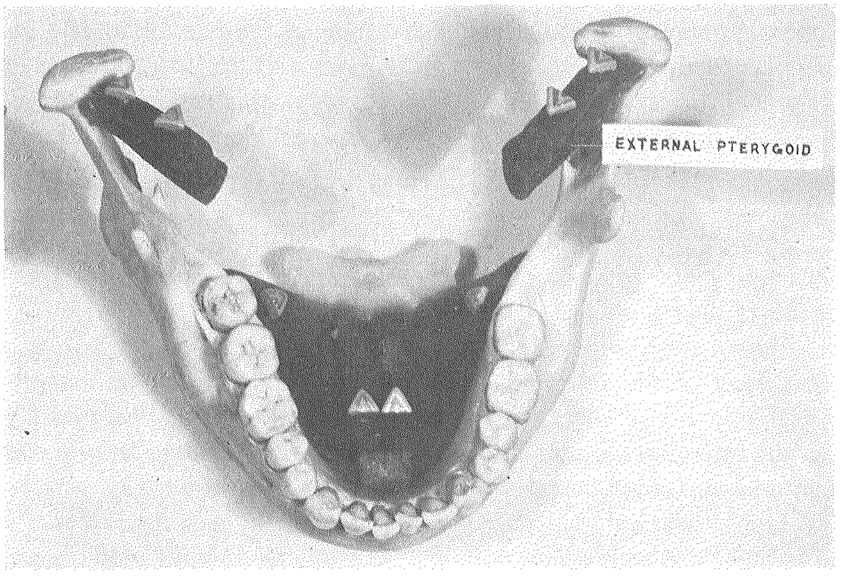

Fig. 22. Photograph of simulated external pterygoid muscle showing the direction of pull by its contraction. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

posterior pull of the temporalis muscle. It effects a muscular balance against any violent jamming of the head of the condyle posteriorly.

The internal pterygoid muscle (Figs. 23 to 25) originates from the palatine

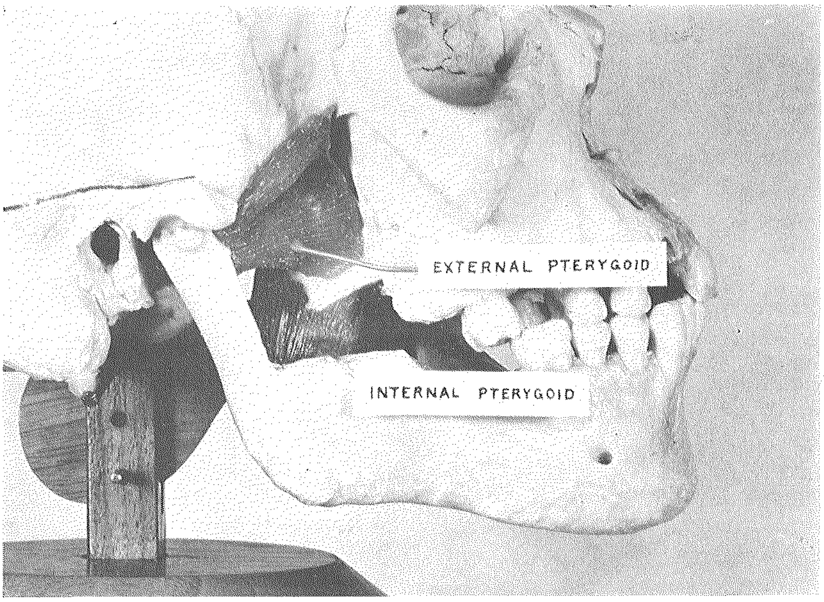

Fig. 23. Photograph of simulated internal pterygoid muscle showing its relation to the external pterygoid. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

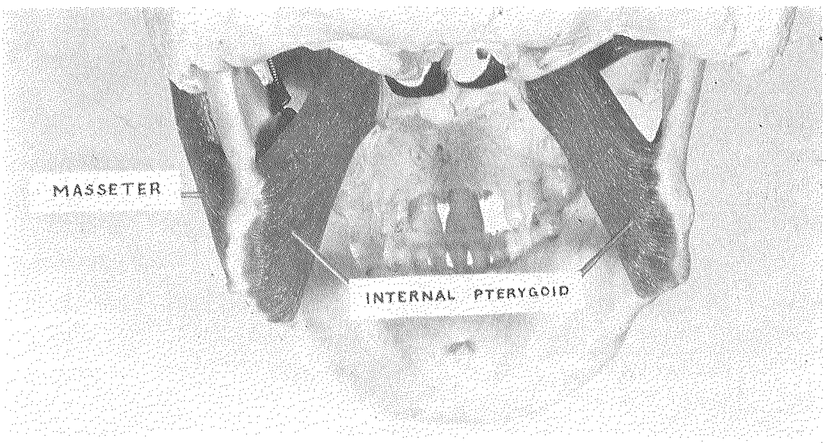

Fig. 24. Photograph of simulated internal pterygoid muscle (rear view) showing direction of fibers. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

bone and the maxilla and from the internal surface of the pterygoid plate. Its fibers are inserted in the lower part of the inner surface of the ramus of the mandible at the angle. They run laterally, downward, and backward.

Bennett movement. The contraction of the internal pterygoid muscle on one side draws the back part of the mandible laterally and assists in protruding and elevating the mandible. It aids the external pterygoid muscle. Fig. 26 shows a

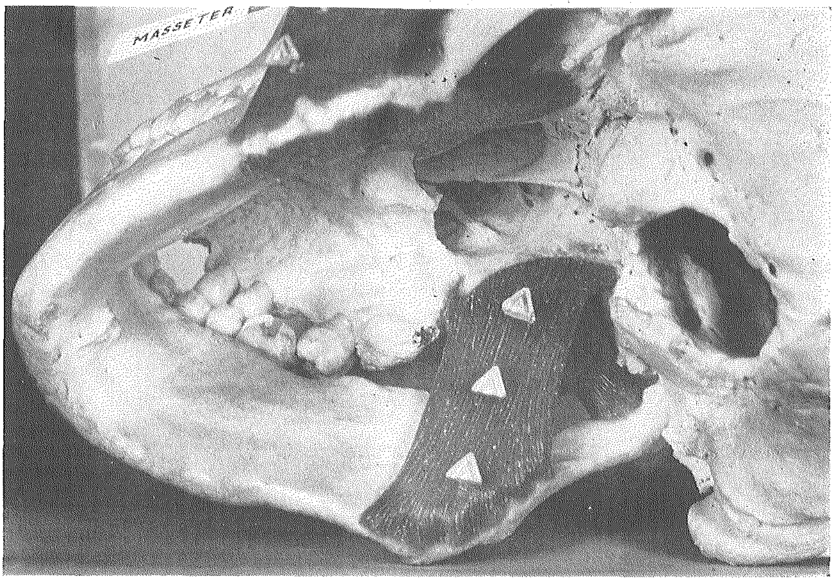

Fig. 25. Photograph of simulated internal pterygoid muscle as viewed from the medial aspect. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

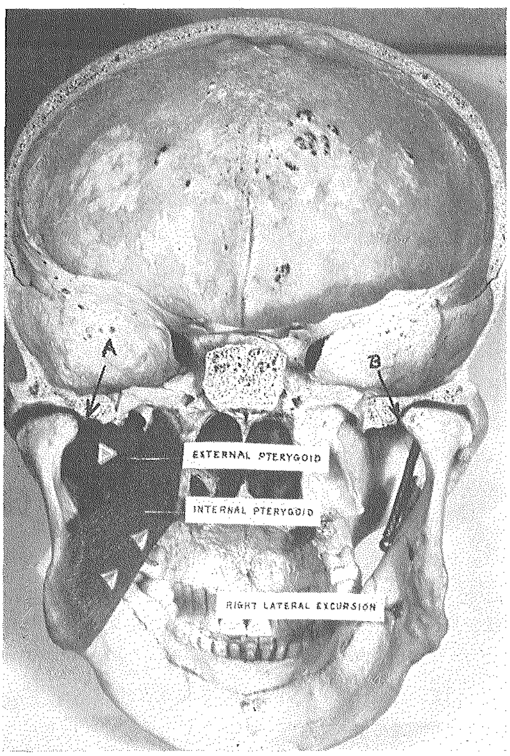

Fig. 26. Photograph of a transverse section through the temporomandibular joints showing the variations in the inner curbing of the glenoid fossae. (Courtesy The Dentists' Supply Company of New York, York, Pa.)

frontal section of the skull through the temporomandibular joints. Note the inclination of the fibers of the internal pterygoid muscle. Note, too, the inner curbings of the glenoid fossae. Notice the difference in the inner curbings of the right, *B,* and left, *A,* joints. When the internal pterygoid muscle contracts to help the external pterygoid muscle cock the mandible in preparation for chewing, the direction and amount of medial movement of the condyle head are dictated by the shape of the inner curbing of the glenoid fossa, just as the base of the glenoid fossa dictates the condyle path in a straight, protrusive movement. The forceful contraction of the masseter and temporalis muscle returns the condyle (and mandible) to centric position, exerting chewing force against a bolus of food. The bracing of the mandible at this point of the chewing stroke can occur only between the condyle and the fossa, with the teeth engaging the bolus of food. The direction of movement has to be guided by the shape of the inner curbing of the fossa.

The cusps are tailored to harmonize with this Bennett movement so that, when the teeth come together as they penetrate the food, the cusps will shear past each other without clashing and jarring the periodontal tissues.

NEUROMUSCULAR COORDINATION

The various structures and individual movements just described are coordinated by a complex integration of the nervous function.

Nociceptive reaction

During mastication, sudden contact of a tooth with a hard object produces discomfort and reflexively opens the mouth. This is called a *nociceptive* reaction and is partially responsible for protecting the chewing mechanism when there are premature contacts in the articulation.

Reciprocal innervation

This nociceptive reaction is able to protect the mechanism because of the phenomenon known as *reciprocal innervation.* This is the simultaneous activation of a flexor reflex and the inhibition of the extensor (stretching) reflex, and vice versa.

Rhythmic chewing is made possible by the efficient reciprocal innervation of the masticatory muscles as they alternately depress and elevate the lower jaw.

During mastication, proprioceptors in the muscles, tendons, and joints send messages through afferent fibers in the trigeminal nerve to the chief sensory nucleus of this nerve. Secondary fibers cross the brain stem, ascend to the thalamus, and finally arrive in the sensory cortex via tertiary tracts. In this manner, an awareness of motion in the jaws and of the position of the maxillae and mandible during chewing movements is permitted. Some proprioceptive impulses pass from the chief sensory nucleus to the cerebellum, thence through a chain of neurons to the motor cortex. The motor cortex is thus informed of the position of the teeth and jaws, and its action makes possible the synchronous mastication movements. Motor activity, whether reflex or voluntary, demands little conscious effort; therefore, it becomes necessary to have all the parts of the masticating mechanism working in harmony with each other to prevent its self-destruction.

MOVEMENTS OF MASTICATION

Let us analyze the basic chewing movements and the structures involved.

Description of chewing cycle

The masticatory movements of the mandible are automatic and occur under considerable force. Mastication begins with the incision of a morsel of food. To accomplish this, the mandible is dropped open by the contraction of the external pterygoids and the infrahyoid and digastric groups of muscles. If the external pterygoids contract equally (which is improbable), the patient will execute a straight protrusive movement. More likely they will contract unequally, and a lateral protrusive position will be assumed. Now the incisor teeth have to be propelled through the food to cut it, and this is accomplished by the contraction of the elevators of the jaw—the temporalis, masseter, and internal pterygoids.

Some food having been prehended, the act of mastication proceeds to prepare this food for real chewing. The bolus is propelled into the mouth by the lips, tongue, and cheeks and probably is rolled onto the bicuspids which cut it up further with the crushing and shearing action of their blades. The temporalis and masseter muscles partially relax, allowing the food to be replaced on the chewing surfaces. The external and internal pterygoids are in a state of alternate relaxation and partial contraction, and the temporalis and masseter again contract to crush the food some more. By this time and after several strokes, the bolus has reached the molar teeth, where now it will get a final milling before it is swallowed. The masseter and temporalis muscles relax; the external and internal pterygoids on the same side contract while those on the opposite side relax, thus cocking the mandible in a lateral protrusive position. The food is now repositioned on the occlusal surfaces of the molars, and the real power of mastication is applied by the masseter, temporalis, and internal pterygoid muscles. As the masseter and temporalis muscles contract and crush the food, the alternate contractions of the internal pterygoids cause a wiping of the lower occlusal surfaces of the molars across the upper occlusal surfaces in a finely triturating action which comminutes the food preparatory to swallowing.

More specificially, if the bolus of food is on the lower right first molar and ready for its final comminution, the temporalis and masseter muscles on both sides relax. The external and internal pterygoids on the right side relax; the external and internal pterygoids on the left side contract and cock the mandible to execute a working occlusion on the right side. Now the temporalis and masseter muscles on both sides contract forcibly to crush through the food. The external pterygoid on the left side relaxes, permitting the mandible on the left side to return home. As the condyles both approach centric position, the internal pterygoid of the right side contracts, executing the Bennett movement. The masseter and temporalis on the right side soon relax, permitting the follow-through of the masticating stroke as the external pterygoid on the right side contracts.

It must be remembered that during all of the jaw movements the condyles and menisci are moving together. For purposes of clarity, however, our description of the act of chewing is somewhat simplified. Again we must emphasize the harmonious relation of the teeth to these movements that should exist if the investing structures are to be protected from destruction.

HARMONY OF FORM AND FUNCTION

Because of the complexity, automation, and forcefulness with which the chewing cycle is executed, it should be apparent that a high degree of harmony must exist between the form and function of the parts. Although nature has a built-in safety device in the proprioceptive reflex mechanism, repeated insults in the form of a premature contact may impose the learning of a new reflex pattern. It may not be so effective as it should be, and soon the additive trauma will begin to take its toll. Then too, with advancing age the sharpness of the protective reflex is lost, and more and more damage is done to the mechanism.

Protection by proprioception

It is interesting to note that the protective proprioceptive reflexes operate best during normal function. The self-protective mechanisms are weak or missing during nonfunctioning movements. It has also been shown that reflex activity is reduced during sleep, with the nonsecretion of the parotid gland. The protective proprioceptive reflex apparently fails to function during bruxism. This is one reason for correcting the malocclusion of patients who practice bruxism, for while it may not cure the habit, it will minimize the damage that is done.

What is meant by harmony of form and function?

Up to now the chewing movements have been outlined briefly, and the anatomy of the masticatory mechanism has been described. Very little has been said about the teeth, the chewing implements, but it has been implied that a harmony of form and function is necessary. In another chapter will be described how the forms of the teeth are made harmonious with the function of the masticatory mechanism, but for the present the subject is limited to a brief discussion.

The objective of maintaining the health of the structures of the mechanism is of prime importance. To accomplish this, we strive to prevent any part of the mechanism from overworking or being abused. A certain amount of work has to be done in the form of chewing. For the moment, let us disregard any bad habits and consider only the normal use of the apparatus to masticate food.

Necessity for equal distribution of masticatory forces

A certain amount of muscular force is necessary and available. How that muscular force is dissipated by the various components (the joints, teeth, and investing structures) is of extreme importance. For instance, if, in the chewing cycle previously described, a single tooth came into contact before the others, what would be the result? As the patient penetrated the food bolus, the premature tooth would receive all the muscular force exerted after penetration of the food. This force in turn woud be transmitted to the periodontal tissues and in time would cause their destruction.

By harmony of form and function, then, is meant an equal distribution of the forces of mastication which will permit the periodontal tissues of all the teeth and the stress-bearing portion of the joints equally to absorb this muscular force. Equal distribution of the functional forces over as much tissue and as great an area as possible will guarantee the health of the entire mechanism and is the objective of the treatment.

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CHAPTER 3

The hinge axis

APPLICATION OF HINGELIKE ACTION OF THE TEMPOROMANDIBULAR JOINT TO DENTISTRY

The successful application of the hinge axis in dentistry was the greatest single contribution of the Gnathological Society. It was the cornerstone of all future accomplishments and is still the basis for articulation.

The hinglelike action of the temporomandibular joint has been described by anatomists for over a hundred years. Its application to dentistry, however, had to wait for the Gnathological Society in the 1920's. Prior to that, Snow, Gysi, and others had been aware of the presence and importance of an opening and closing

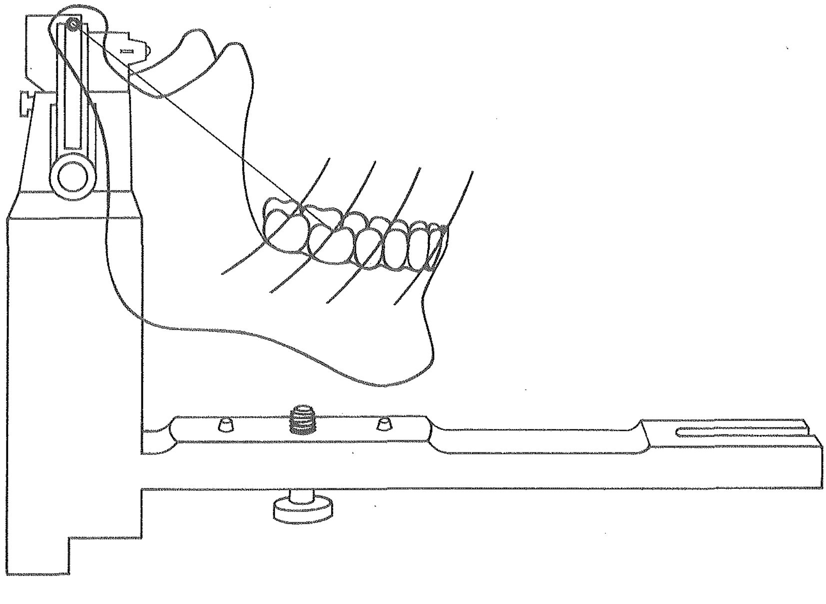

Fig. 27. Drawing of the lower member of an articulator with a lower jaw superimposed. The axis of the condyle is aligned with the axis of the instrument.

axis. Yet their methods were so crude that they concluded that the axis was some place below the condyles. This inaccuracy led them to believe that changing vertical dimensions was still a chair operation.

The desirability of being able to reproduce the opening and closing component of jaw movements on an articulator must have been evident. That they were not able to accomplish this was the fault of the methods used and the fact that there was no articulator which could duplicate this movement. The Gnathological Society developed a means of attaching a face-bow rigidly to the mandibular teeth. This permitted accurate location of the opening and closing axis. Many refinements in equipment were of course necessary to make this a practical procedure. For example, easy adjustment of the caliper points was essential. After it had been clinically demonstrated that there was a usable hinge axis, it became necessary to design an instrument which would duplicate this component. The articulator had to have an intercondylar axis which could be aligned with the axis located on the patient (Fig. 27).

DEFINITION OF THE HINGE AXIS

What is the hinge axis?

The head of the condyle rotates on the under surface of the meniscus. While it rotates on the meniscus, the meniscus and condyle can move on the surface of the glenoid fossa. The movement can be forward, to the side, or anything in-between. While the meniscus and condyle are thus translating, the condyle can execute a pure hinge movement any place along this translation. Consequently, mandibular movements appear to be very complicated and confusing. It is practical to locate the center of vertical motion. It is also practical to locate the center of lateral motion. The center of vertical motion and the center of lateral motion are one and the same—the center of rotation, and there is one in each condyle.

Location

The hinge axis is an imaginary line connecting the center of rotation of one condyle to the center of rotation of the other condyle (Fig. 28). From the centers of rotation originate the vertical opening and closing movements, as well as the pure lateral movements. Any combination of vertical and lateral movement has its center in the same point. The center of rotation of each condyle is constant to the condyle and hence to the mandible. The hinge axis (the imaginary line joining these centers) then is constant to the mandible (and teeth). As the mandible moves in its various excursions, the hinge axis moves right along with it. The mandible is capable of executing a hingelike closure in any position (Fig. 29). This is one reason why the hinge axis is so important. It permits duplication of all the arcs of closure of the mandible on an instrument and thus the cusps can be tailored to harmonize with these arcs.

One point of confusion about the hinge axis stems from the method of its

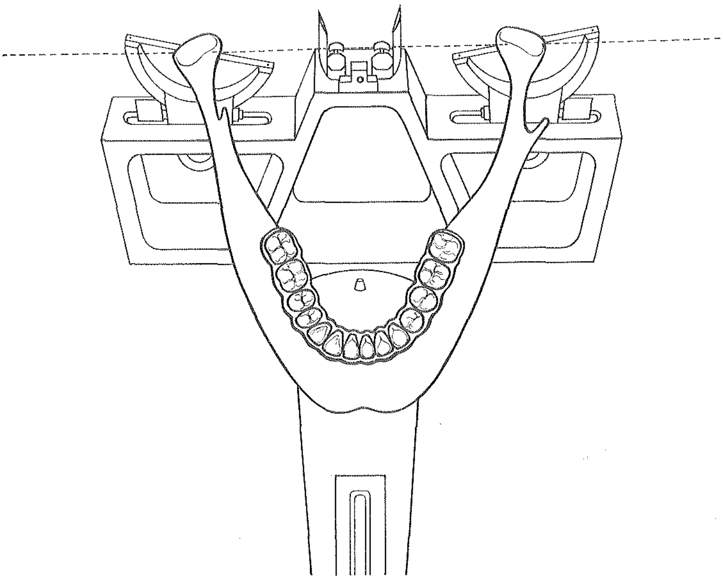

Fig. 28. Drawing of the hinge axis of the lower jaw coinciding with the hinge axis of the articulator.

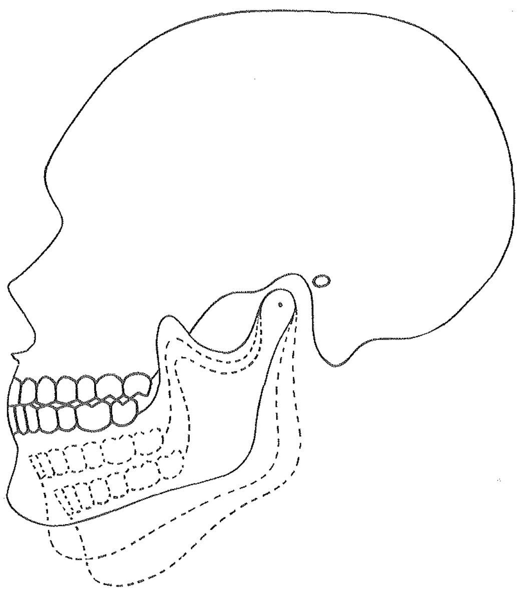

Fig. 29. Drawing showing that the hinge action can take place in any position of the mandible.

location. It is located in the most retruded position of the mandible—the terminal hinge position (Fig. 30). It is located in this position because only here can it be repeatedly *separated* from the other components of jaw motion. The patient,

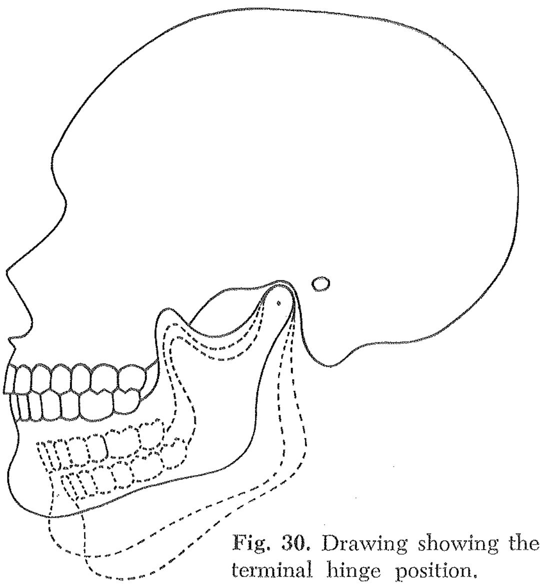

Fig. 30. Drawing showing the hinge action in the terminal hinge position.

of course, does not function in this terminal hinge position. He is purposely made to execute a terminal hinge closure so that the center can be located. Once it is located, we endeavor to trace the path of this center in order to be able to duplicate every possible combination of these two movements which the patient will use in function.

Importance

The importance of the hinge axis lies in the fact that, by its determination and transference to an articulator, it is possible to have casts of the mouth (teeth) in the exact *dynamic relationship* to each other as exists in the patient's head. Only by use of the hinge axis is it possible to have teeth approach each other on an articulator exactly as they do in the mouth. The hinge axis permits control of the vertical dimension on the articulator. It makes it possible to duplicate all the eccentric relations and all possible contacts of the teeth in these relations. It makes possible thorough study and diagnosis of tooth relations, with confidence that they are exactly as they exist in the patient's mouth. It permits return of the work (whether dentures or natural tooth reconstruction) to the instrument for correction, with the knowledge that any changes in vertical relations will be harmonious when placed in the patient's mouth. It is only by means of the hinge axis (and centric relation) that the teeth can be related accurately to the terminal hinge position.

HINGE AXIS AND CENTRIC RELATION

The act of securing a centric interocclusal record is related to the terminal hinge closure. We attempt to "freeze" the terminal hinge closure at a convenient vertical opening, but were it not for the hinge axis, it would not be possible to secure an accurate centric interocclusal record. It is agreed that in order to obtain such a record, the recording medium must not be penetrated by the teeth or the occlusion rims. (The implication is that the mandible would deviate because of the guidance of the penetrating teeth or rims.) In order that there be no penetration (at least in dentulous patients), the centric interocclusal record must be obtained in an open relationship. Yet if the same arcs of closure were not used, our efforts would be useless.

A final point is this: *it is impossible to check a centric interocclusal record without an axis mounting.* During my training in prosthetics, countless hours were wasted while we attempted to check a centric interocclusal record on casts that were not axis-mounted. We were able to do this only when, *by accident,* we obtained the correct centric relation at the same time that we happened to have an interocclusal record of the exact thickness as the one which our instructor had. If the casts had been axis-mounted, our only concern would have been to get the correct centric relation. The thickness would not have mattered, and much time would have been saved.

TECHNIQUE FOR LOCATING THE HINGE AXIS

The location and transference of the hinge axis are not very difficult procedures, but they must be carried out with great care because they are the foundation for many other procedures.

A convenient type of face-bow is used. It must be rigidly attached to the mandible so that actually we have an extension of the mandible in the face-bow. The face-bow consists of a crossbar (Fig. 31) which is attached to the man-

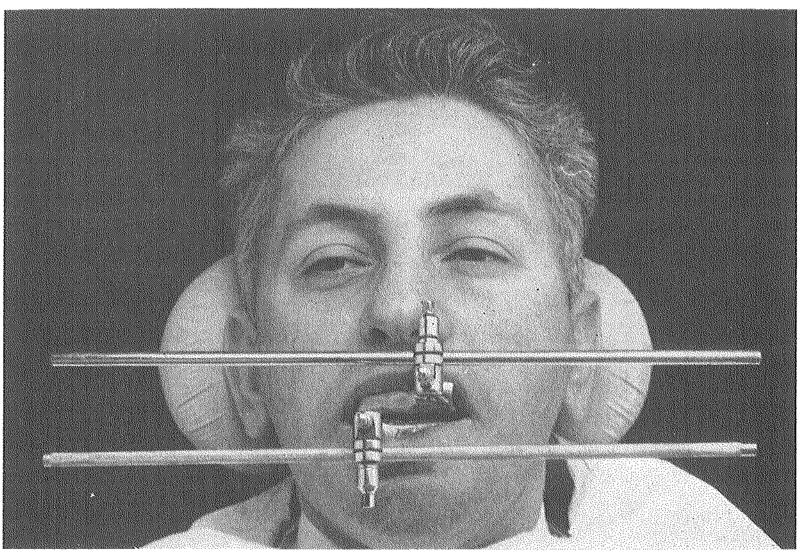

Fig. 31. Crossbars of the hinge-bow attached to clutches.

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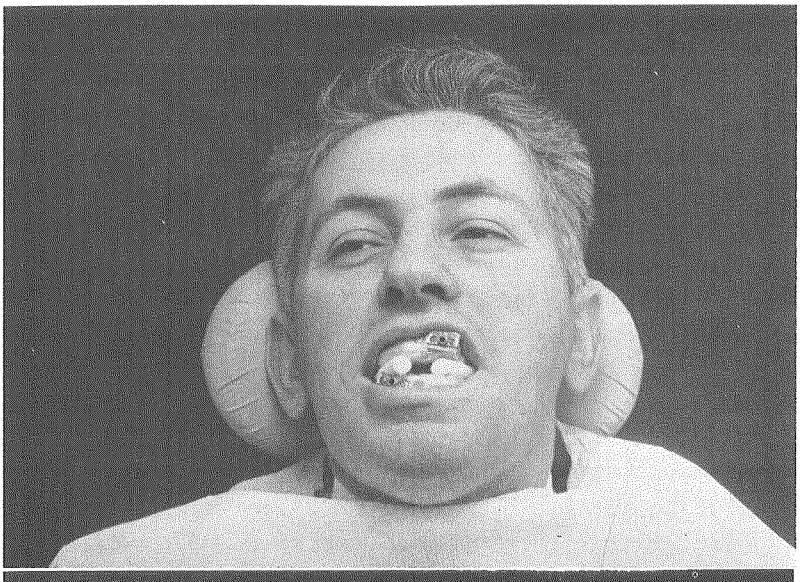

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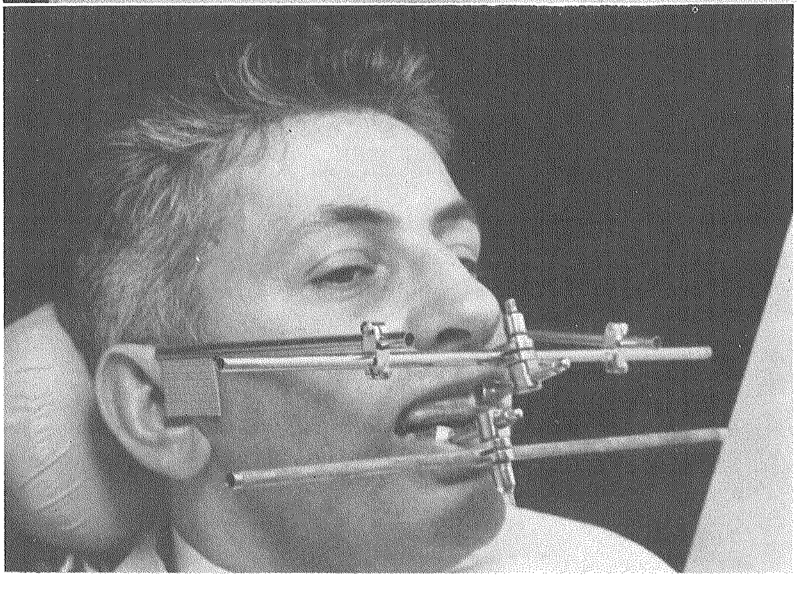

Fig. 32. Clutches cemented to patient's teeth.
Fig. 33. Graph-lined flags are attached to upper crossbar and to upper jaw. Flags are close to the skin.

dible by means of a clutch (Fig. 32). A graph-lined flag is placed on the side of the face over the condyle to eliminate any skin movement distraction (Fig. 33). These flags may be attached to the maxillae by means of a crossbar and a maxillary clutch. They may also be held in place by a head cap or other contrivance. Adjustable sidearms are placed on the crossbar with a stylus in the vicinity of the condyle (Fig. 34).

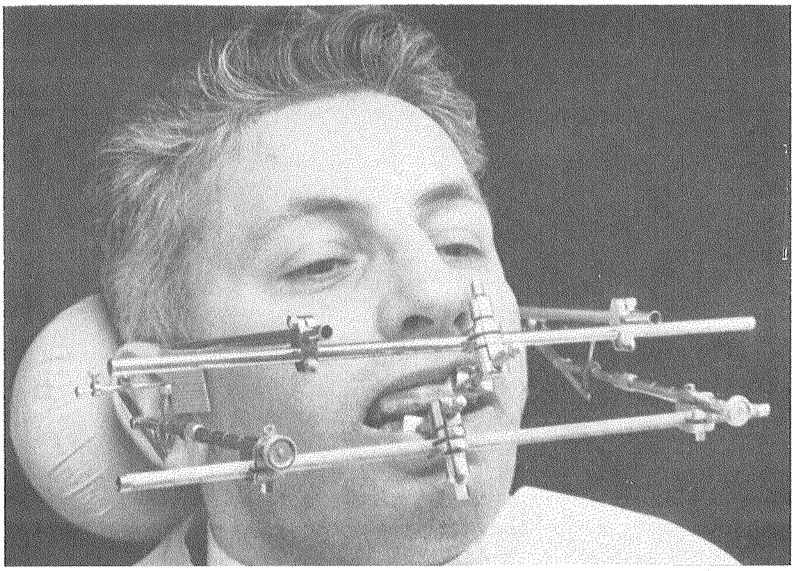

Fig. 34. Stylus arms attached by means of crossbar to lower jaw by the clutch.

Instruction of patient in hinge type of movement

The patient must now be instructed in the hinge type of movement (Fig. 35). As previously indicated, this is not a normal movement for the patient—it is for our convenience only. The patient must be coached to let his mouth drop open. This necessitates the relaxation of the external pterygoid muscles, and some patients may have difficulty in comprehending this movement. It helps sometimes to have the patient place his hand on our chin as we demonstrate the type of relaxed opening and closing that is desired.

Use of trainer. Dr. Raymond Cohen* has designed a "trainer," which is an improvement over the Hickok retruder. By means of this trainer (Fig. 36) the patient learns the rhythmic opening and closing that is essential for the location of the axis. The trainer is left on the patient for five to ten minutes and then removed. The patient seems to cooperate better after this training.

The trainer is also valuable if used just before the taking of a centric interocclusal record. Again it is placed on the patient for five to ten minutes, during which time the patient is instructed to open and close the mouth repeatedly. The trainer is then removed, and the centric interocclusal record is taken. The patient is instructed to keep his teeth separated until the centric record is taken in order to prevent the proprioceptive reflex from guiding the closure into the habitual relationship. After all, the objective is to record the true hinge closure in the terminal relation, not in the acquired position.

The patient naturally opens the jaw downward and forward—a combination

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*Dr. Raymond Cohen, New York, N. Y.

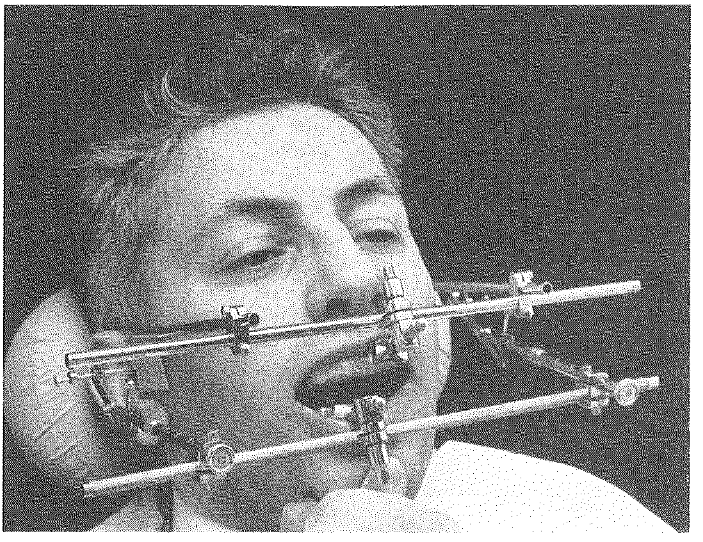


Fig. 35. Patient must be guided to execute a pure hinge movement.

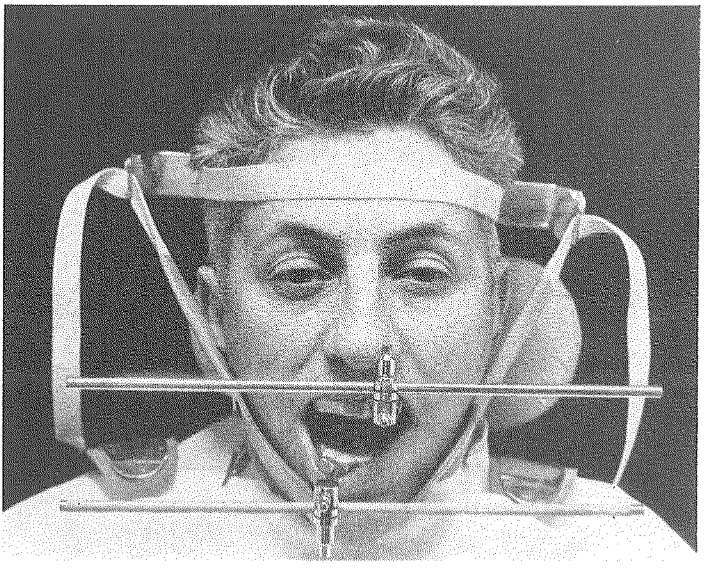


Fig. 36. The trainer on the patient.

of rotation and translation. The rotation must be separated from the translation so that the center of vertical opening can be located. In addition, this opening and closing must be accomplished in the most retruded position—the terminal hinge position—for here it is possible to get repeated concentric arcs which will permit location of their center. Any other arcs will serve only to confuse the issue at this point. What we actually have is a compass with bent rigid arms. The pivoting part of the compass is on the center of rotation in the patient's condyle.

The stylus point is the tracing part of the compass. If the operator succeeds in getting the tracing point exactly over the pivoting point, there will be no arcing of the tracing point (Figs. 37 and 38). Geometrically, if there were two concentric arcs and to the chords of these arcs were erected bisecting perpendiculars, they would intersect at the center of the arcs (Figs. 39 to 41). However, there

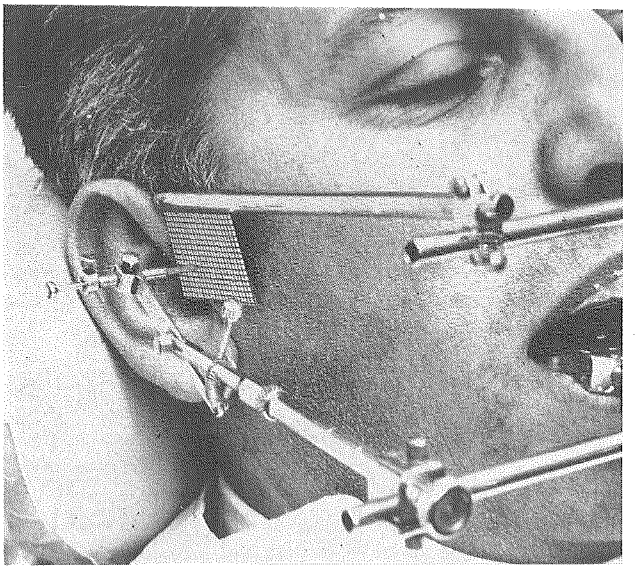


Fig. 37. Stylus stays on mark with jaw open.

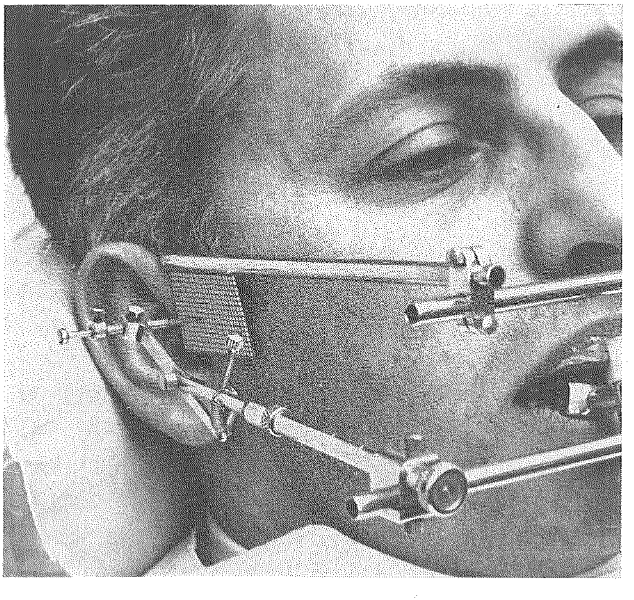
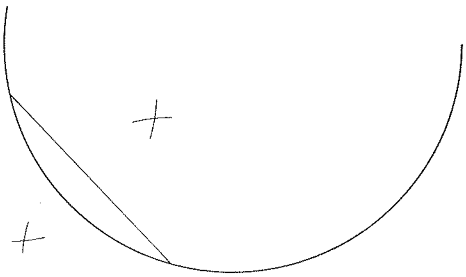
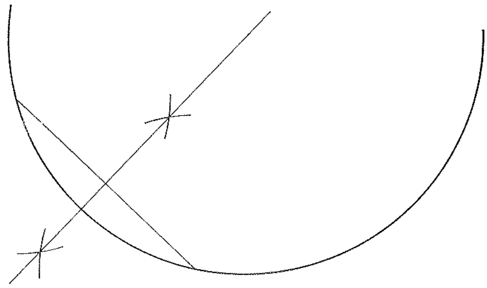


Fig. 38. Stylus on mark in closed position of jaw.

39   40

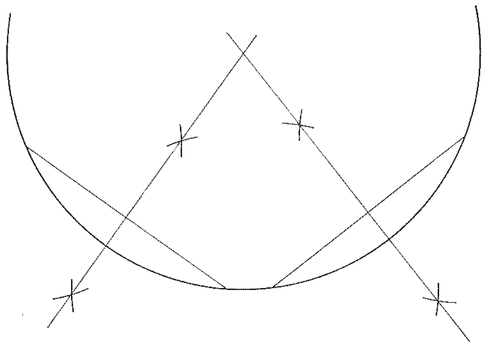


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Fig. 39. A bisecting perpendicular to a chord of an arc is determined by the intersection of the arcs made with the ends of the chord as centers and a radius greater than half the length of the chord.
Fig. 40. Bisecting perpendicular erected to a chord of an arc (circle).
Fig. 41. The intersection of two bisecting perpendiculars of two chords of the same arc (circle) locates the center of the arc (circle).

is no practical method for making such a plotting. The trial-and-error method first used by Dr. McCollum is still the only practical way to locate the axis.

When we succeed in getting the patient to execute a rhythmic opening and closing in the terminal position and the stylus *point* is arcing, we visualize where a center would have to be for scribing such an arc (Fig. 42). Thus we will have an idea of which way to move the stylus in order to reach the center. After an adjustment is made in this direction, another try is made. As the center is approached, the arcs will become smaller, and a little more opening will be required to magnify the arc. After several adjustments we will be close to the center. A magnifying glass should now be used to help see whether there is still any arcing of the stylus tip. The graph lines will aid the eye in determining this. By viewing down one line and then down the crossing line, it is possible to see whether there is any slight arcing. If there is, adjustment is continued until it disappears completely.

We must learn to distinguish between the pure hinge movement and the movement with some translation. Every patient inadvertently will make a trans-

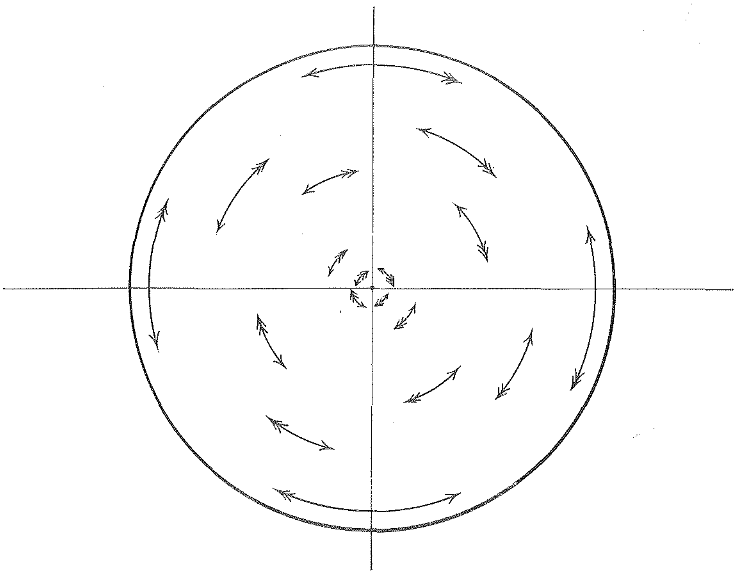


Fig. 42. The character of the movement of the stylus point of the hinge-bow indicates in which direction the stylus must be moved in order to find the center of rotation. The double arrowhead indicates the direction of movement of the stylus point on the opening stroke.

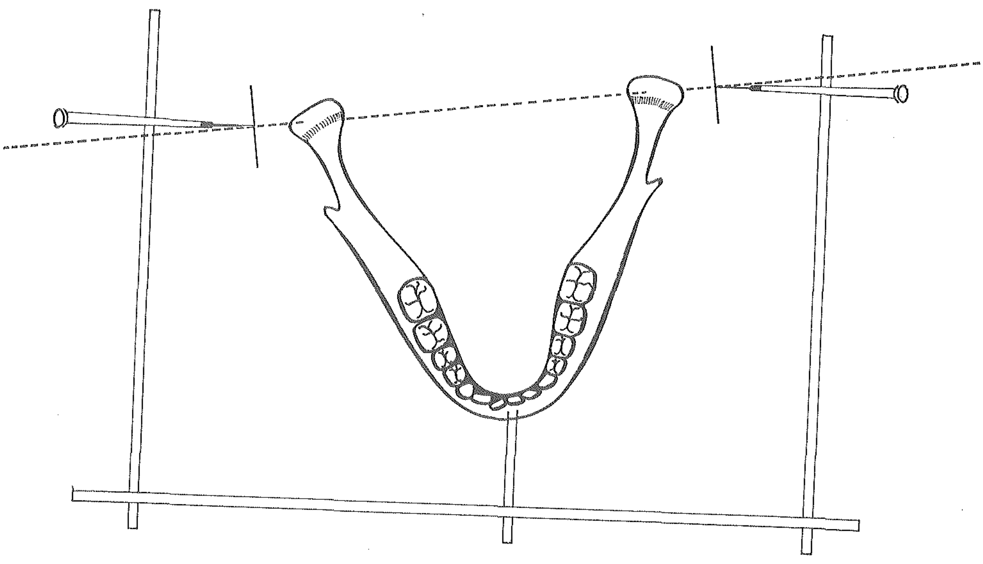


Fig. 43. Only the tip of the stylus of an adjustable hinge-bow is on the axis. The cards must be close to the skin to avoid error. When a transfer is made, the stylus pins cannot be moved in or out.

latory movement every third or fourth try. Some patients will be most cooperative. Others will be exasperating. Nevertheless, an axis must be achieved if the rest of the procedures are to be correct.

The axis center must be located on each side. What is being located is the hinge *action* on the side of the face. It is a point on the hinge axis and not the actual center of rotation (Fig. 43). Consequently, the location of this point must be made as close to the skin as possible. This means that the flag must be very close to the skin.

Marking the axis location on the patient

When the operator is satisfied that these points have been located on the axis, the flags are removed from the patient. A marking medium, such as an indelible pencil, is rubbed on the end of the stylus. Make sure the patient is in the terminal hinge position and then have him move his head out of the head rest, making sure that he does not also move out of the terminal hinge position. The stylus is gently pushed against his face to transfer the point to the skin (Fig. 44). These marks are made permanent by using a special needle and a little pink marking dye—sulfide of mercury.

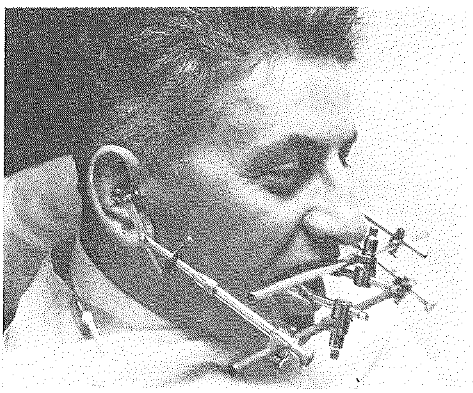


Fig. 44. Position of patient when axis location is marked on patient. Patient is in centric relation.

In all subsequent transfers we must try to simulate these conditions—the skin in the same relaxed position and the stylus pins locked the same distance from the face as they were before the flags were removed. This is usually one sixteenth of an inch from the skin. By so doing, any possible error in transference is reduced to an absolute minimum. In addition, the stylus pins must be locked and not moved until the mounting is completed. The articulator has to have an intercondylar axis that can be extended to these points so that the transfer is accurately lined up with the axis of the machine.

Selection of a face-bow

From a purely theoretical point of view, an ordinary face-bow such as a Snow or Hanau can be used to locate the hinge axis. To attempt to use either one of them in actual practice, however, is an impossibility. Just let one try to make micrometer adjustments from a universal joint on the front bar and see how far he will get. It is a bit more practical to use one of these bows as a transfer instrument, provided that the styli are perfectly lined up one to the other. As a matter of fact, if the styli are perfectly lined up and if the bow can be locked by means of the universal joint in front so that the points of the styli are on the axis locations, then it will not be necessary to have an articulator with an expansible intercondylar axis. Under these circumstances, it is possible to bring in the styli pins an equal degree toward the intercondylar axis of the articulator and still stay on the axis.

From practical experience, however, it is far easier and more accurate to use a fully adjustable face-bow (i.e., one with arms that can be independently adjusted by means of micrometer screws) for both axis locations and transfers.

By means of a face-bow transfer and the mounting frame (which will be described later), the upper cast can be properly mounted to the axis of the patient.

The procedure of relating the upper cast to the marks on the patient's face may be confusing. After locating the axis by means of an attachment to the lower jaw, why is the upper cast related to these marks?

HINGE AXIS AND PLANE OF REFERENCE

The hinge axis is constant to the mandible, as has been indicated. The terminal hinge position, which is actually centric relation, is constant to both the mandible and the maxillae. All our mountings are made in this relation. Therefore, the only practical way to maintain constant relationships throughout treatment is to use the axis points and a fixed third point at the base of the right orbit as the plane of reference. Thus, the axis orbital plane will give a constant position for the upper jaw, and a correct centric interocclusal record will establish the position of the lower jaw to the constant upper jaw. In this way repeated mountings will have a constant relation to the records and to the patient's centers of rotation.

DISCUSSION AND CONCLUSION

Many have attempted to find fault with the hinge axis and to disprove it. Their criticisms cover such things as skin mobility, change of the axis, the introduction of errors by moving the stylus tip a slight degree, the presence of a separate axis for each condyle, etc.

Skin mobility

Actually, skin mobility is reduced to a minimum by the precaution of having the patient move his head out of the head rest when all references are made to the marks. Any changes that might occur over the years from loss of weight and the like would be minor.

Change in axis

As far as change in the axis is concerned, the only changes I have observed have been in the joints with pathologic conditions. There, the change is usually slight, and we always plan to relocate the axis on such patients a year or two after the condition has cleared up.

Why use the hinge axis in these patients?

The answer is simple. It is still the only means of establishing a starting point to which one can repeatedly return and to which one can definitely relate the work as it progresses.

In every patient with normal joints whom we have rechecked over the years for demonstration purposes and to satisfy our own curiosity, we have always been able to relocate the axis within very acceptable limits, namely, the thickness of the tattoo mark.

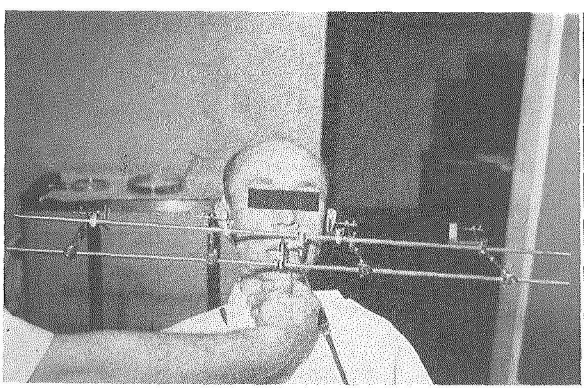
Possibility of error due to movement

The most ridiculous criticism is the charge that error is introduced because the stylus pin has to be moved through the thickness of the card covering the face. Would that all our worries were of this magnitude!

Single transverse axis

The allegation that there is a separate axis for each condyle is mumbo-jumbo. The anatomy and physiology of the joints I have studied would not permit a two-axis arrangement.

About 1950, Dr. William Branstad, Dr. Raymond Garvey, and the late Dr. Robert Okey conducted an experiment to determine whether there was one transverse axis through both condyles or an axis for each condyle. They found that there was one transverse axis.

45 

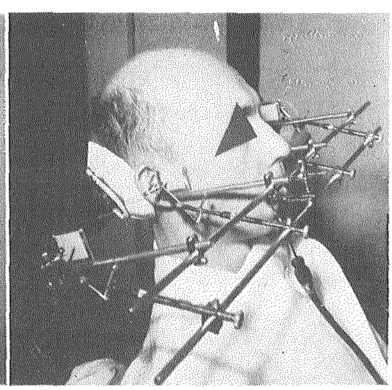
 46

Fig. 45. Rigid clutches used to attach 36-inch crossbars to patient's teeth.
Fig. 46. Graph-lined flags attached to upper bar; adjustable styli attached to lower bar; axis center located in four areas.

Dr. Arne Lauritzen, working with a study group, repeated the same experiment about 1957 and arrived at the same finding.

Dr. Frank Celenza and I repeated the experiment during the summer of 1959, with the same result.

In the fall of 1959, the Hinge Axis Committee of the Greater New York Academy of Prosthodontics repeated this experiment and concluded that there was only one transverse axis through both condyles.

This, in brief, was the experiment. Clutches were cemented to the patient's teeth. A crossbar 36 inches long was attached to the upper clutch, and another of the same length was attached to the lower clutch (Fig. 45).

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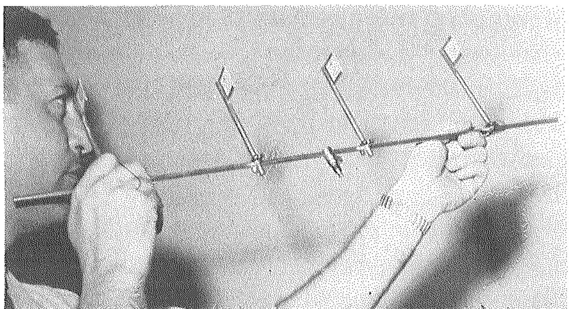

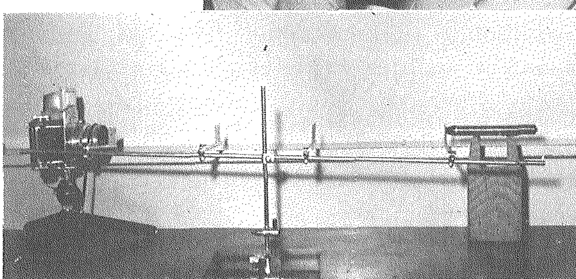

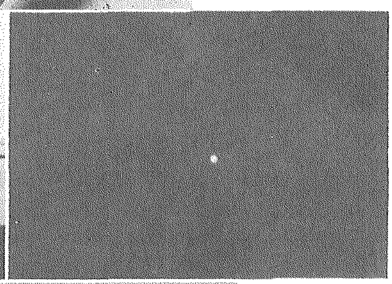

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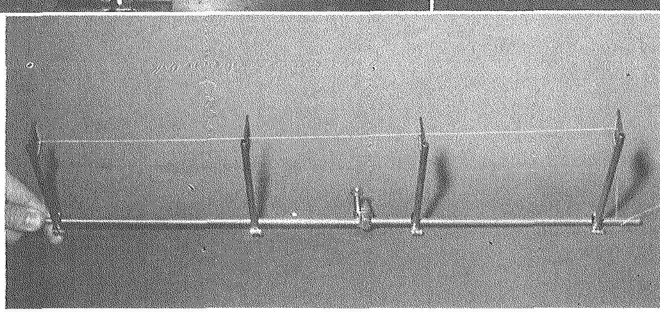

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Fig. 47. Light rays are visible through all four pinholes made where centers were located.
Fig. 48. Camera set up with pen light as the source of light at far end of flags.
Fig. 49. Light recorded on film plate proving a single transverse axis.
Fig. 50. Dental floss threaded through four pinholes makes a straight line when pulled taut.

Four graph-lined flags were attached to the upper bar for the purpose of accurately locating the center of rotation. One flag was placed on each side of the face, close to the skin. The other two were attached near the ends of the upper bar, about 12 inches from the flags against the face.

To the lower bar were attached four adjustable sidearms, to be used in locating the center of rotation. As in Fig. 46, each sidearm was placed against a flag.

The center of rotation was located in each of the four areas, i.e., each sidearm was adjusted against its corresponding flag until there no longer was any arcing but only rotation of the stylus point. When all four centers of rotation had been accurately located and the patient held in centric relation (terminal hinge position), the cards on the flags were carefully marked with the tips of the styli.

The upper bar with flags attached was then removed from the clutch. With a fine, heated instrument a tiny hole was burned through each card where it had been marked. When the four flags were held up to the light, it was possible to see the light through all four flag holes (Fig. 47), thus proving that the four points had to be on a straight line. Thus, it was concluded that there was only one transverse axis.

To demonstrate this more emphatically, we set up the bar and flags as in Fig. 48 and with a small pen light passed rays of light through the four holes. The camera at the other end of the four flags recorded the light rays coming through the four pinholes (Fig. 49). In addition, a piece of dental floss was threaded through the holes. When pulled taut, it was perfectly straight (Fig. 50). This was conclusive proof of the existence of only one transverse hinge axis.

Reference

1. McCollum, B. B.: A Research Report. Part 1, Fundamentals Involved in Prescribing Restorative Dental Remedies. Reprinted in 1941 from Dental Items of Interest, June, July, Aug. Sept., Oct., Nov., and Dec., 1939, and Jan., and Feb., 1940.

CHAPTER 4

The construction of clutches

DEFINITION AND PURPOSE

Clutches are appliances which secure the writing apparatus to the patient's jaw. They are of extreme importance and should be made with great care. Their design and construction can spell the success or failure of extraoral tracings.

For some reason, the making of clutches seems to be a major stumbling block to many men when they first attempt this work. It is true that certain procedures not related to dentistry are involved, but they are not so complicated that they cannot be mastered quickly by any dentist or technician.

The purpose of a clutch is to enable the equipment to be attached rigidly to the patient's jaws for the purpose of recording the mandibular movements. The attachment must be so rigid that any possibility of movement between the apparatus and the jaw bone is absolutely eliminated.

Clutches are not stock appliances. They must be individually constructed for each patient. Edentulous patients require additional attention, which will be described separately.

Study casts should be mounted on an articulator by means of an approximate face-bow mounting and a good centric interocclusal record. Unless the casts are properly mounted, the clutches will not be correctly related to each other and to the patient. This will cause serious problems when registrations are secured.

The procedures which follow may appear to be unnecessarily complicated, and there may be a temptation to take short cuts. To do so, however, could be disastrous, for experience has demonstrated that these steps are absolutely essential.

PREPARATION OF THE CASTS

Upper cast

A strip of Tenax* baseplate wax is adapted and luted to the labial and lingual surfaces of the teeth. The strip extends from the occlusal surfaces to the mucobuccal fold labially. Lingually, the wax strip extends from the occlusal surfaces to the gingival crests and covers the entire palate (Fig. 51). All edentulous

*S. S. White Dental Manufacturing Co., Philadelphia, Pa.

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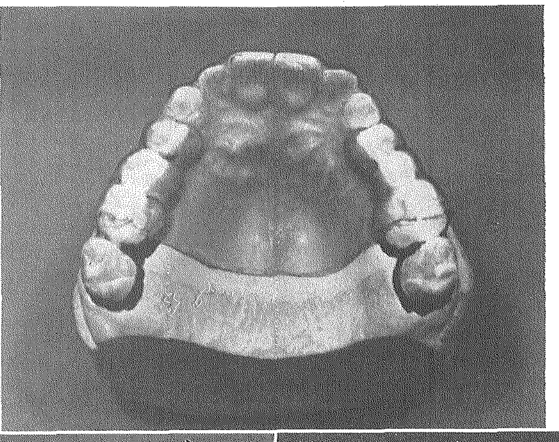

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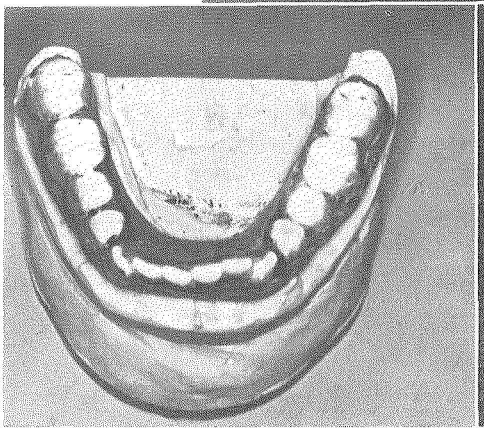

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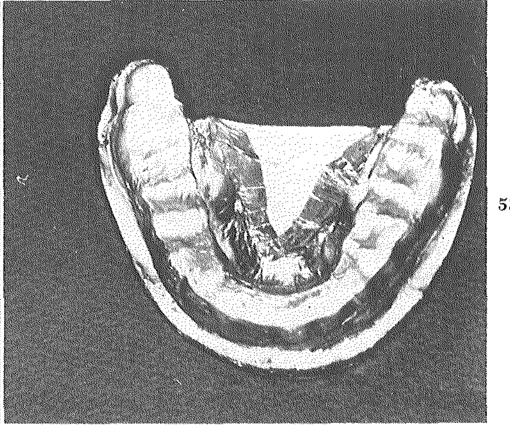


Fig. 51. Wax relief on upper cast. Note edentulous areas filled in with wax.
Fig. 52. Wax relief on buccal and lingual surfaces of teeth on lower cast.
Fig. 53. Lower cast with wax relief covered with 1/1,000-inch tin foil.

spaces are blocked in with a roll of wax so that the filled-in space is continuous with the adjacent teeth. A layer of 1/1,000 inch of tin foil is adapted over the entire cast, covering the occlusal surfaces, palate, and labial structures beyond the mucobuccal fold.

Lower cast

Strips of Tenax baseplate wax are adapted to the buccal and lingual surfaces of the teeth. On the buccal surface, the strip extends to the mucobuccal fold. On the lingual surface, the strip extends slightly beyond the gingival crests (Fig. 52). Over the entire cast a layer of 1/1,000 inch of tin foil is adapted (Fig. 53). The occlusal, labial, and lingual surfaces are all covered with tin foil. A thin layer of petrolatum is applied over the tin foil on both upper and lower casts.

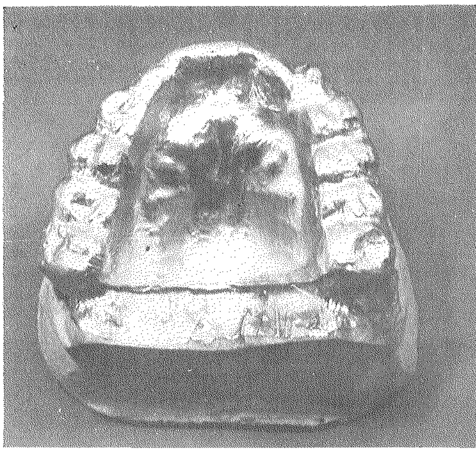
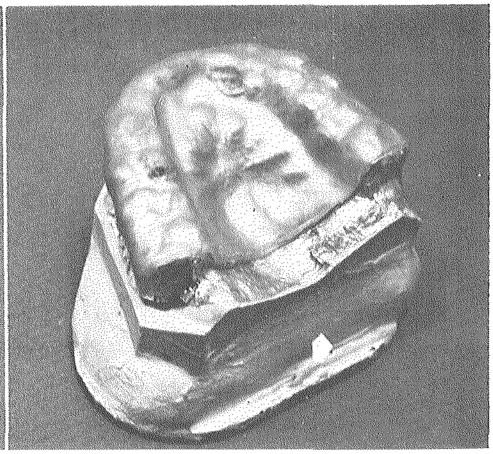
54   55

Fig. 54. Tin foil over wax relief on upper cast.
Fig. 55. Wax adapted over lubricated tin foil on upper cast to begin clutch pattern.

WAXING UP THE CLUTCH PATTERNS

Upper cast

Tin foil is adapted over the relief wax on the upper cast (Fig. 54). Over the lubricated tin foil covering the wax relief a layer of Tenax is loosely adapted. Care must be taken not to thin out the wax as it is adapted over the palatal area. If necessary, the wax can be cut in the middle of the palate and joined to a piece from the other side, being sure that the ends are luted together thoroughly and smoothly.

Wax adaptation. The wax pattern is carried just short of the mucobuccal fold labially, care being taken to keep it short of any muscle attachments. Posteriorly, it is carried to the molar area, usually distal of the first molar. (If the first molar is missing, we carry it to the second molar.) The posterior border is continued from one side of the arch to the other, similar to a full denture outline (Fig. 55).

Placement of wax blocks. The wax pattern is then chilled and removed and trimmed with a warm spatula until the desired outline is achieved. Following this, it is replaced on the cast and carefully readapted. On both sides, labially in the molar area (or on the side of the last tooth included in the clutch pattern), a Tenax wax block ½-inch square and ¼-inch wide is placed and luted to the wax pattern with a warm spatula (Fig. 56).* Since these blocks of wax

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*This wax block is the area where the clutch will later be separated into halves. We must always be sure to have the separation block in the middle of the last tooth included in the clutch; otherwise the cement will lock the body portion of the clutch too securely, and there may be considerable difficulty in removing it. If the separation is made through the middle of the last included tooth, the labial portion of the clutch will then unlock the cement and facilitate the removal of the body of the clutch.

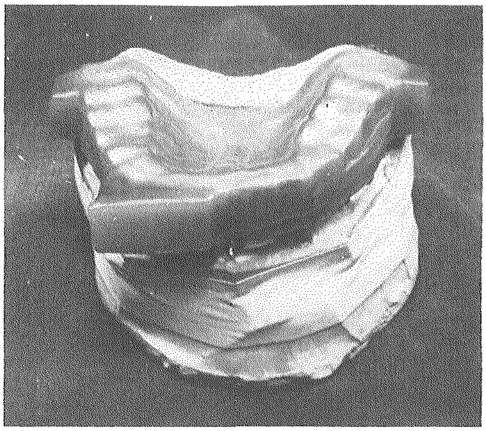

Fig. 56. Wax pattern of upper clutch with blocks added on distobuccal surfaces and anteriorly. Note reinforcing rib on side of clutch pattern.

are the areas into which the screws will later be placed, they must be of sufficient thickness to permit drilling and tapping for a 2/56 screw. The posterior portion of the wax block is tapered to blend with the wax pattern so that the finished clutch will be comfortable for the patient.

In the anterior region on the labial surface of the wax pattern, another wax block is placed to accommodate the attachment of the stud (Fig. 56). On the upper pattern this is usually placed to the left of the patient's midline. The exact spacing of this block which will carry the stud depends upon the particular type of writing apparatus used. For the McCollum gnathograph a spacing instrument is available which gives adequate clearance for the apparatus (Fig. 57). A spacing instrument is also available for the Stuart instrument (Fig. 58). Actually, the spacing is the same for McCollum's and Stuart's writing apparatuses. With Granger's apparatus the studs have to be placed farther apart laterally and closer vertically than with McCollum's instrument. The space required for the extraoral bearing pin and plate is the reason for this (Fig. 59). In all of these instruments the studs must be parallel to each other and at right angles to the hinge axis in both the vertical and horizontal planes.

To add rigidity to the finished clutch, a strip of Tenax wax ⅛-inch square is luted to the labial surface of the wax pattern between the posterior wax block and the stud wax block (Fig. 60).

Consideration of bearing device. If an intraoral bearing device is to be used, then a piece of 14-gauge brass or nickel silver must be cut out and placed in the middle of the palate, extending to the lingual of the anterior portion of the wax pattern. This is waxed to place so that it will be held in the aluminum after the pattern is cast (Fig. 60).

If the patient has a very deep vertical overlap, the bearing plate of the upper cast may be made concave by a gradual bend in the middle. Also, the

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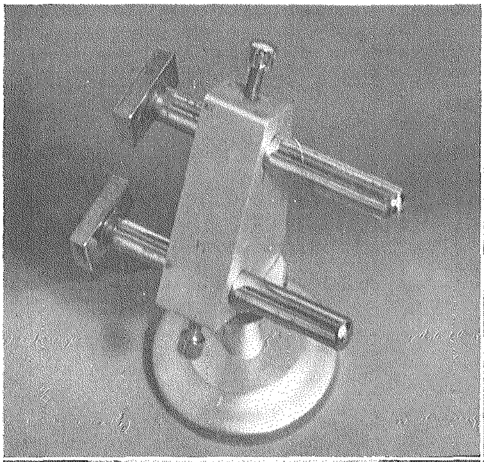
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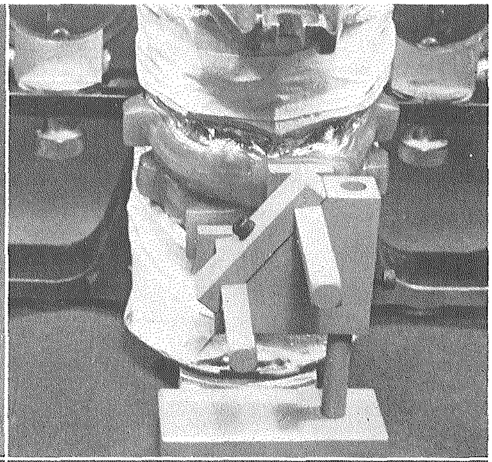
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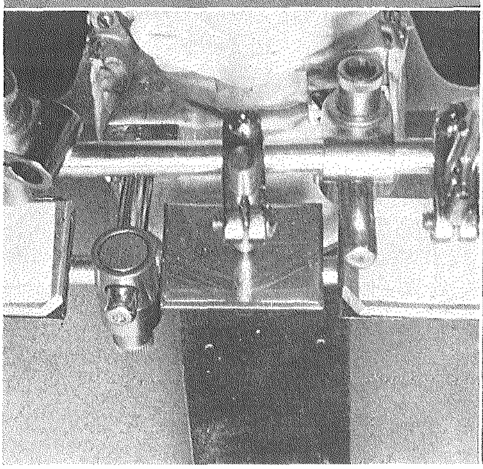
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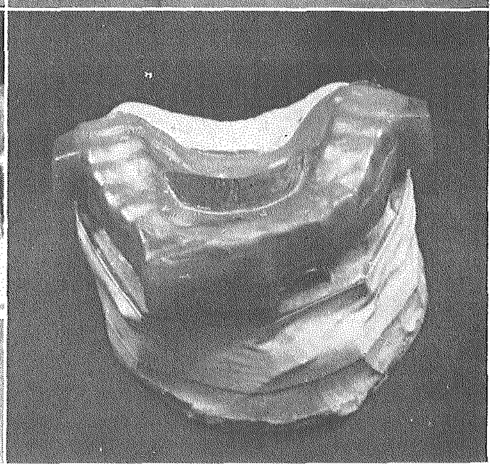

Fig. 57. Stud spacer for McCollum gnathograph.
Fig. 58. Stuart's stud spacer used to position studs properly to clutch wax patterns.
Fig. 59. Granger's external bearing pin and plate require greater lateral space between studs.
Fig. 60. Bearing plate waxed to place in center of upper clutch wax pattern.

anteroposterior inclination may be arranged to give adequate clearance of the anterior teeth without excessive separation of the teeth in the centric relation.

When an extraoral bearing device is used, this plate is eliminated altogether.

Lower cast

Wax adaptation. The lower wax pattern is similarly waxed up. A layer of Tenax is adapted over the foil covering the teeth and carried just short of the mucobuccal fold labially. Lingually, it is carried to just beyond the gingival crest (Fig. 61). Posteriorly, the lower wax pattern is terminated in the molar area (the first molars, if present; otherwise the second molars). If the area distal to the bicuspids is edentulous, a short saddle area is advisable to ensure stability of the clutch during the registrations.

Placement of wax blocks. Wax blocks are attached labially in each molar area and tapered posteriorly to blend with the distal edge of the clutch (Fig. 62). The anterior wax block is positioned to carry the stud (usually to the right of the patient's midline), the exact position depending upon the particular writing apparatus to be used (Fig. 63). The lower stud block is related to the upper stud block in a very exact manner to facilitate the positioning of the apparatus on the patient. The wax blocks for the studs must so be placed that the studs can be positioned parallel to each other. The im-

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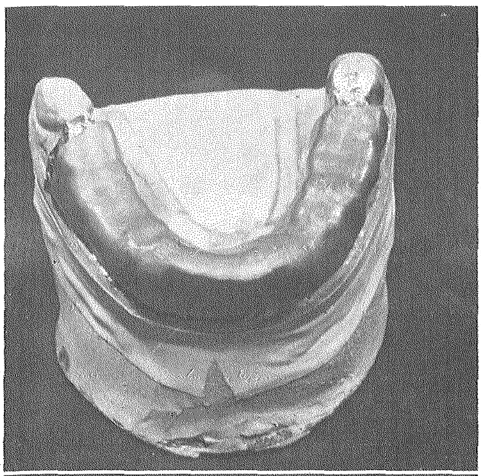
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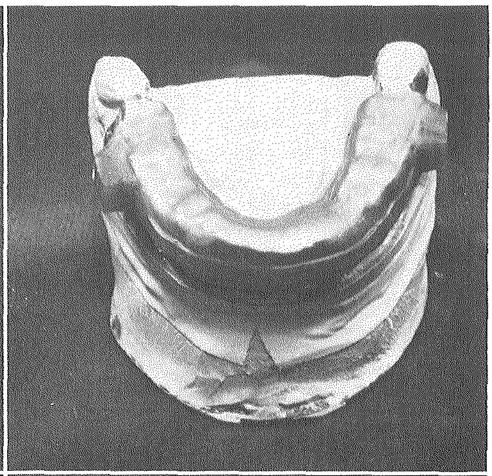
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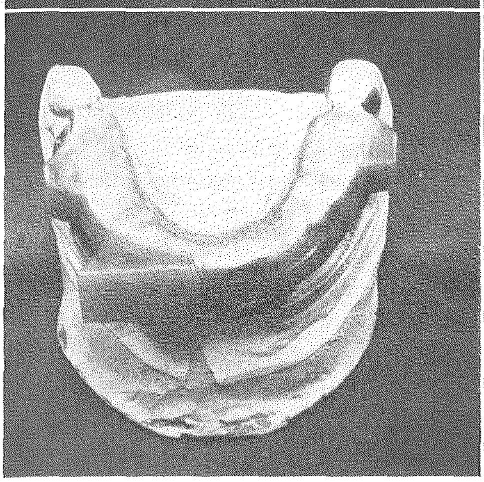
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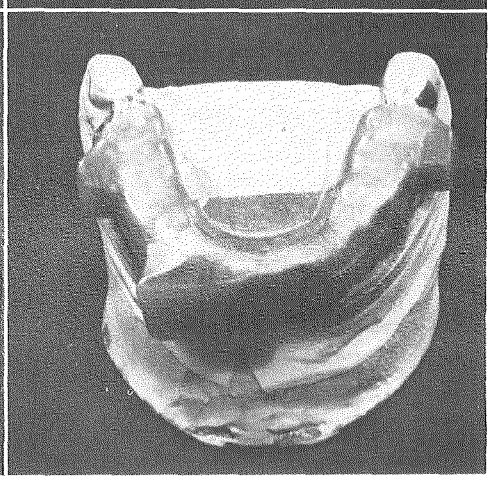


Fig. 61. Wax adapted to lubricated tin foil on lower cast to begin lower clutch pattern.
Fig. 62. Wax blocks added to wax pattern being developed for lower clutch. Note reinforcement strip on side of pattern.
Fig. 63. Labial block of wax added for stud attachment.
Fig. 64. Plate of 14-gauge brass or nickel silver waxed to place. This plate will be drilled and tapped for bearing screw.

portance of this will become evident when the locked writing apparatus is removed from the patient.

The lower wax pattern is reinforced with a ⅛-inch square strip of Tenax wax around the labial area—between the posterior and anterior wax blocks (Fig. 63).

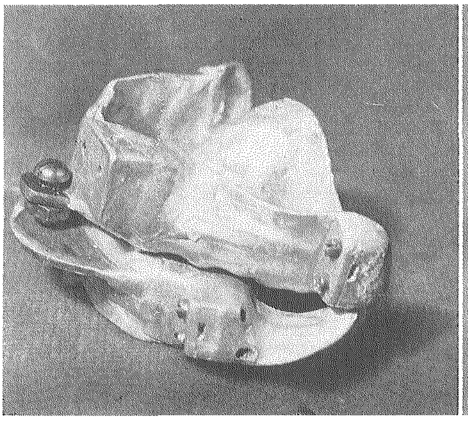
Consideration of bearing device. If an intraoral bearing device is to be used, it is then necessary to place a piece of 14-gauge brass or nickel silver in the lingual anterior area of the clutch pattern so that it will be engaged in the aluminum when the pattern is cast. This is horseshoe-shaped to prevent it from impinging too much upon the tongue (Fig. 64).

If an extraoral bearing device is used, there is no need for a plate in the lower clutch.

The use of Granger's external bearing plate and pin attached to the writing apparatus is obviously advantageous. It makes it easier for the patient to keep the condyles from dropping down into physiological rest position during the extraoral tracing registrations. It also makes it much easier to move the articulator for adjustment to the writings.

However, there are also some complications and disadvantages. These are encountered if there are insufficient teeth to retain the clutches. Frequently the clutches will be loosened before completion of the writing. Of even greater consequence is the ability of the patient to strain the apparatus while it is being locked together.

In order to take advantage of the benefits of the extraoral bearing arrangement and still eliminate the disadvantages, we decided to attach the bearing apparatus directly to the clutches, but in the labial areas instead of in the lingual areas as we had done for many years (Figs. 65 and 66). This solved

65 

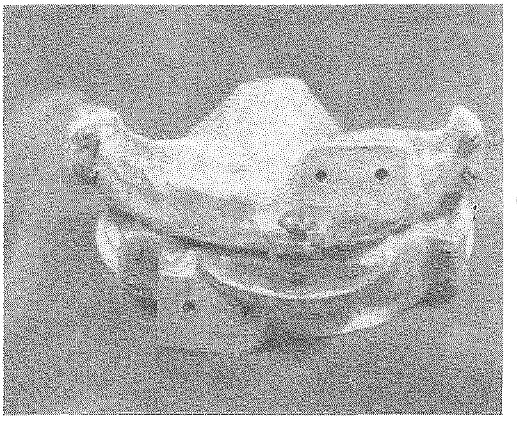
 66

Fig. 65. Side view of clutches with the newer external bearing arrangement attached directly to clutches.
Fig. 66. Front view showing relation of screw on upper clutch to plate on lower clutch in the newer external bearing arrangement.

the problem very satisfactorily. It is more convenient to place the bearing plate on the lower clutch labially and just above the stud block. This plate can be bent in the middle to allow lateral clearance of the teeth without excessive opening in the centric relation. The plate can be positioned (tilted from anterior to posterior) so that it clears the teeth in protrusive movement, again with a minimum of opening.

The bearing pin is attached to the upper clutch labially and above the stud block, where it can conveniently be adjusted if necessary, after the clutches are cemented to place. This arrangement simulates the anterior guide of an articulator and has a similar function.

We have found that this method realizes all the advantages of an extraoral bearing arrangement without any of the disadvantages.

SPRUING, INVESTING, AND CASTING OF CLUTCH PATTERNS

Having decided on the type of bearing method to be used, we are now ready to sprue the clutch patterns for investing and casting. The type of spruing will depend upon the casting machine to be used. If it is to be a centrifugal end-over-end machine, the patterns are best sprued from the back end (Figs. 67 and 68). Flat sprues made of three layers of Tenax baseplate wax are attached to each side of the pattern, joined together, and made into a sprue former. An oval ring 4 inches in diameter is suitable for this type of spruing and investing (Fig. 69). A mix of any kind of casting investment is made, and the ring

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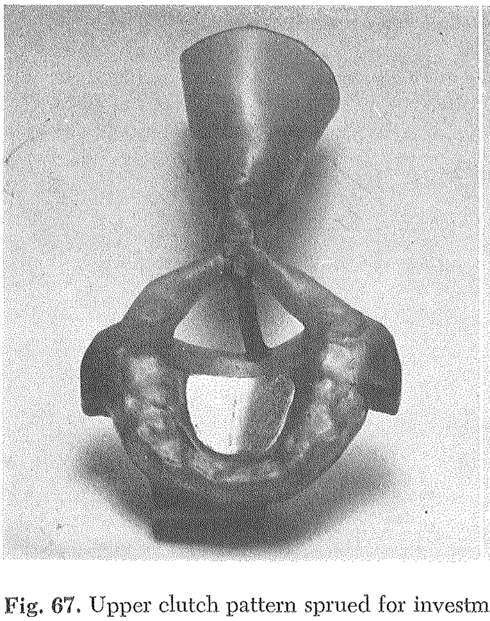

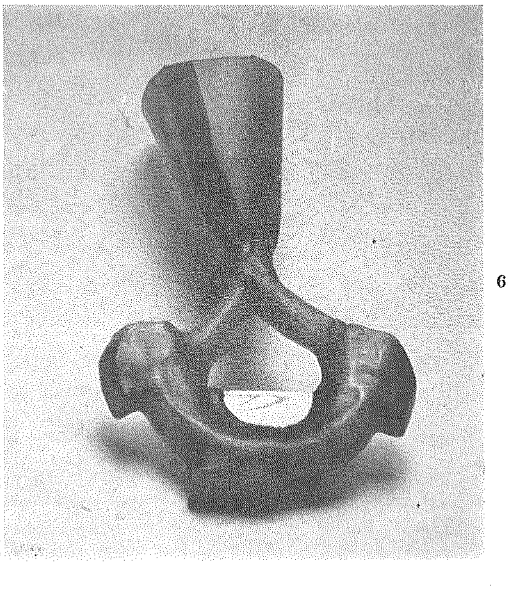
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Fig. 67. Upper clutch pattern sprued for investment.
Fig. 68. Lower clutch pattern sprued for investment.

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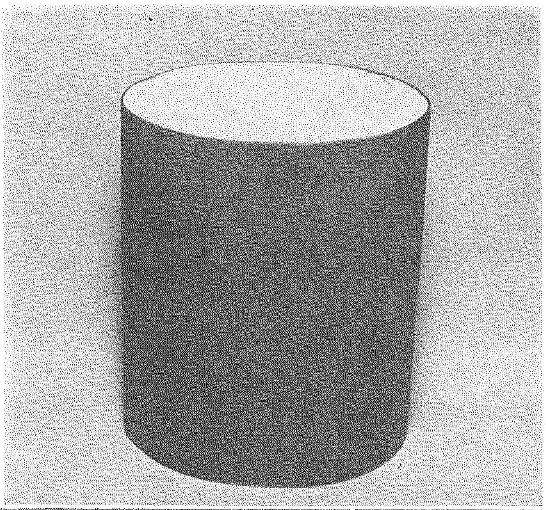

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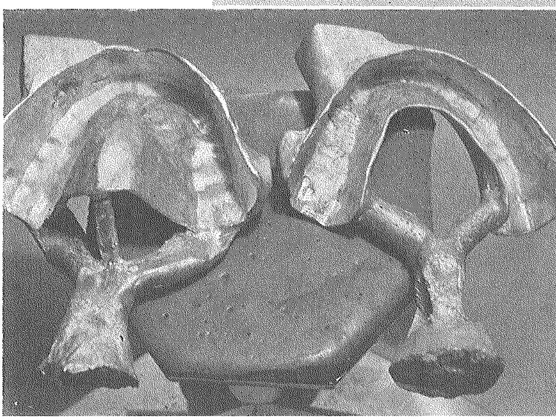

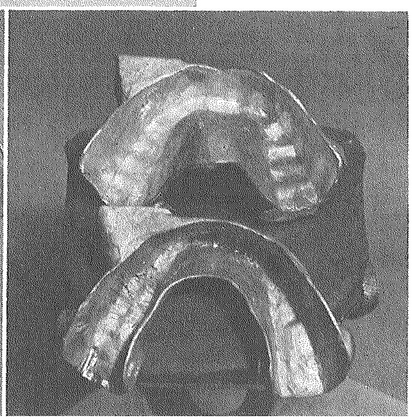

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Fig. 69. Oval flask used for investment of clutch patterns when latter are sprued from posterior segments.
Fig. 70. Aluminum clutches as they are removed from investment after casting.
Fig. 71. Cast clutches with sprues removed.

is filled up. The wax pattern is then painted with investment and inserted into the ring investment. These are not precision castings. They are to be loose-fitting castings which will be cemented over the teeth.

The wax pattern is now eliminated. This can be partially accomplished with boiling water and with the sprue holes facing up. After the bulk of the wax is thus removed, the flasks are transferred to a burnout oven for complete elimination of the wax residue. The flasks must be burned out just as they would be for a gold casting. After the pattern and residue have been thoroughly eliminated, the flasks are permitted to cool to *room temperature.* Then the aluminum is melted and cast into the mold and allowed to bench cool before being quenched.

The castings are now cleaned (Fig. 70); the sprues are removed with a carborundum disc or gold saw; and the castings are ready to be machined to the final condition. They are smoothed, if necessary, with heatless stones, and the sprue ends are removed (Fig. 71).

MACHINING THE CLUTCHES

The thickened portions (wax blocks) are the areas where the castings are separated. The purpose of the separation is to facilitate the removal of the clutches after the registrations are completed. Prior to cutting through the blocks, however, we must drill and tap them so that the two parts can be held together during the procedure.

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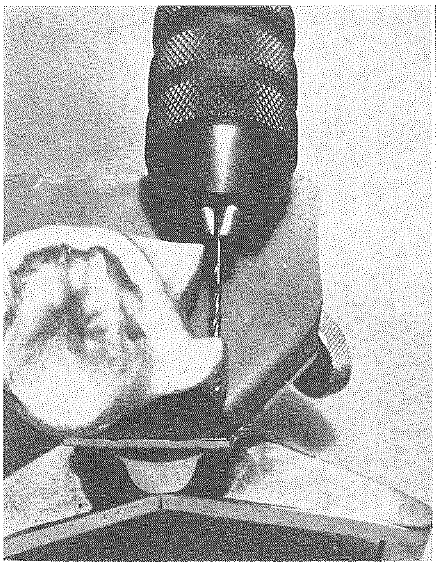
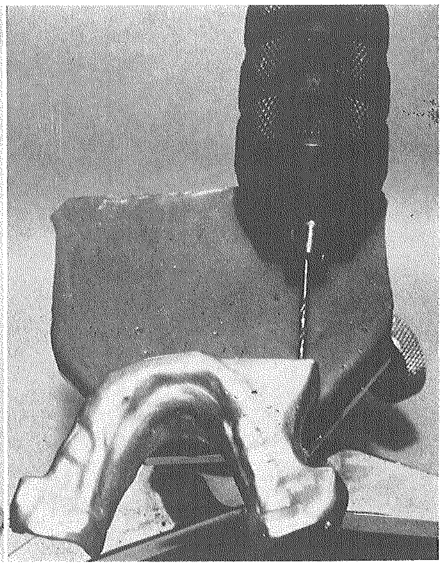
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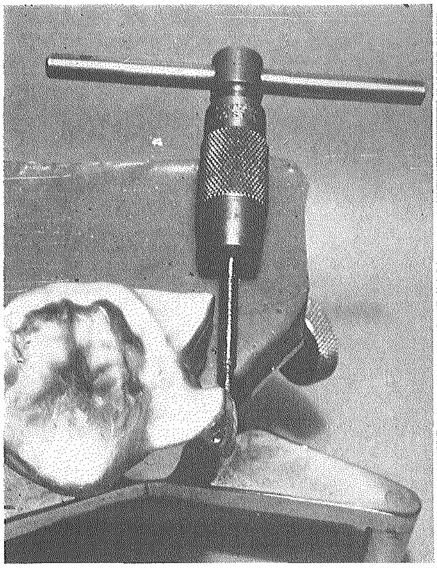
Fig. 72. Drilling holes in separation blocks.
Fig. 73. Drilling holes in stud blocks.

Drilling and tapping procedure

A No. 49 airplane type of drill is used either in a small drill press or in a Jacobs chuck* on a lathe. Two holes (one above the other) are drilled into each block (Fig. 72). Two holes are also drilled into the stud block (Fig. 73). The latter holes must be accurately positioned so that the stud plate can be securely fastened to the aluminum stud block. After all the holes are drilled, a 2/56 tap and hand wrench are used to tap the holes for screws (Figs. 74 and 75). Turpentine is an excellent lubricant for aluminum tapping.

*Jacobs Mfg. Co., Hartford, Conn.

74 

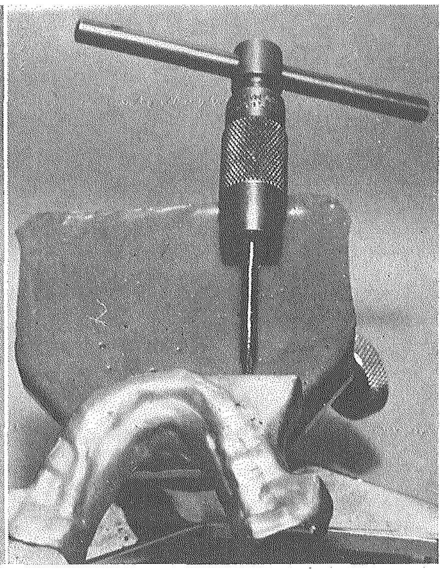
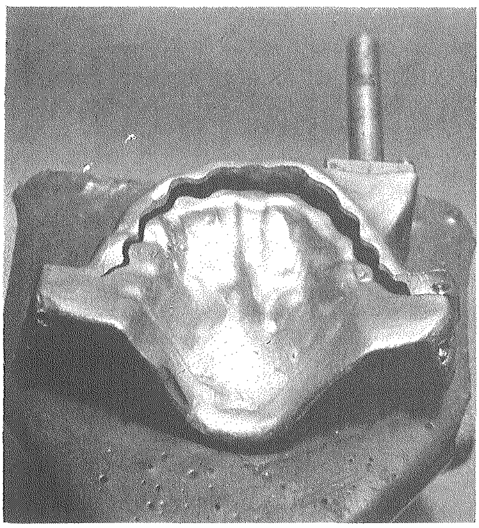
 75

Fig. 74. Tapping holes in separation blocks.
Fig. 75. Tapping holes in stud blocks.

Separation of clutch

After all the holes are drilled and tapped, the clutch is separated into its two halves (Figs. 76 and 77). This is accomplished with a gold saw. The stud is at-

76 

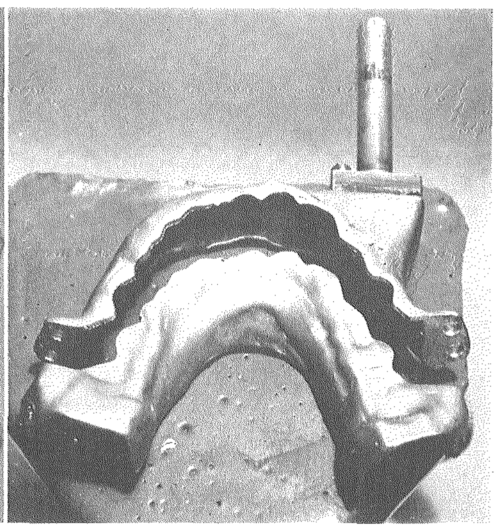
 77

Fig. 76. Clutch after labial portion has been separated from body. Note stud in place to facilitate handling during separation. Note, also, that this clutch is for external bearing arrangement and has no plate in vault.
Fig. 77. Lower clutch separated into two parts. Note stud in place to facilitate handling during separation. This clutch is for external bearing arrangement because it has no intraoral plate.

tached to the stud block, the stud being used as a handle while the casting is cut. The stud may be placed in the Jacobs chuck of the lathe and used as a bench vise while this is being done. With a thin saw blade, we cut through the blocks and continue the cut through the occlusal surface in a zigzag manner until it joins the cut through the block on the other side. This will separate the clutch into two parts.

Assembly of clutch halves

With a crosscut fissure bur, the threads are removed from the blocks of the labial portion of the clutch. This will facilitate the assembly of the clutch halves. With this bur, a slight groove is made on the blocks of the body portion of the clutch (Fig. 78). This groove will permit the insertion of a small screw driver to help pry apart the two halves of the clutch when they are removed from the mouth. These details are very important!

The clutch halves are now reassembled, the screws are placed in position, and the clutches are examined for any sharp areas that might be uncomfortable for the patient.

If an internal bearing device is being used, the spot on the lower plate

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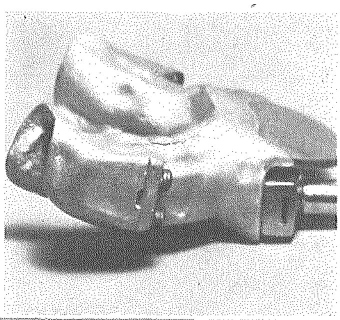

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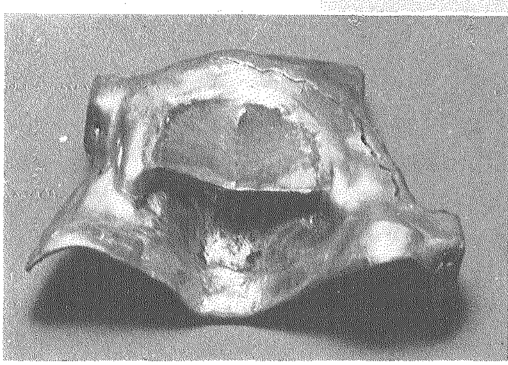

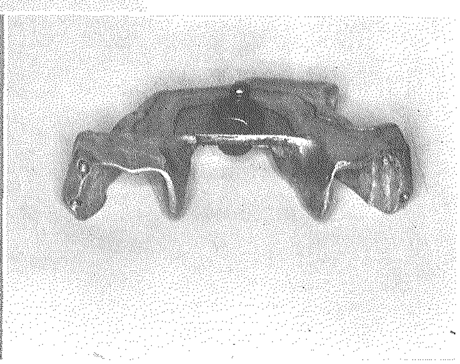

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Fig. 78. Groove in separation block permits insertion of small screw driver to pry apart clutch section.
Fig. 79. Completed upper clutch with central bearing plate.
Fig. 80. Completed lower clutch with central bearing point.

that is to be drilled and tapped for a 6/32 screw is located. (The tip of the screw should be rounded over if it is to be used as a bearing point.) The location must be carefully made. The assembled clutches are placed on the models on the articulator, and the hole is located so that the bearing screw will fall in the middle of the upper plate (from side to side) and as far forward as the lower anterior teeth will permit.

The clutches are now ready for the patient (Figs. 79 and 80).

CHAPTER 5

Registrations

Since the practice of dentistry began, men have attempted to conveniently relate casts of the upper and lower jaws. From the early emphasis on convenience to the more recent emphasis on extreme accuracy, there have been many variations in equipment and procedure.

PROBLEM OF DUPLICATING JAW MOVEMENTS

Early efforts were concerned with a simple method of bringing the upper and lower teeth together—occlusal contact, the end result. Unfortunately, this is as far as probably 95 per cent of the dentistry goes today. There have been many attempts over the years to better simulate the actual movements of the jaws so that a more accurate correlation could be made of the various parts of the masticating mechanism. Because for a long time the efforts along these lines were not successful, men who were trying to do better dentistry spent many hours attempting to accomplish this by working directly in the mouth. Obviously, this was very difficult and frustrating, and the ideal end result was never attained.

The basic fundamentals of jaw movements were not fully understood. Attempts to duplicate jaw movements fell short of the expected results, and men would go back to the old methods of trying to adjust restorations in the mouth. The fact that there are over 750 patents on articulators in the patent office in Washington is impressive evidence of this lack of understanding! Although considerable progress was made as a result of all these instruments, not more than half a dozen came close to actually duplicating the jaw movements.

Obviously, if any extensive restorations are to be constructed and if these restorations are to function harmoniously in the patient's mouth, they should be made on an instrument which accurately reproduces the patient's jaw movements. It would in fact be desirable to have the patient's head on the laboratory bench!

SPECIFICATIONS FOR AN ARTICULATOR

Chapter 2 indirectly lays out the specifications for an articulator. The first requisite is an opening and closing axis so located that casts of the mouth can conveniently be placed the corresponding distance from the axis. Adjustable centers of rotation are the next requisite in order that the articulator can be adjusted for all patients. There must also be some means of reproducing the inclination and curvature of the articular eminence.

In addition, a means of limiting the amount of side shift (Bennett movement) must be provided. This must be accurately adjustable and replaceable so that a new part can be carved for each patient.

The most important specification, without which fidelity of movement reproductions cannot be obtained, is the split axis. This enables the side shift to be duplicated exactly as it is recorded from the patient. The movement in the condyle region may be upward and backward, downward and backward, or upward and forward.

When the fundamental movements are reproducible, the other refinements are merely for convenience, e.g., adjustable anterior guide, method of cast mounting, separation of upper and lower bows, type and amount of tension between upper and lower bows, etc.

Once we understand the fundamental movements and have an articulator that will reproduce them, the next consideration is a means of recording the movements and transferring them to the articulator.

This effort ran a course parallel to that of articulator design.

One of the more serious errors perpetrated until recently was the failure to recognize the hingelike action of the temporomandibular joint. Barn-door hinges and articulators of similar design were not made to accommodate the proper mounting of casts to the axis of the articulator. Even later, when men began to design articulators with bows so situated that casts could be placed in proper relationship to the joint, attention was still not paid to the exact location of the centers of rotation. Yet it was a step in the right direction.

Because most of the work in this field had to do with full dentures, slight errors were not very discernible and inferior results were accepted. Those who applied the techniques to natural teeth, however, soon saw the errors and consequently discarded the equipment and proceeded to work in the mouth. The use of interocclusal records was very limited because the casts were not mounted to the exact hinge axis. So many handicaps were involved that such records were soon abandoned. One of the problems which resulted from the lack of a correct axis mounting was the necessity of establishing the exact vertical dimension at the time of securing the interocclusal records. This was an impossible task. The casts did not approach each other on the same arc of closure because the centers of vertical rotation had not been located. Areas came into contact on the articulator which did not correspond to the contacting areas in the mouth. Only the extremes of motion (fixed positions) could be recorded by means of interocclusal records. The in-between curvatures were not recorded, and these were the most important.

Gysi, with his extraoral tracing apparatus, came closest to the truth as far as jaw motions were concerned. His recording apparatus was the forerunner of the present-day extraoral writing devices. Unfortunately, he made several serious mistakes. First, he was experimenting with full denture patients but was unable to develop a method whereby the writing apparatus could be rigidly attached to a patient's edentulous jaws. Second, he did not make use of the hinge axis. Because of the crude way in which the apparatus was attached to the edentulous patient, Gysi came to the conclusion that the Bennett movement—the most important of all the registrations—could not be recorded or accurately duplicated. He thus concluded that the Bennett movement was neither constant nor important and that an approximate setting was acceptable. Yet we know from the work done by McCollum and the Gnathological Society from 1921 to 1940 that the hinge axis is present and usable. We know, too, that it is possible and practical to register and reproduce the Bennett movement with accuracy for each patient.

Generally speaking, the adjustment of any articulator capable of adjustment is basically the same. General directional adjustments produce similar changes in movement. In other words, moving a center of rotation in or out produces a similar effect on all the instruments. However, it must be determined whether the controlling factors are similarly placed. For example, in one articulator (the gnatholator) the Bennett guides may be on the upper member, whereas in another (the gnathoscope) they may be on the lower member. The surfaces limiting the side shift (Bennett movement) would be just the opposite in these two instruments.

The best way to clarify the particular adjustments of any articulator is to assemble a writing apparatus on an articulator and make a set of tracings with the instrument at a convenient arbitrary setting. By carefully changing a control in each direction, we may observe what effect this has on the relation of the styli to the tracings. If this is done with all the controls, one at a time, returning the control to the original position after each observation, we can visualize how each control would have to be moved in order to make the styli follow the tracing of a practical case.

MAKING THE REGISTRATIONS

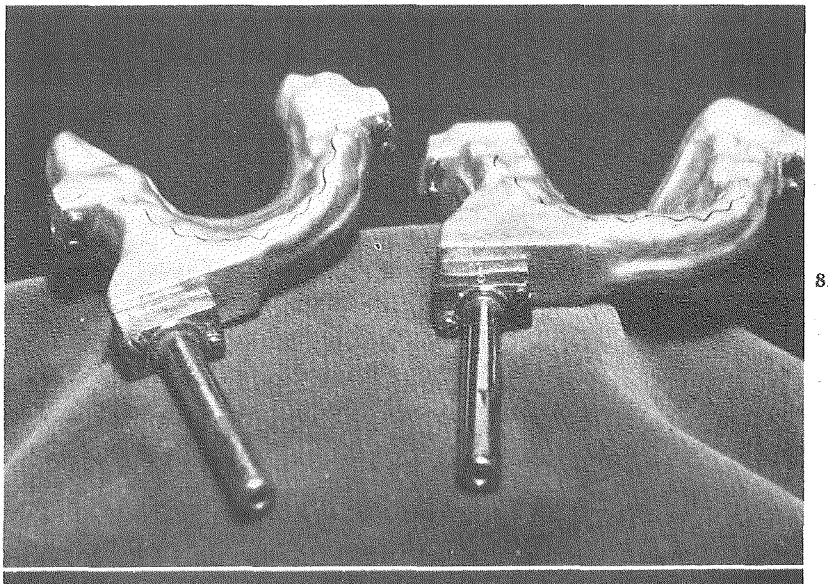
Gnathograph

The most accurate practical method of recording jaw movements is the use of an extraoral tracing device.*,† Actually, this is a pantograph that scribes

*H. D. Justi & Son, Inc., Philadelphia, Pa.
†Dr. Charles E. Stuart, Ventura, Calif.

the paths of the centers of rotation of the mandible. The tracings are made in three dimensions simultaneously. They are made in certain areas for convenience and facility although, theoretically, they could be made in any three planes at right angles to each other.

The writing apparatus must be rigidly attached to the maxillary and mandibular teeth. This is accomplished by cementing loose-fitting aluminum castings



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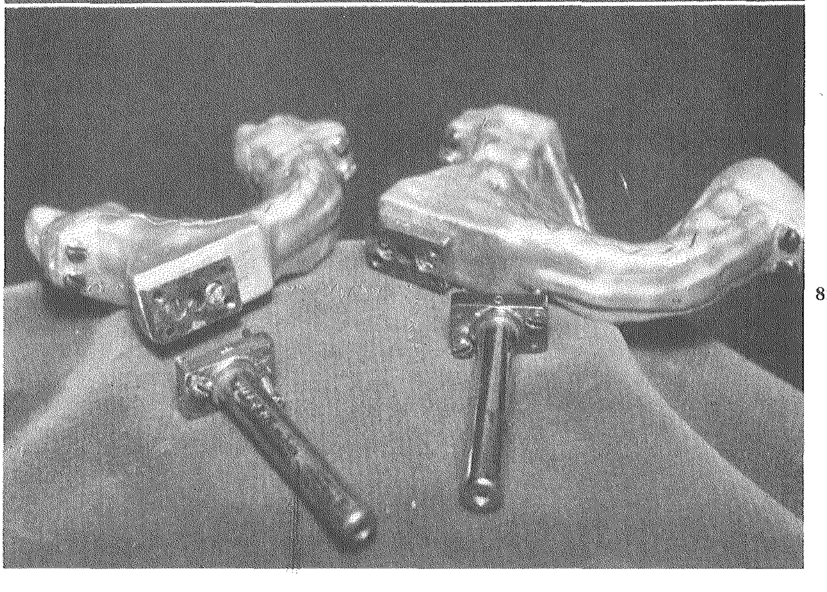

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Fig. 81. Aluminum clutches with studs attached ready for registrations. Note absence of bearing plate and screw. These clutches are to be used with the external bearing plate and pin.
Fig. 82. Separable feature of stud, which permits accurate reassembly of the clutch to the stud in preparation for mounting the writing on the articulator.

over the teeth. (In edentulous mouths special clamps are used to attach the writing apparatus to the jaws.) A stud projects from the front of each of these castings (Fig. 81), and it is so constructed that it can easily be separated from the clutch and then accurately repositioned against the clutch (Fig. 82).

The clutches are made in such a way that the labial part can be detached by removing several screws. This facilitates removal of the clutches when the writings are completed. The clutches have to be separated vertically so that there will be no tooth guidance during the registrations. The minimum amount of separation that will ensure this is desired. A bearing screw in the lower clutch working against a plate in the upper clutch provides for this separation (Fig. 83).

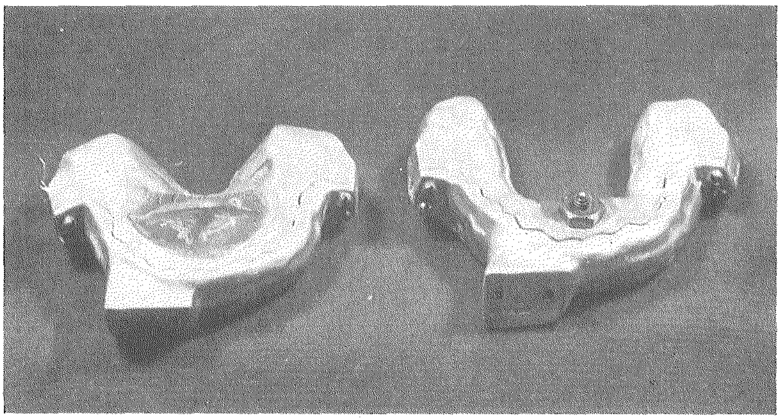

Fig. 83. Clutches with intraoral bearing arrangement.

Extraoral bearing arrangements

Granger has developed an extraoral bearing point which can be adjusted and which has some real advantages over the intraoral bearing point (Fig. 84). However, sufficient teeth must be present, and they must be well gripped to ensure clutch stability during the writings; otherwise, the increased leverage developed because of the position of the bearing point may readily dislodge the apparatus. We subsequently devised a method of placing the bearing plate and screw on the anterior labial flanges of the clutches, thereby eliminating the disadvantages of the extraoral bearing arrangement while still realizing all its advantages (Figs. 85 and 86).

Fig. 87 shows the apparatus necessary for obtaining the required registrations. In practice, it is assembled on the articulator in the laboratory in order that the patient is not unduly inconvenienced (Fig. 88).

The clutches are tried in the mouth to make sure that there is proper clearance in all directions. Then a relatively heavy mix of zinc oxide and eugenol paste (Ackerman's powder and liquid) is prepared and applied to the upper and lower clutches. The clutches are inserted in the mouth and seated firmly

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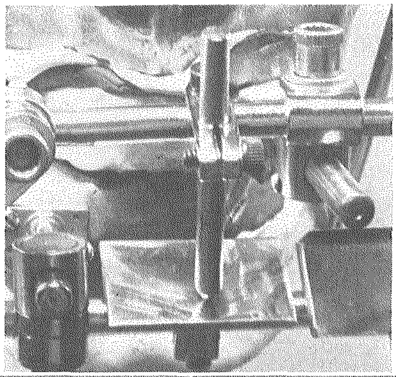

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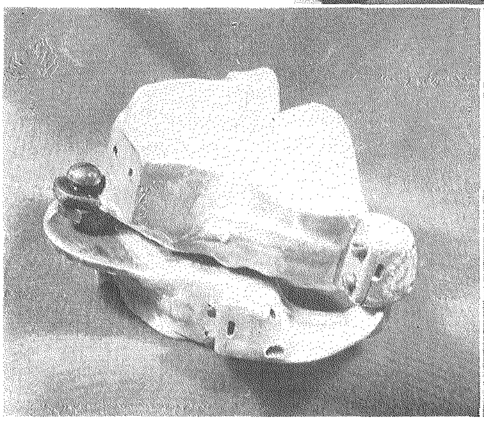

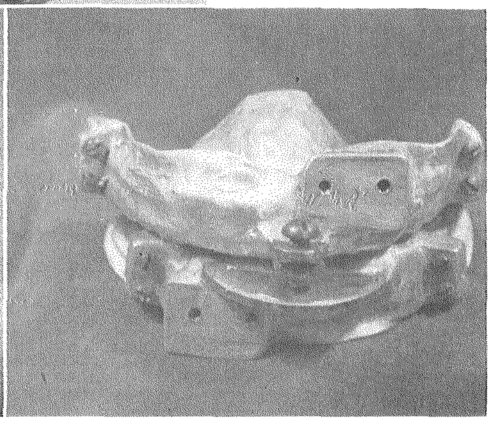

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Fig. 84. Extraoral bearing arrangement designed by Granger.
Fig. 85. Extraoral bearing arrangement attached to clutches developed by Lucia (side view).
Fig. 86. Front view of Lucia's extraoral bearing arrangement.

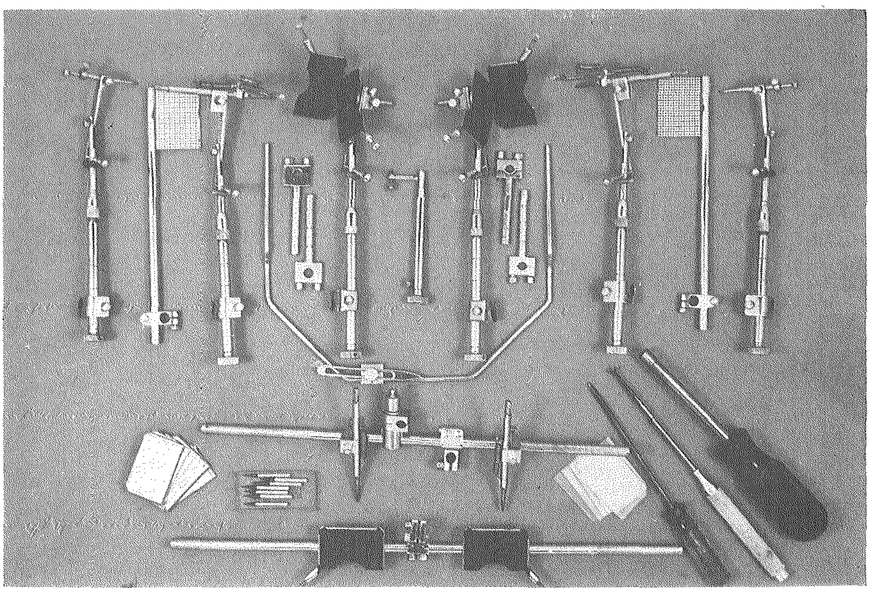


Fig. 87. Various parts of a gnathograph prior to assembly.

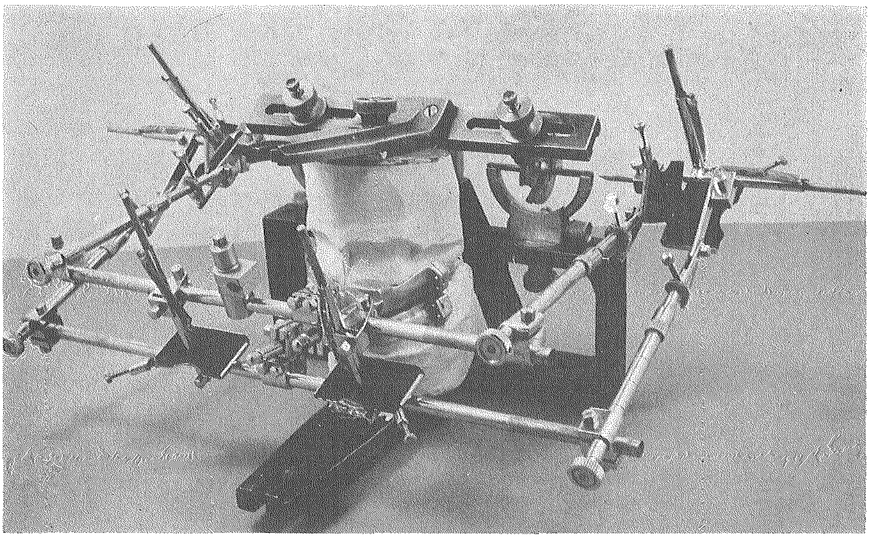


Fig. 88. Gnathograph assembled on articulator to facilitate procedures on patient.

to place. Cotton rolls are used to ensure their proper positioning while the mix is setting.

Assembly of writing apparatus on patient

After the clutches are securely fastened to the maxillae and mandible (Fig. 89), the writing apparatus is assembled on the patient.

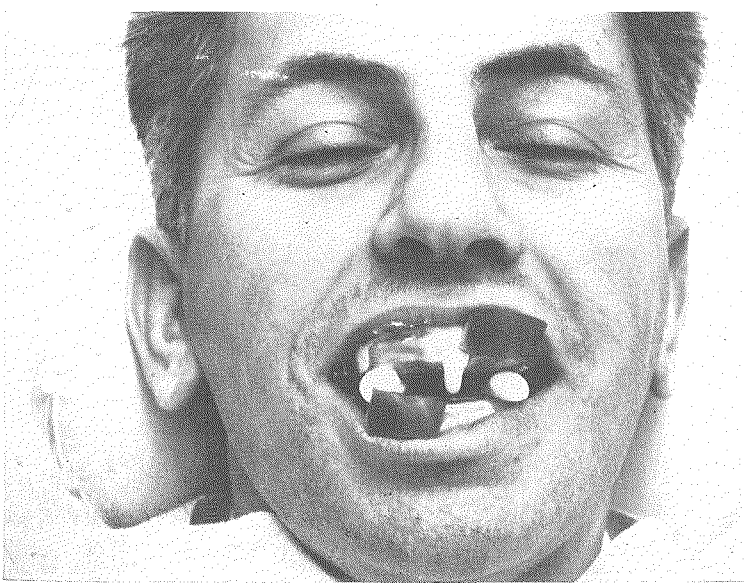
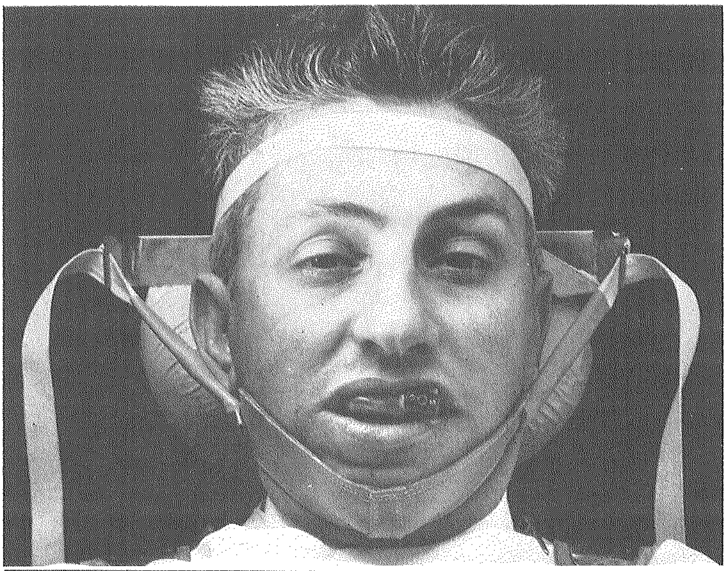


Fig. 89. Clutches cemented in patient's mouth. Note cotton rolls for accurate seating of clutches and soft wax covering stud plates to prevent excess cement from getting on plates.



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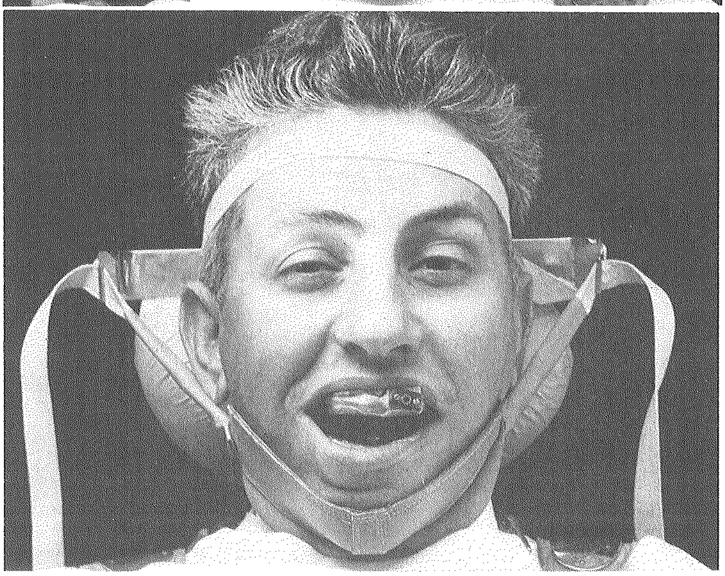

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Fig. 90. Cohen's trainer on patient (closed position).
Fig. 91. Trainer on patient (open position).

Because the location of the axis requires an unfamiliar jaw movement, it is advisable to have the patient practice this movement before the apparatus is attached. To aid the patient in separating the hingelike action from mandibular movements, we recommend the use of the trainer designed by Dr. Raymond Cohen, which is fully described in Chapter 2. This device will help the patient to open and close the mouth without protruding the jaw (Figs. 90 and 91).

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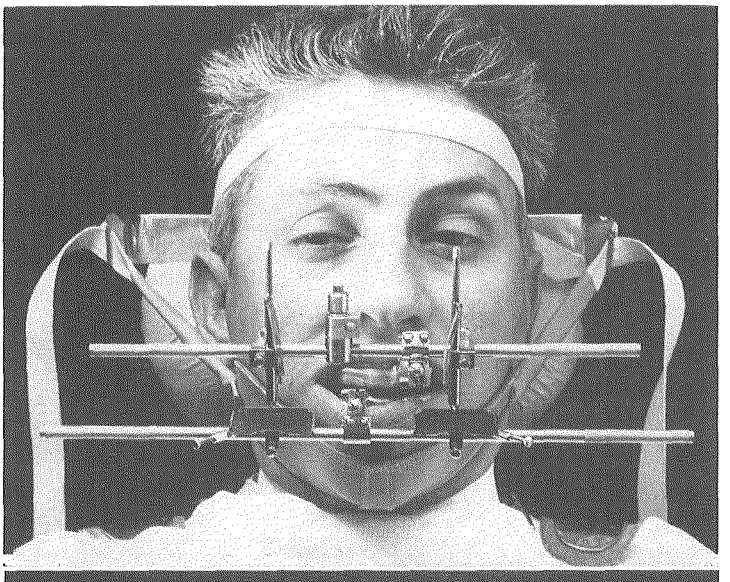

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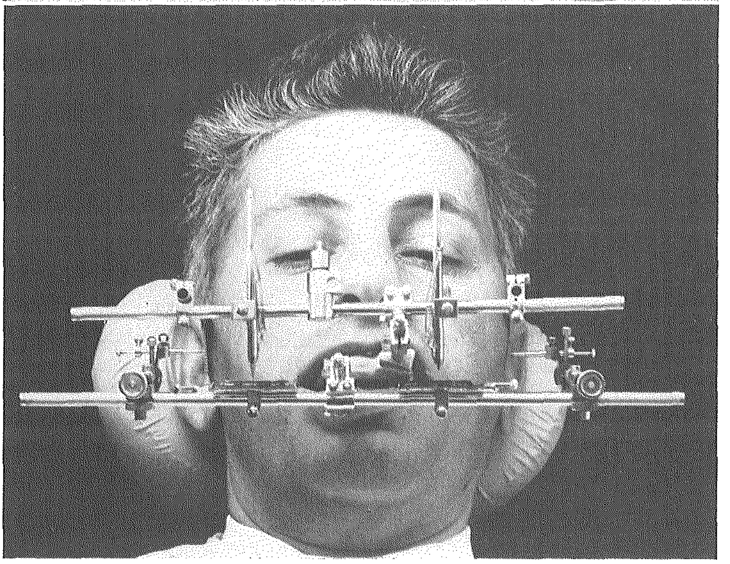

Fig. 92. Upper and lower crossbars carrying toggle for axis-orbital support, pins, and slide holders for anterior tracings are quickly placed by means of the separable feature of the stud. **Fig. 93.** Graph-lined flags are placed on upper bar. Adjustable sidearms are placed on lower bar for axis location.

The crossbars which were fastened to the studs by means of the universal joints are now attached to the clutches by the separable feature of the stud (Fig. 92). Undue torque on the clutches is avoided since the universal joints were tightened prior to insertion in the patient's mouth. The bars are approximately parallel and thus will not interfere with each other nor with the rest of the equipment.

The patient is now asked to open and close the mouth a few more times before the trainer is removed. After this is done, a graph-lined flag is attached to the upper bar over the condyle area. One flag is placed snugly against the patient's face on each side. Attached to the lower bar is an adjustable sidearm, carrying a stylus pin, which is placed on the side of the flag in the joint area, one on each side (Fig. 93).

Location of hinge axis

When this much of the apparatus is securely tightened, the location of the axis is undertaken. As has been previously pointed out, a pure hingelike movement is not natural to a patient—hence the necessity for some coaching. In addition to the trainer method which we have discussed, an effective way of explaining this type of movement is to have the patient place a finger on the operator's chin while he demonstrates the type of unstrained opening and closing motion desired. Some patients will be quicker than others to comprehend what is wanted. Most patients, however, will persist in executing some translation with the hingelike action about every third or fourth time. We soon learn to distinguish this from the pure hingelike action.

After it has been successfully demonstrated to the patient what is needed, attention is next directed to the action of the *tip* of the stylus as the patient executes the hingelike movement. The tip of the stylus will arc in a definite direction, depending upon its relation to the actual centers of rotation. By visualizing the center that a compass must have in order to generate the arc that we see,

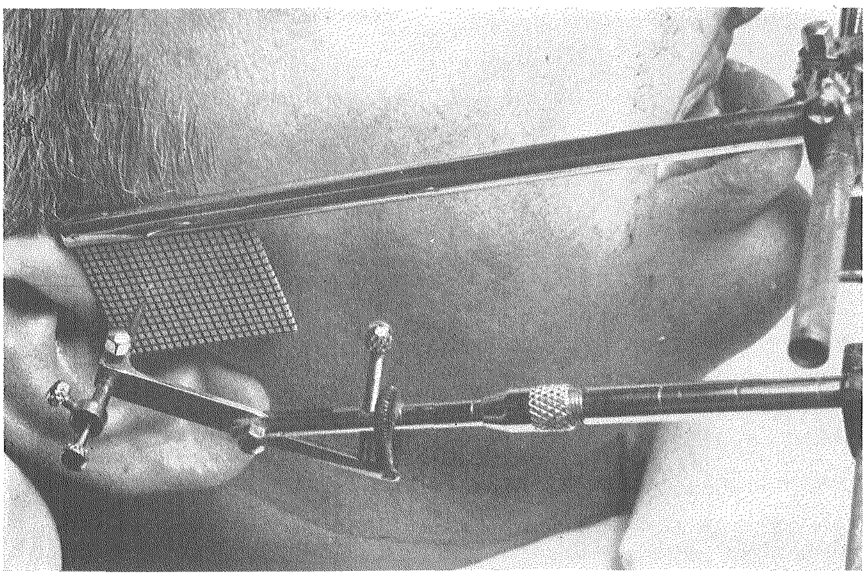

Fig. 94. Tip of stylus in relation to graph lines on flag. Patient in closed-jaw position.

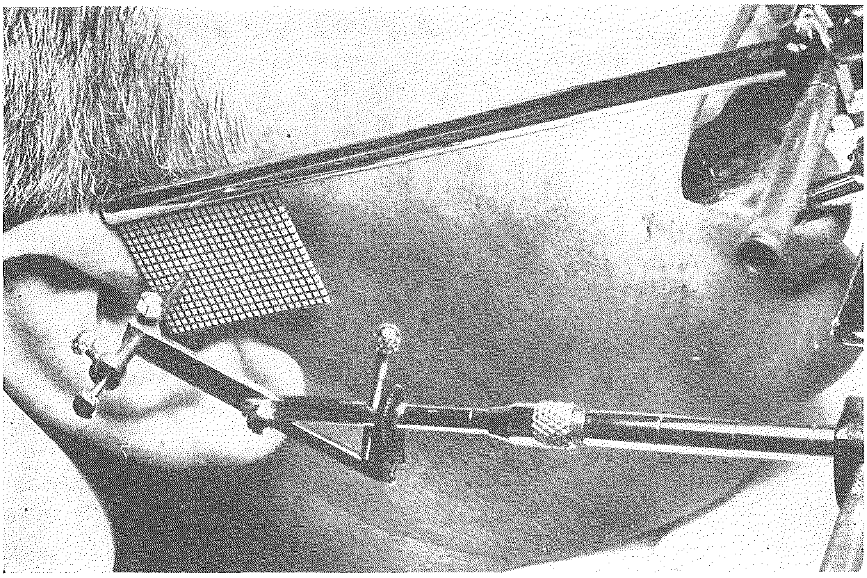

Fig. 95. Tip of stylus in relation to graph lines on flag. Patient in opened-jaw position.

it can immediately be determined in which direction the stylus tip has to be moved to get closer to the center of rotation. By trial and error and repeated adjustments, it is possible to arrive quite readily at the exact center of rotation (Figs. 94 and 95), which is indicated when the tip of the stylus will no longer arc; it will merely rotate. Remember, we are interested only in the *point* of the stylus. The rest of the stylus will continue to arc, unless by pure luck the entire stylus is exactly in line with the patient's hinge axis. This is not practical, nor important.

After the centers of rotation are located on each side, a permanent mark of the location must be made, for these centers will be referred to many times during the course of treatment. In order to minimize the possible error of skin movement, the patient must sit upright in the chair.* This will eliminate any possible skin displacement which could occur from pressure against the head rest. When it is determined that the patient is in the terminal hinge position, the graph-lined flags are removed, and the mark against the patient's skin is carefully transferred by moving in the stylus tip so it will touch the face (Fig. 96). A wet indelible pencil rubbed against the stylus tip will do the job neatly and quickly. The marks are made permanent with a thin tattoo needle and some English vermilion (sulfide of mercury). This completes the use of the flags attached to the upper bar and the sidearms carrying the stylus pins atached to the

*In subsequent reference to the centers of vertical rotation (hinge axis), the patient is always seated upright in the chair to simulate the conditions that existed when the original markings were made.

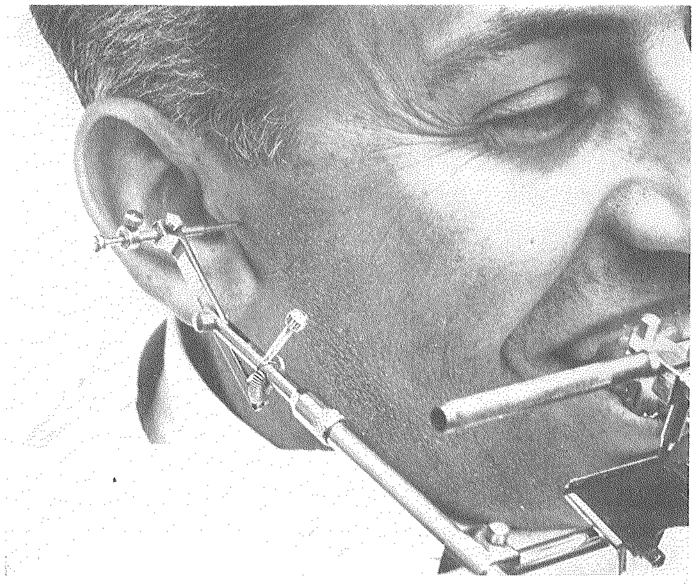

Fig. 96. Transferring the location from the stylus tip to the skin.

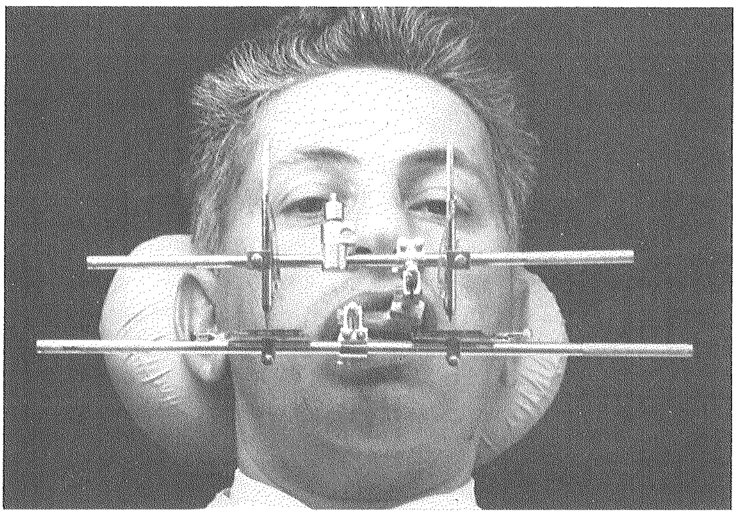

Fig. 97. Flags and hinge axis locating arms removed.

lower bar. They are, therefore, removed, and the crossbars are left in place for the next part of the registrations (Fig. 97).

On the upper bar are located two tubes for the anterior styli—one on each side of the stud. Between the stud and the stylus tube on the patient's right side, there is a universal clamp which will be used to hold the axis-orbital support. The sidearms with the slide holders are placed on each end of the upper crossbar (Fig. 98), and they are positioned so that the center of rotation pin coming from the face side of the vertical (condyle) slide is situated over the center of rotation (Fig. 99). The pins are of several sizes, and selection is according to the width of the face. The wider the face, the shorter the pin will be. The object is to space the sidearms so that they will not interfere with the articulator adjustments when the gnathograph is mounted on the articulator for its adjustment. When the pin of proper length is selected, the sidearm (and

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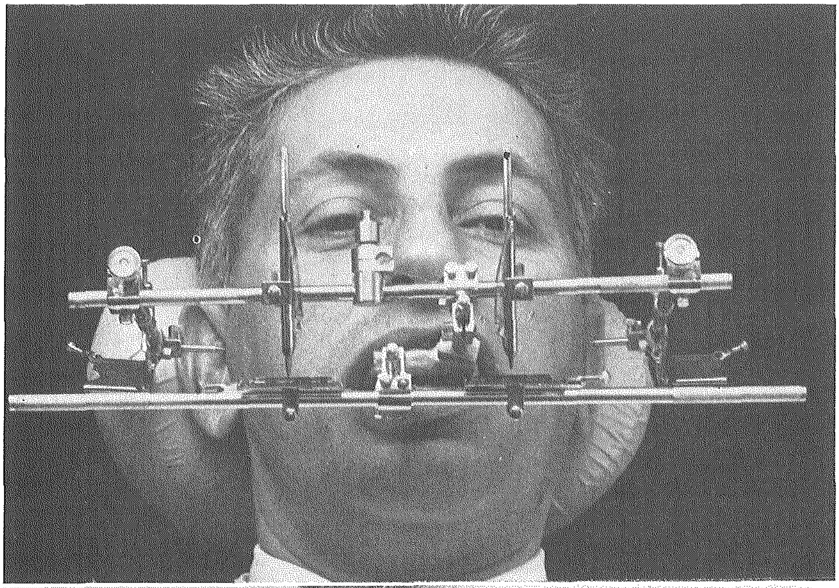

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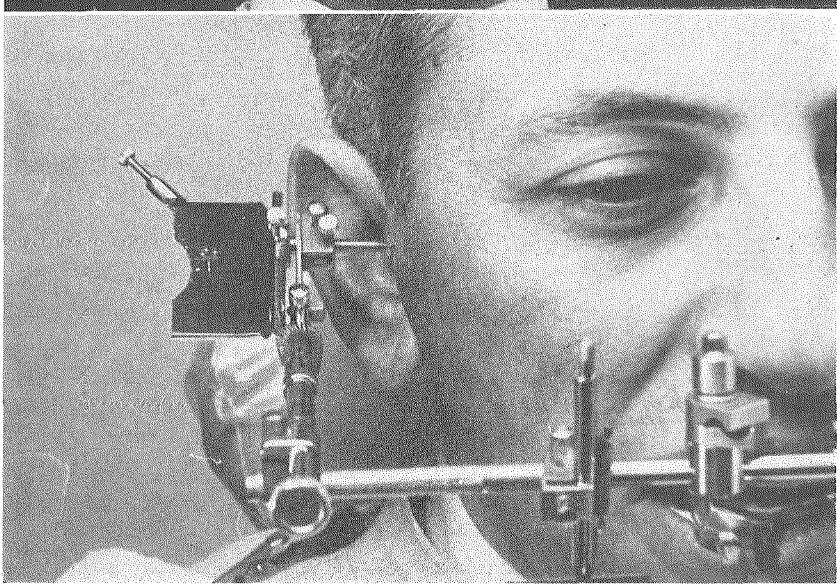
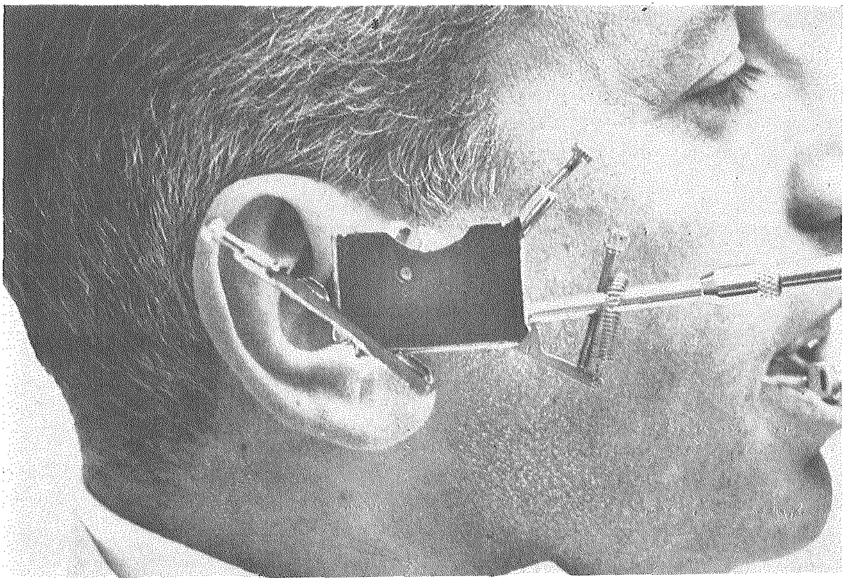


Fig. 98. Slide holder sidearms are placed on upper crossbar.
Fig. 99. Pin of slide holder adjusted to axis located on side of face. Patient in upright position.



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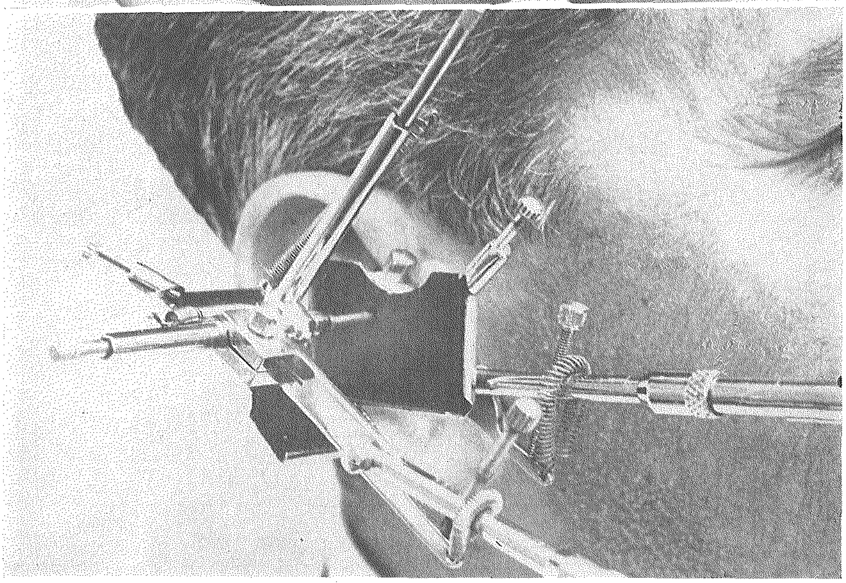

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Fig. 100. Bennett slide holder approximates the condyle path inclination.
Fig. 101. Horizontal pin adjusted to axis projection. Patient must be in the terminal hinge position.

slide holder) is brought against the face until the tip of the pin barely touches the skin without any impingement. The patient is seated upright for this adjustment. The horizontal slide holder (Bennett movement) is at a right angle to the vertical (condyle) slide holder and at a convenient angle approximating the condyle path direction (Fig. 100). The sidearm is similarly positioned on the other side.

The lower bar attached to the lower clutch has two horizontal slide holders, one on each side of the stud and inside the outer edge of the face. They are inclined at a convenient angle, again approximating the condylar inclination. The sidearms used on the lower have the stylus tubes—one vertical to trace against the horizontal (Bennett) slide and the other horizontal to trace against the vertical (condyle) slide. The horizontal stylus is adjusted so that it, too, is situated over the center of rotation when the patient is in the centric relation position (all the way back), as in Fig. 101. After this is repeated for the opposite side, the writings are taken.

The tracings

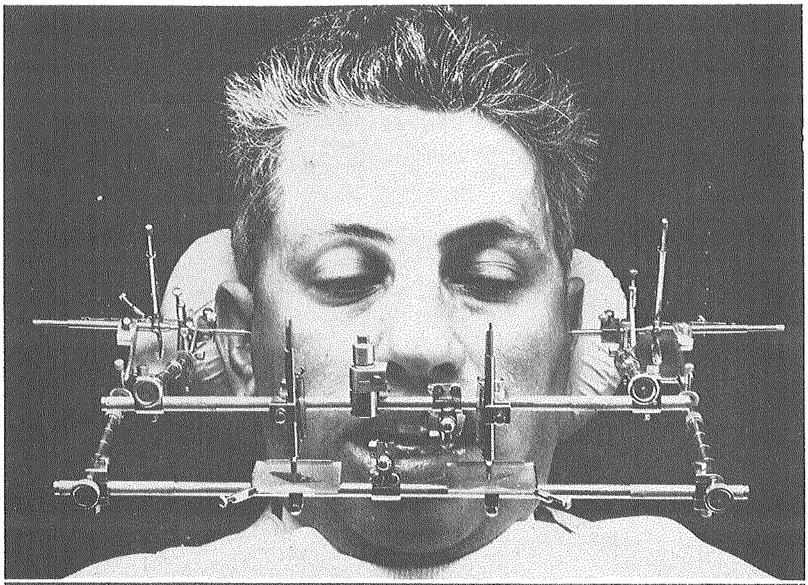
McCollum, Stuart, and Granger methods. In the earlier gnathograph developed by McCollum and associates, waxed glass slides were used to make the tracings. A very thin layer of carnauba wax was melted over one side of the glass slide, and after the tracings were made, they were etched with hydrofluoric acid. The remainder of the wax was then melted off the glass slides, and the permanent etchings were used to set the articulator. The one great advantage of this method was the fact that several tracings would be taken and superimposed to ensure that the extreme base tracings for the patient had been recorded.

The method had disadvantages, too. There were the difficulty of waxing the slides correctly, the nuisance of etching the slides with the very dangerous hydrofluoric acid, and, most important, the possibility of being fooled in setting the articulator because of the "ditch" of the etchings. Still, it was the most accurate way of doing the job until recently, when Stuart and Granger brought out true writing apparatuses.

Stuart's method is to paint tin oxide on the slides (on the holder, actually). After the stylus cuts a path in the oxide, the tracing is preserved by covering it with cellophane tape. Granger uses a finely sharpened pencil lead which scribes on a piece of white paper glued to a slide. After the tracing is obtained, it, too, is protected with cellophane tape. Neither of these procedures makes it easy to superimpose tracings. Stuart retraces his tracings, and if they do not smear, it is assumed that the base tracing has been recorded. With Granger's method, onion skin paper could be used and the tracings superimposed. Actually, though, if a chew-in for the envelope of motion is taken and then the single tracing on a separate set of slides, it is possible with a little experience to determine whether the base tracings have been obtained.

To obtain the most accurate registrations possible, we recently combined the old McCollum method of waxed glass slides with Granger's pencil tracings on white paper.

Six thinly waxed slides are placed in the holders. The replaceable metal pins are sharpened to a needle point, and the chew-in is obtained. This gives the border movements of the patient (Fig. 102). The metal pins are now replaced with sharpened lead points, and the waxed glass slides are replaced with the



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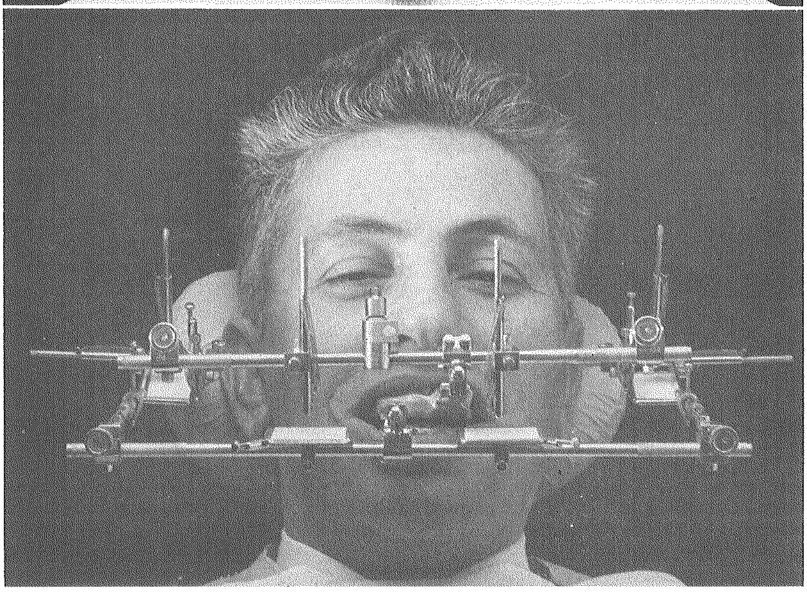

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Fig. 102. Chew-in on wax-covered slides gives the border movements.
Fig. 103. The waxed glass slides are replaced with paper-covered metal slides.

paper-covered aluminum slides (Fig. 103). When satisfactory tracings are made on these slides, they can be checked for accuracy by superimposing the chewed-in waxed slides over them. To be accurate, the border limits must coincide. This is easily visible, for the chewed-in waxed slides are transparent, and the pencil line can be seen through them.

Directing patient into the excursions. Whichever the choice of procedure may be, the tracings are secured in the same manner. The patient is instructed as to the movements required. There must be no separation of the jaws, just a sliding in the various directions. Usually as a practice run and to check the apparatus for clearance, we have the patient move in every direction. By so doing, he will develop the envelope of motion. Next, we have him practice giving

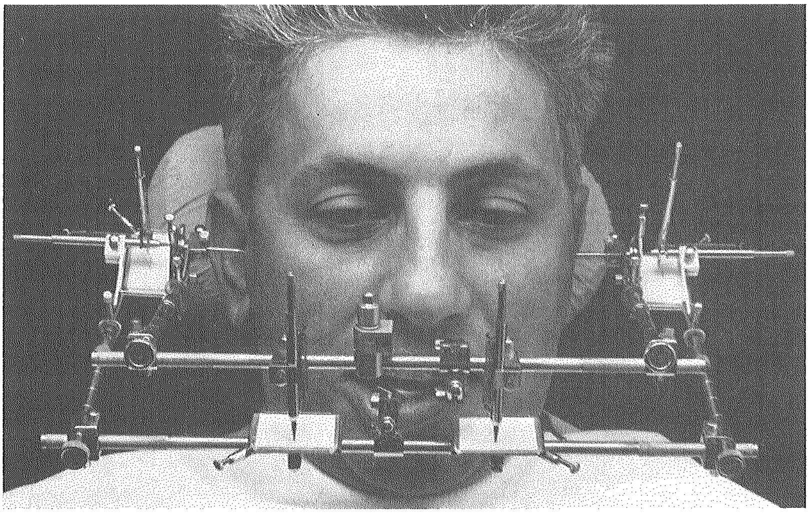

Fig. 104. Patient in protrusive excursion.

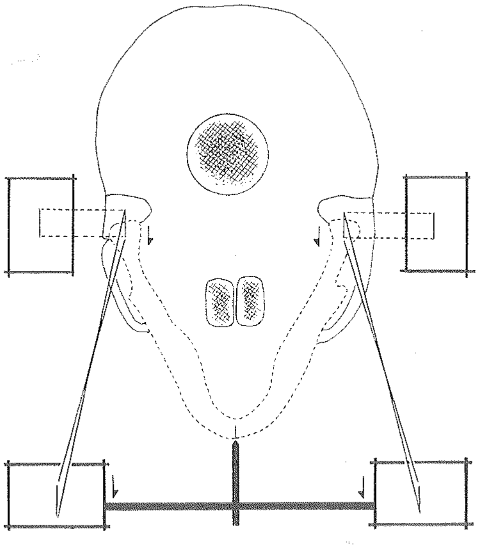

Fig. 105. Schematic drawing of a protrusive tracing. Note that on the posterior slides the tracings follow the movement of the condyles. On the anterior slides they seem to go backward. This is so because the anterior slides are attached to the lower jaw, and the tracing pins are on the upper jaw. The posterior slides are fastened to the maxillae, and the tracing pins are fastened to the mandible.

single, directed tracings. We go through the retraction of the styli after each excursion so that he will know what to expect when we do it for the final tracings.

The patient is directed to the centric position, the starting point. All the pins are released against the slides. He is instructed to move forward as far as possible and to hold there for a moment until we retract the styli and secure them out of contact (Figs. 104 and 105).

We instruct the patient to return to the starting point, and the pins are released against the slides again. He is directed to move to one side and to hold that position (Figs. 106 and 107). It is advisable to place a thumb on the side of the patient's jaw to guide him into the lateral excursion being recorded. This will ensure the recording of the full Bennett movement. Many patients, when they have had lateral interferences, will not use the full Bennett range for a while. If the full Bennett movement is not recorded, the restorations to be constructed will interfere in the lateral excursions. Therefore, it is necessary to record the full Bennett range in order that the restorations will be built to the border movements. When patients are permitted this freedom, they will use the full range.

The pins are now retracted and locked out of contact with the slides, and the patient is instructed to return to the starting point.

Before the pins are released, it must be ascertained that the patient has returned to the centric position. Sometimes it will be necessary to have him move into the protrusive relation and then go back to the centric. (In order not to smear the tracings, the styli should be out of contact when this is done.) When it is certain that the patient has returned to the centric position, the styli are

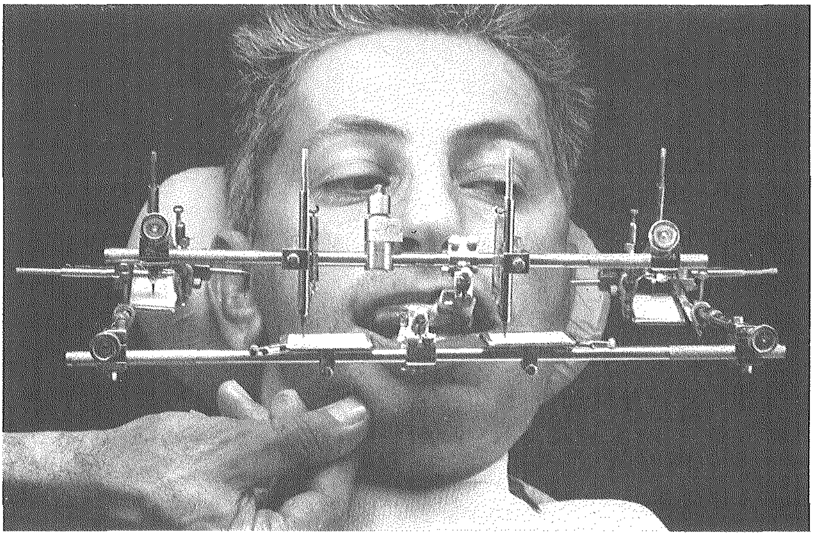

Fig. 106. Patient in left lateral excursion.

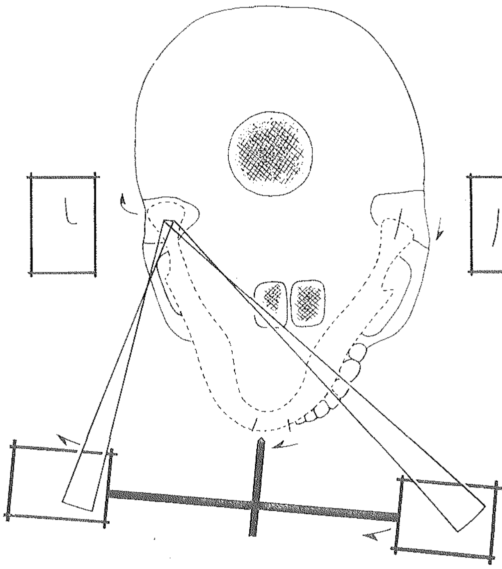

Fig. 107. Schematic drawing of the left lateral excursion. The characteristics of lateral tracings are shown. They are individual for each patient.

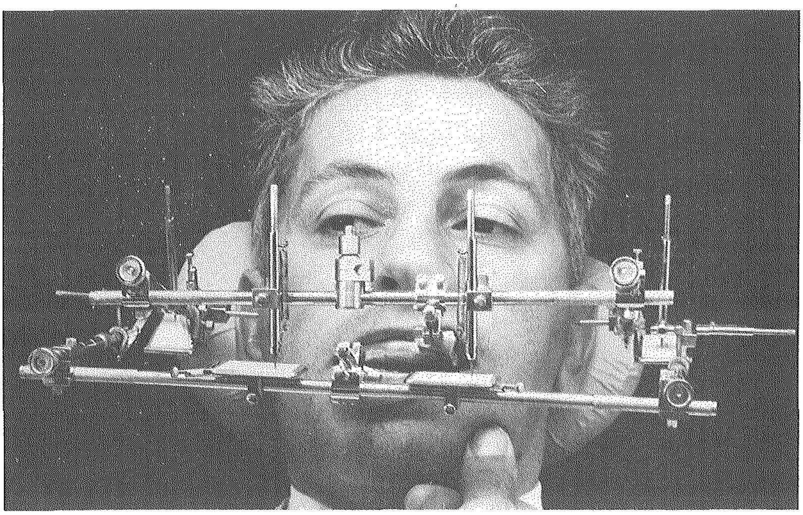

Fig. 108. Patient in right lateral excursion.

released against the slides, and the patient is then instructed to move to the other side. Gentle pressure on the side of the mandible will assist this movement (Figs. 108 and 109). The styli are retracted, and the patient returns to the centric position (Fig. 110).

It will be noticed that the patient is not instructed in right and left directions. There is good reason for this. Many patients become confused when they

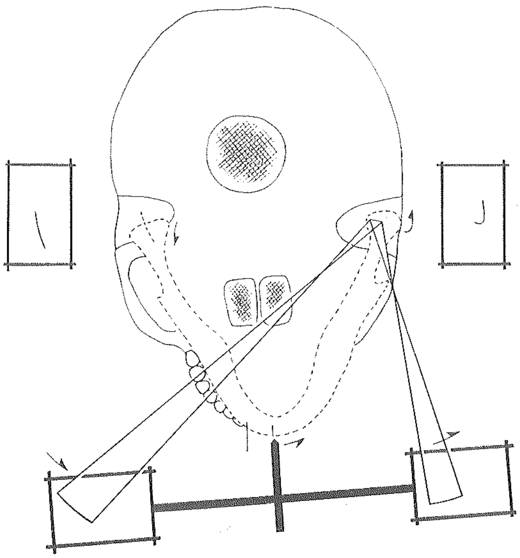

Fig. 109. Schematic drawing of the right lateral excursion. Note correlation of the tracings from one side to the other.

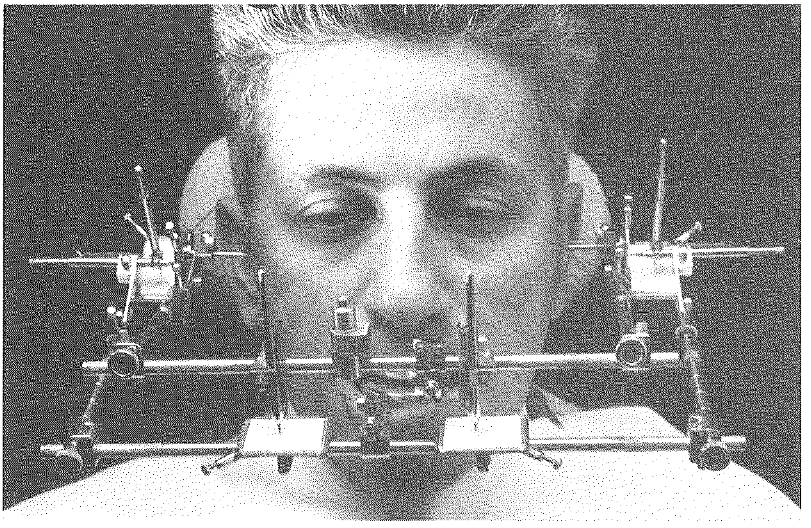

Fig. 110. Patient in centric relation (at conclusion of tracings).

have to distinguish between right and left and will very often spoil the tracing by retracing a path. Therefore, it is easier to tell them to go to the opposite side. It also prevents our own confusion, for if we instruct a patient to go to the right and instead he goes to the left, we are liable to become befuddled and call the wrong signal. Then we are in a mess. Consequently, it is always safer to instruct the patient to move to one side and then to the opposite side.

Check for accuracy. If the tracings appear to be in order—all starting from the same centers, all clearly traced—we are ready to check them for accuracy. The slides are covered with cellophane tape, the styli are released against them, and the patient repeats the tracings. If the styli follow exactly, the tracings

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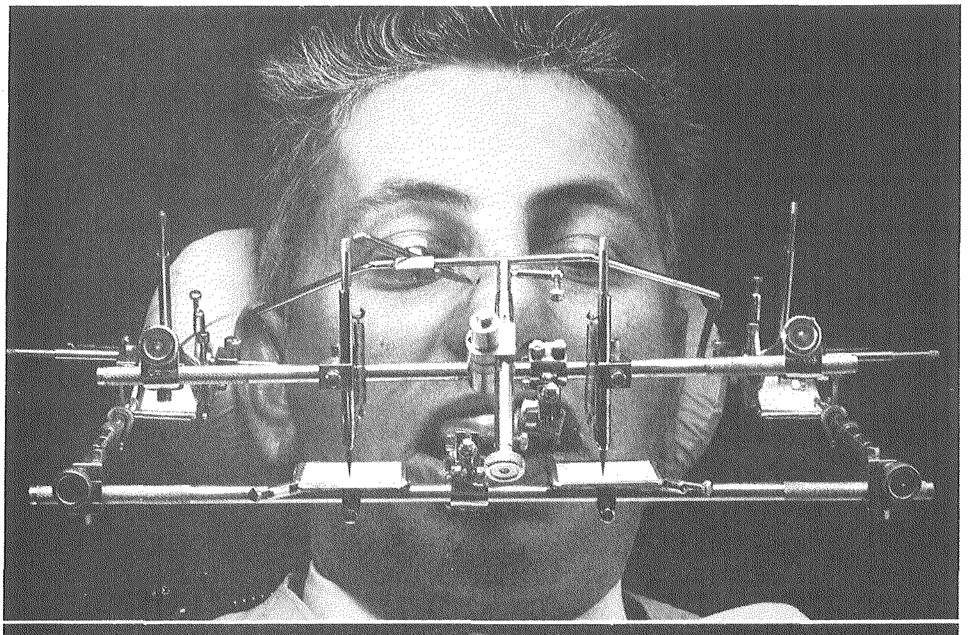

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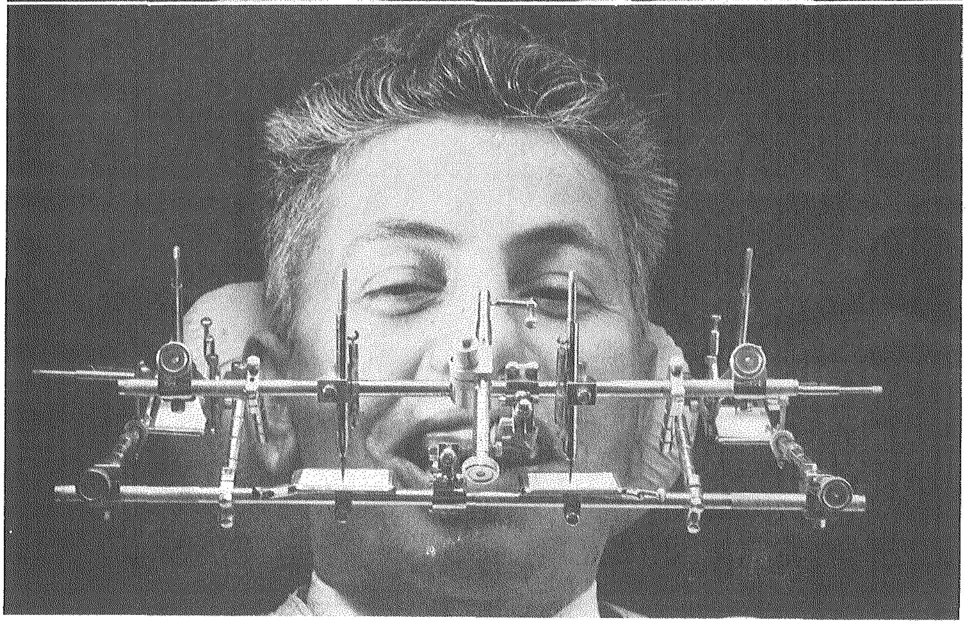
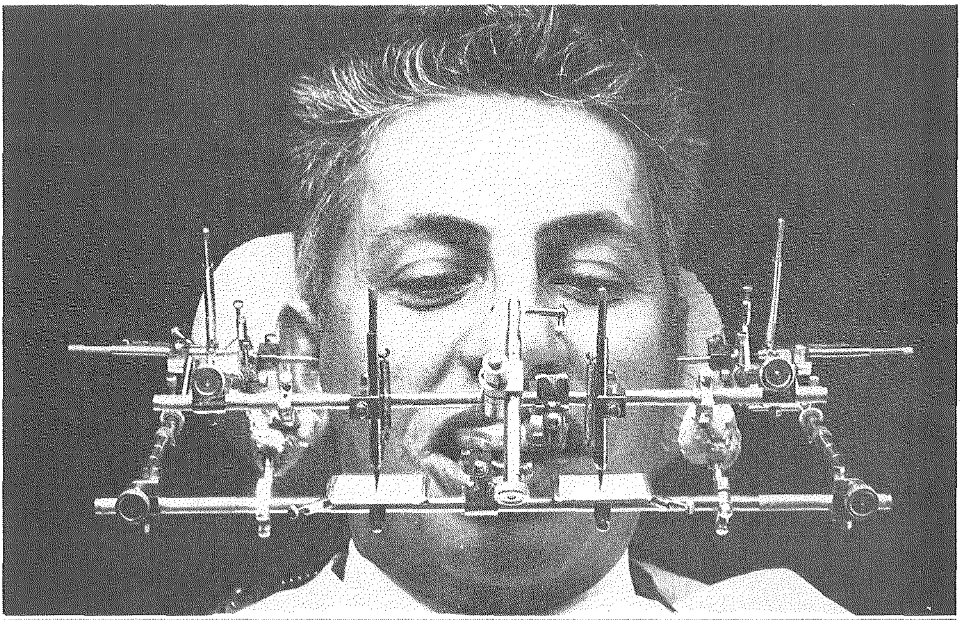


Fig. 111. Axis-orbital plane in position.
Fig. 112. Vise grips in position.

can be accepted as accurate. An additional check is made by superimposing the glass, chewed-in slides to see if the border movements were recorded.

Final steps. The axis-orbital support is now put in place on the upper bar, and the orbital point to fix the axis-orbital plane with the two axis points is se-



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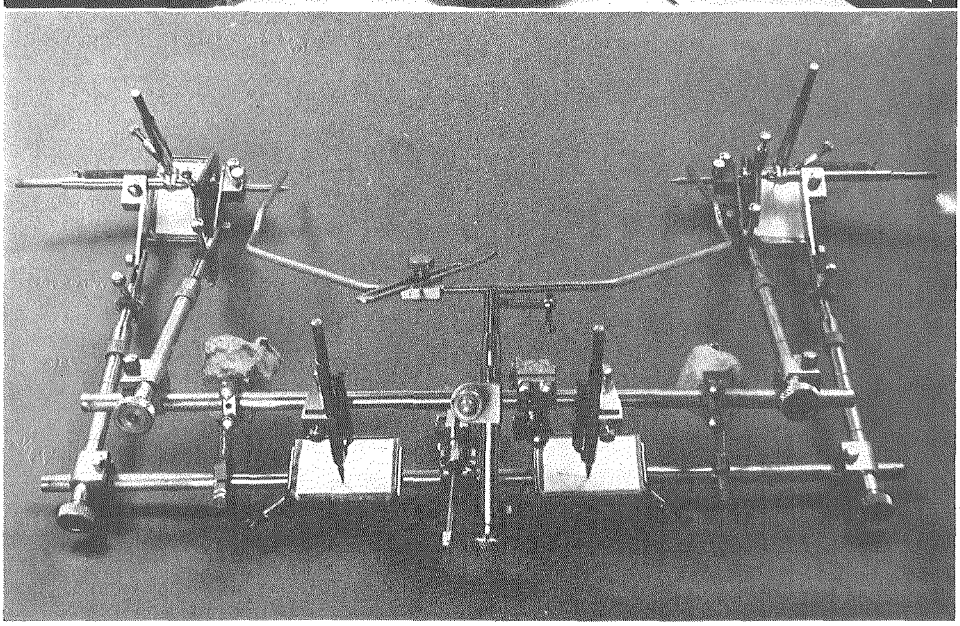

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Fig. 113. Stone on vise grips.
Fig. 114. Locked writing as removed from the patient.

lected. The axis-orbital indicator is placed on the axis pins and on the support. The point is marked on the side of the nose, and the indicator is removed after the support is locked securely in place (Fig. 111). If this step is forgotten, the writings will be useless!

The vise grips are attached on the upper and lower bars so as to approximate each other. Four grips are used—two on each bar, and they are placed in the space between the sidearms and the anterior tracings (Fig. 112). Fast-setting stone is used to lock the vise grips together after it is ascertained that the patient is in the centric relation. This is accomplished by having the patient move forward and back several times before the stone is positioned on the grips. The patient is instructed to hold everything together firmly while the stone sets thoroughly (Fig. 113).

The entire apparatus is now removed—upper and lower members locked together—by separating the detachable studs. This feature facilitates the removal of the apparatus without distortion (Fig. 114). The clutches are taken from the mouth, and the apparatus is ready for the laboratory procedure of relating it to the articulator.

CHAPTER 6

The mounting frame and its use

DEFINITION OF MOUNTING FRAME

The mounting frame is a jig that conveniently holds a face-bow in proper relation to an articulator. It permits accurate relationship of the cast to the articulator while the attaching stone sets.

There are several designs of mounting frames. Basically, however, they all perform the same job—conveniently hold two things together while they are being permanently related to each other.

McCOLLUM SYSTEM

Description

With the McCollum system, the upper bow of the articulator is automatically centered in the movable part of the mounting frame. The condyle paths fit on two balls, which are the same size as the balls on the lower frame of the articulator (Fig. 115). This serves to make the axis of the upper bow of the articulator continuous with the axis of the mounting frame. On each side of the mounting frame there are two calibrated rods (extensions of the axis) which permit the frame to be centered between the face-bow (Fig. 116). There is a universal clamp on the base of the mounting frame at the front end which makes it possible to hold the face-bow rigidly in position. Before this clamp is tightened, the face-bow is lined up approximately with the movable part of the mounting frame on which the upper bow is positioned. The more closely this is approximated, the easier will be the final adjustment to its exact position. By means of the extension rods of the movable part of the frame, the upper bow is centered between the points on the face-bow. The elevating thumbscrews on the base of the movable part of the frame permit micrometer adjustment to the points of the face-bow. When the movable part of the mounting frame (carrying the upper bow of the articulator) is centered and in exact line with the points of the face-bow, the axis of the articulator bow and the axis of the face-bow are continuous.

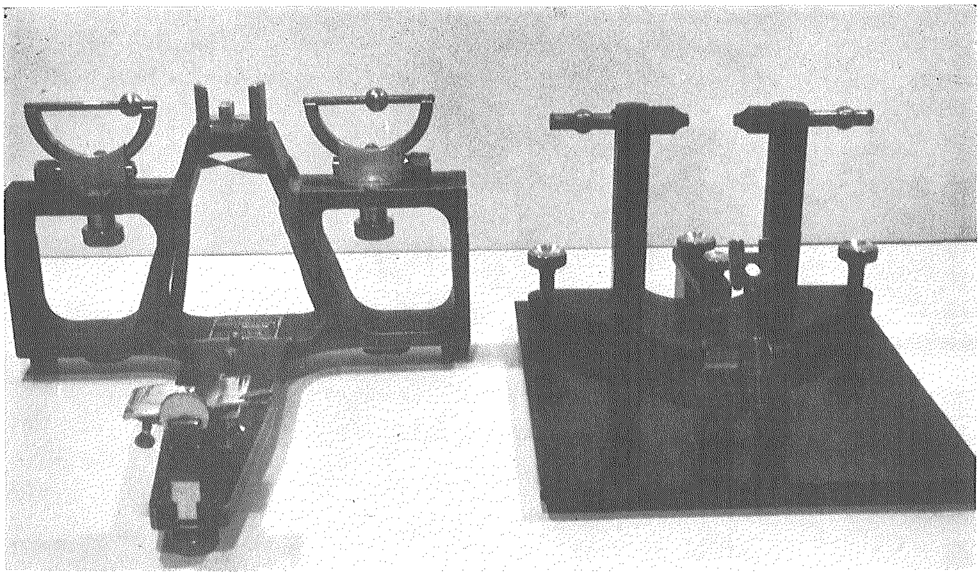

Fig. 115. The mounting frame serves as a jig in place of the lower member of the articulator.

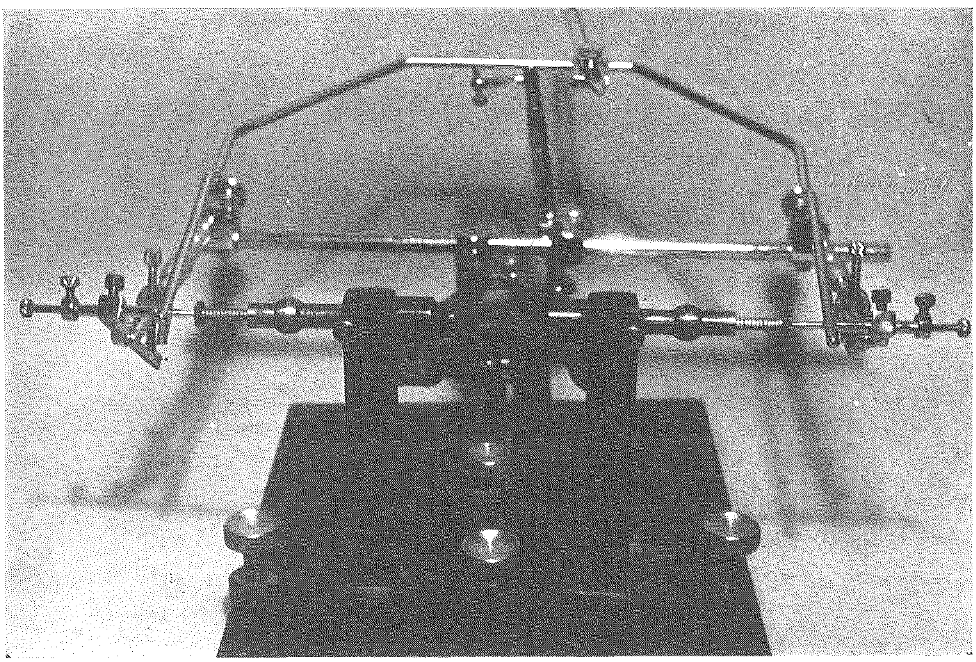

Fig. 116. Rear view of the McCollum mounting frame. Note stylus pins lined up with intercondylar rods of mounting frame and equal calibrations of extension rods.

Technique for mounting study casts, working casts, or remount casts to articulator

The movable member of the mounting frame is now locked to the base (Fig. 117), and thus the two parts are held rigidly together on the mounting frame base. After it is ascertained that the two axes are still continuous after the movable part has been tightened, the cast resting on the face-bow fork (Fig. 118) is attached. The leveling device is in position on the front of the upper bow and rests on the axis-orbital plane. This arrangement automatically makes the upper bow parallel to the axis-orbital plane.

A workable mix of stone is prepared, and the cast is attached to the mounting plate on the upper bow of the articulator (Fig. 119). The upper bow can be conveniently raised to permit placement of the stone. Its return to the proper level is ensured by the leveling device on the bow of the articulator. After making sure that nothing has moved, allow the stone to set firmly.

By the preceding method an upper cast is attached to the upper bow of the articulator. To complete the mounting of a set of casts, the face-bow is detached from the mounting frame, and the upper articulator bow is removed with the newly attached upper cast. By means of a centric interocclusal record, the lower cast is related to the upper cast, and they are attached with sticky wax on matchsticks or applicator sticks. The upper bow of the articulator is then as-

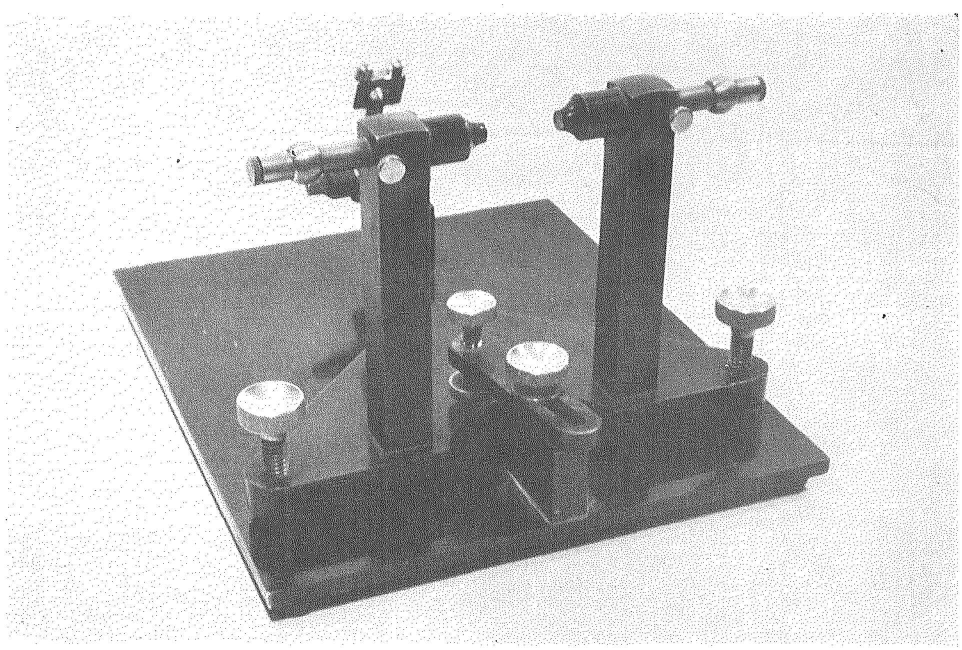

Fig. 117. Close-up of locking device which holds the two parts of the mounting frame rigidly together.

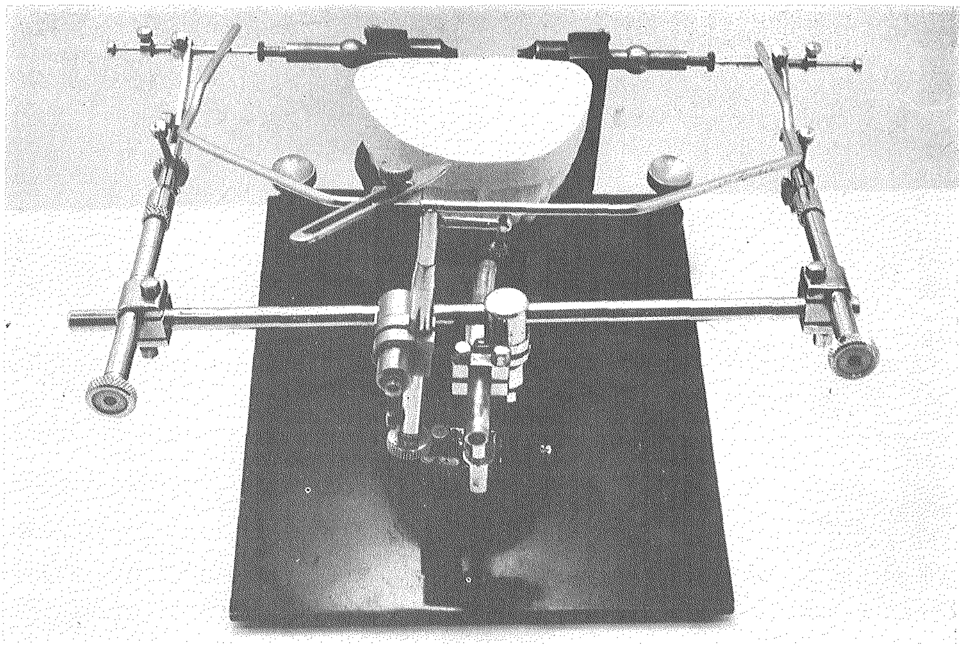

Fig. 118. Upper cast in position on face-bow fork of transfer bow.

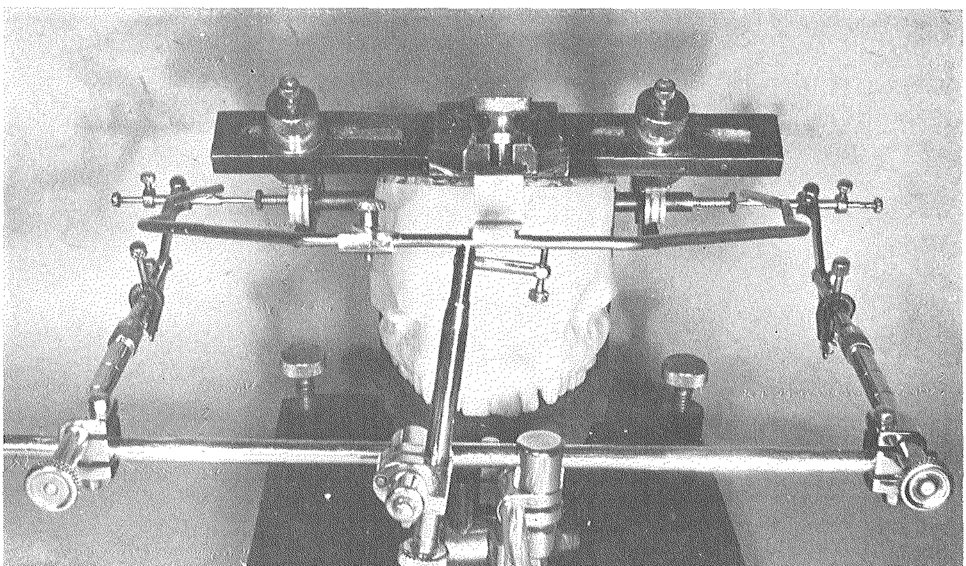

Fig. 119. Upper bow of articulator in position on mounting frame and attached to upper cast. Note leveling device which made upper bow parallel to axis-orbital plane.

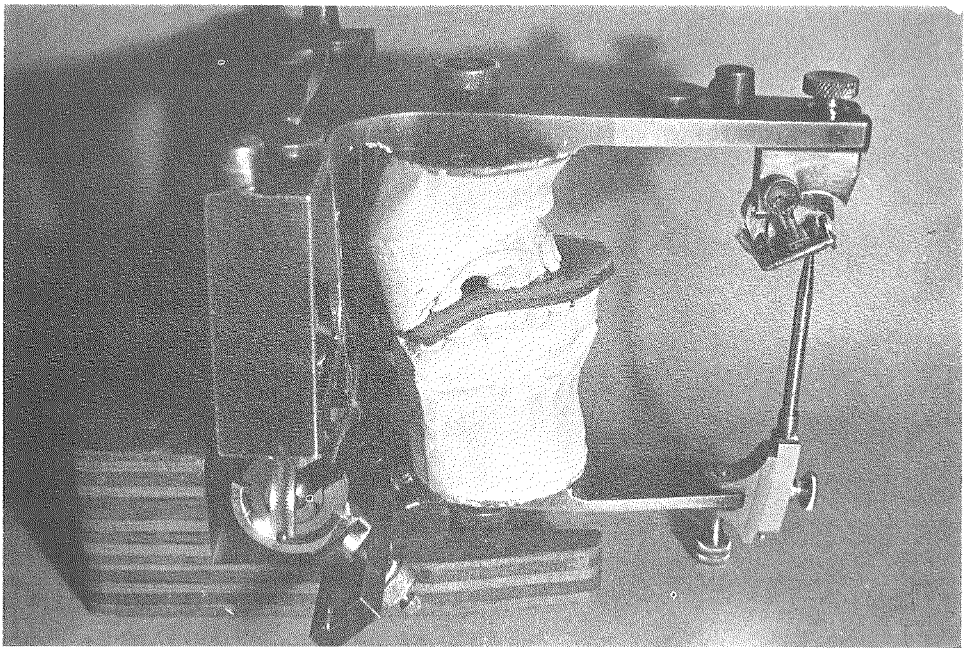

Fig. 120. Lower cast attached to lower bow of inverted articulator. Wax centric relation record is used to orient lower cast to upper cast.

sembled onto the lower bow, and the lower cast is attached to the mounting plate of the lower bow of the articulator (Fig. 120).

The technique just outlined permits accurate and convenient mounting of study casts, working casts, or remount casts to the articulator.

Technique for mounting pantograph to articulator

By a similar procedure the pantograph can be mounted to the articulator in order that the latter may be set to the patient's "jaw writings."

As it is removed from the patient, the entire pantograph (upper and lower members locked together) is attached to the mounting frame and held in position until the upper clutch is attached to the upper bow (Fig. 121).

In completion of the mounting of the pantograph, the upper bow and the pantograph are removed together (Fig. 122). The axis-orbital support and indicator can be removed without any of the remaining parts being disturbed. The lower articulator bow is assembled to the upper articulator bow, and the lower clutch model of the pantograph is attached to the mounting plate on the lower bow of the articulator (Fig. 123). In both cases, before the attaching stone is set, care must be taken to see that the articulator is in centric position. On the gnathoscope and the gnatholator the condyle slots must be tight against the balls. On Stuart's articulator the condyle ball must be against the posterior border of the glenoid fossa.

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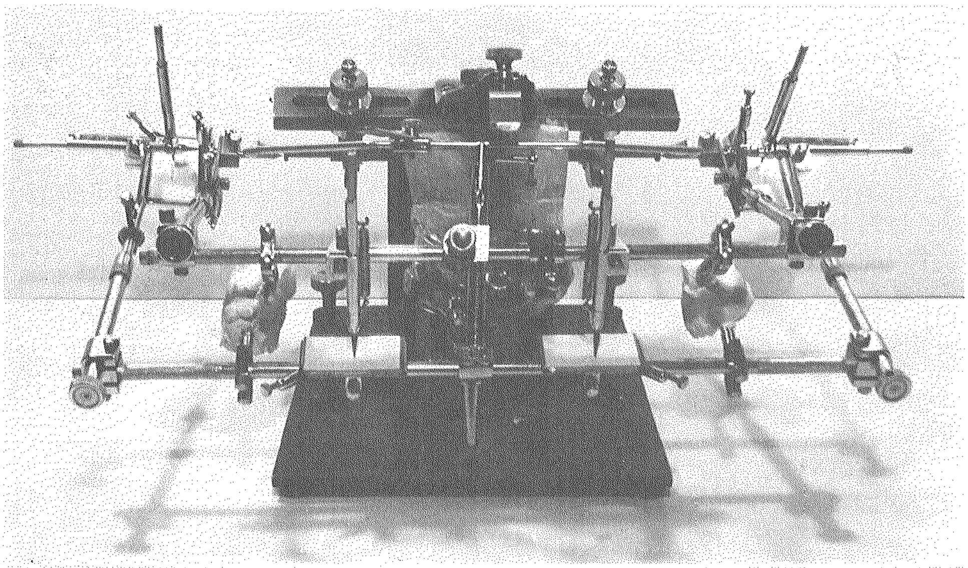

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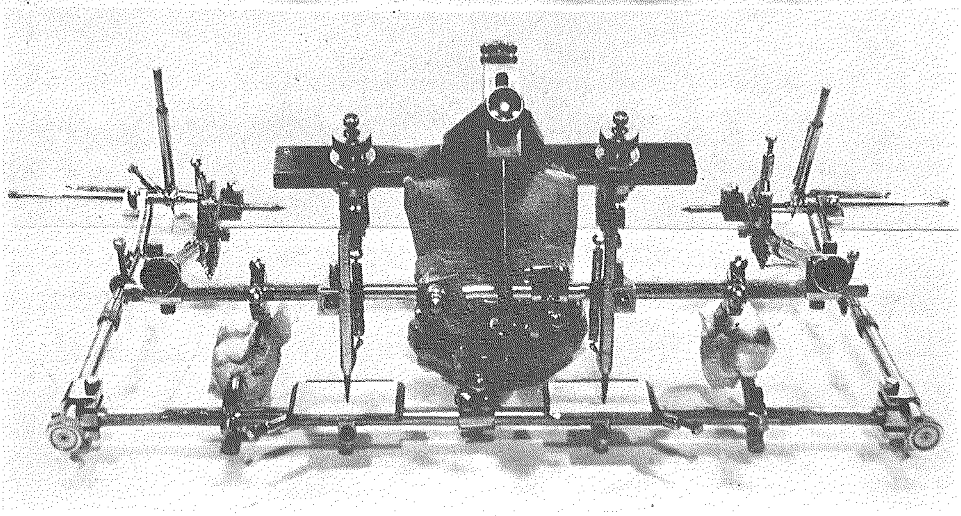


Fig. 121. Pantograph in position on mounting frame and attached to upper bow of articulator by means of upper clutch.
Fig. 122. Upper bow and pantograph removed from mounting frame.

When the mounting frame is in use, it must be remembered that the side pins of the face-bow cannot be moved in or out. Once they are set on the patient's face, they cannot be moved again until the mounting is complete. Reference to this was made in Chapter 3, but it bears repeating lest one be tempted to try it. The hinge action is located on the side of the face. The hinge action in the plane of the face is on the hinge axis. However, the hinge axis may be at an angle in relation to the front of the face or the top of the head. There is no practical way to line up the pins of the transfer bow so that they are exactly

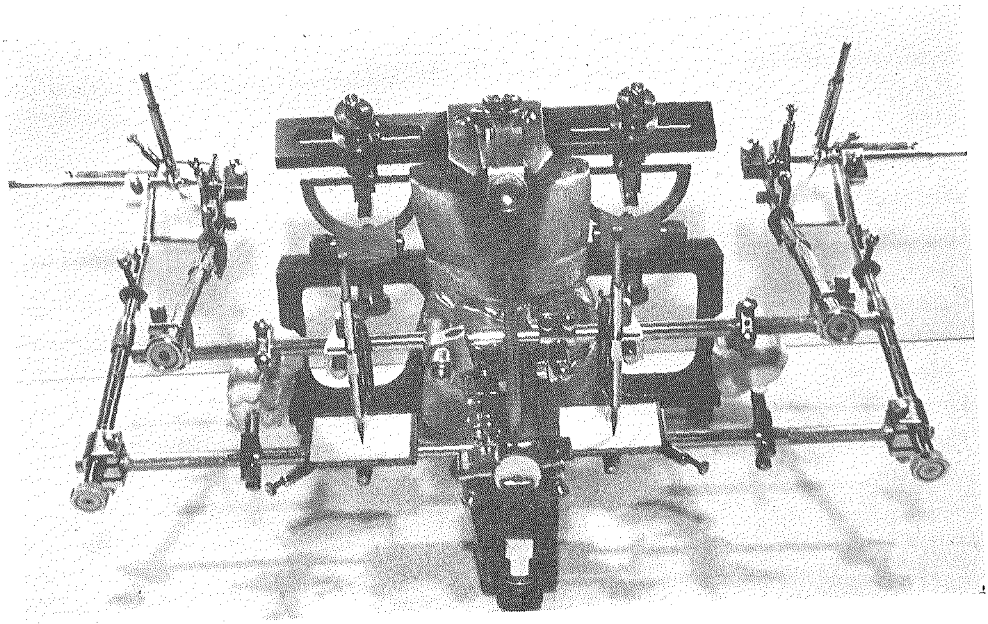


Fig. 123. Lower clutch cast attached to lower bow of articulator. Articulator must be in centric position.

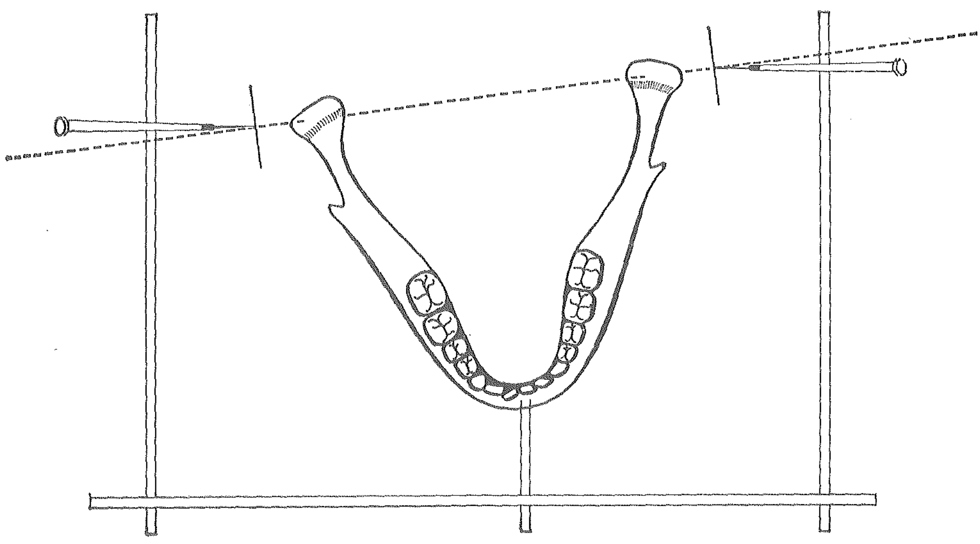


Fig. 124. Drawing showing why transfer bow pins cannot be moved in or out once they are set.

in line with the hinge axis.* Therefore, by locking the pins to the facial plane (the plane in which the hinge action has been located) and not moving them in or out until the mounting is complete, one eliminates the possible introduction of error (Fig. 124).

The only instance in which the side pins of the transfer bow could be moved in or out without incorporating an error would be when the entire pin on each side was exactly continuous with the hinge axis. However, this is neither practical nor necessary so long as it is remembered not to move the pins in or out once they are set. The reason for a mounting frame with telescoping intercondylar pins is to permit the axis of the articulator to be extended until it can be aligned exactly with the *tips* of the transfer bow.

In a similar manner, by means of a face-bow transfer, study casts, working casts, or remount casts containing all the restorations can be accurately mounted. The mounting frame facilitates the relation of the upper cast to the axis of the articulator. The centric interocclusal record permits the location of the lower cast to the upper cast and to the lower member of the articulator. Thus, with convenience, the casts can be mounted in the articulator so that they will have the exact relationship as the teeth have in the patient's mouth.

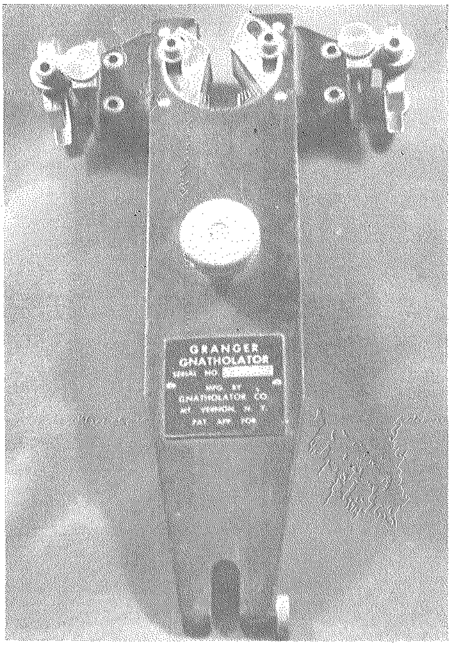
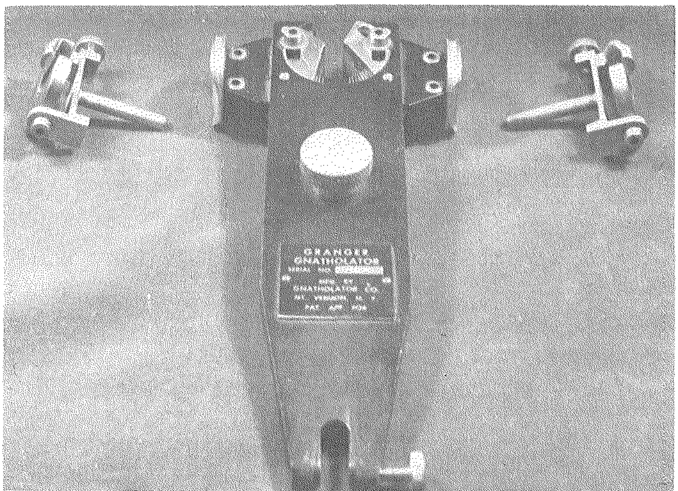


Fig. 125. Upper bow of gnatholator with condyle assemblies in position.

*The Hanau face-bow could be used to make a transfer if it were possible to lock the universal joint accurately while the telescoping rods were held exactly on the axis. This is almost impossible to do. If it were possible, then the telescoping rods could be moved in or out. However, it still does not have an orbital reference point.

GRANGER SYSTEM

With Granger's gnatholator* the mounting frame is slightly different although the principle is exactly the same.



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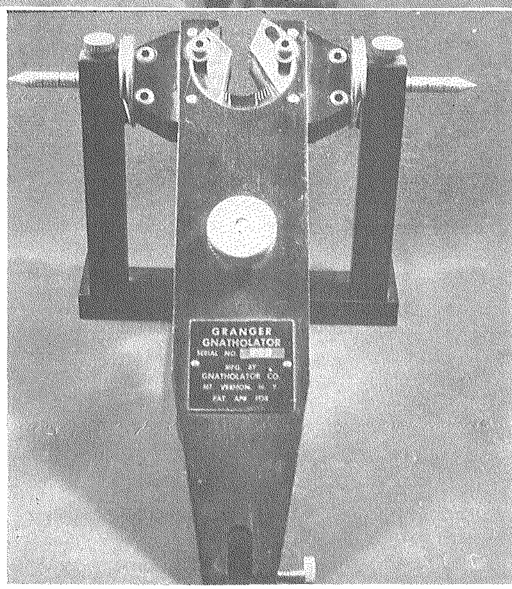

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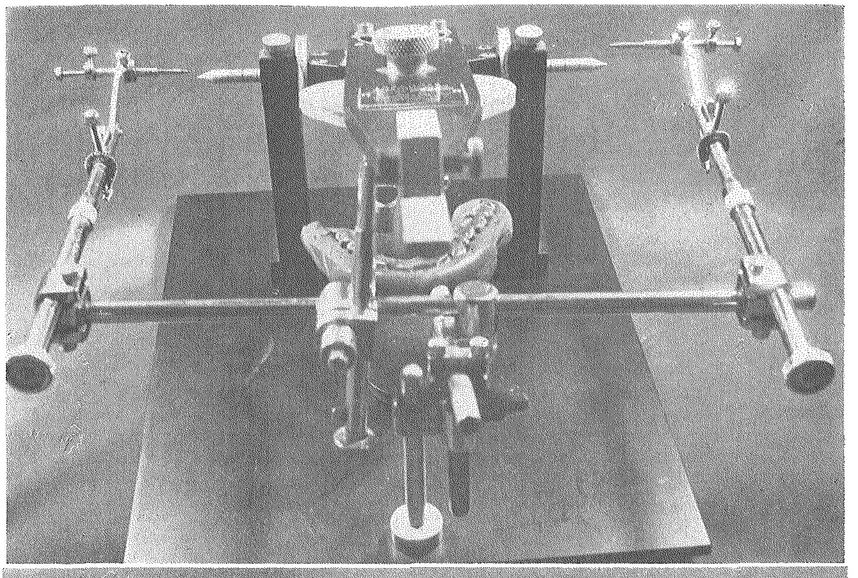
Fig. 126. Condyle assemblies removed in preparation for positioning on mounting frame.
Fig. 127. Upper bow held in position on mounting frame by means of telescoping rods.

The condyle path and holder (Fig. 125) are removed from each side of the upper bow (Fig. 126). The upper bow is positioned in the adjustable part of the mounting frame and held there by the telescoping rods of the frame (Fig.

*H. D. Justi & Son, Inc., Philadelphia, Pa.

128 

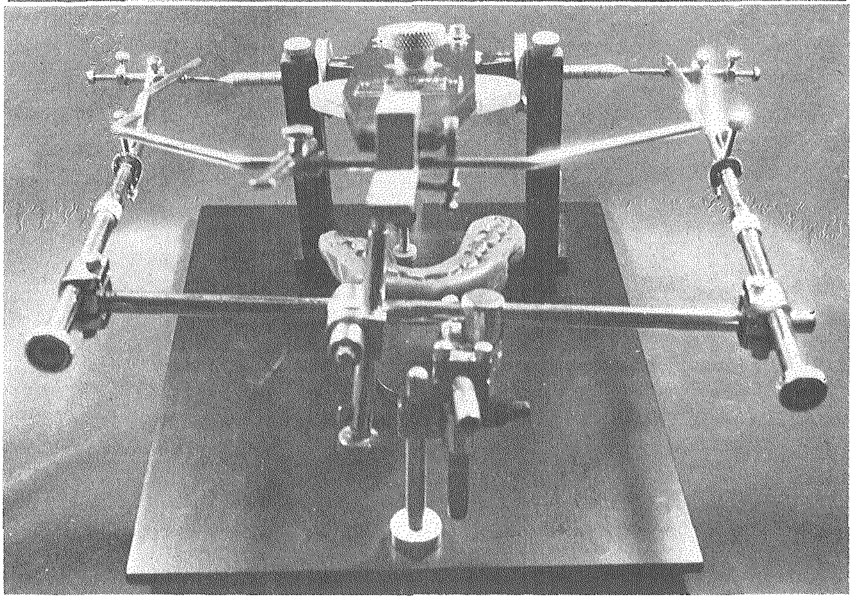
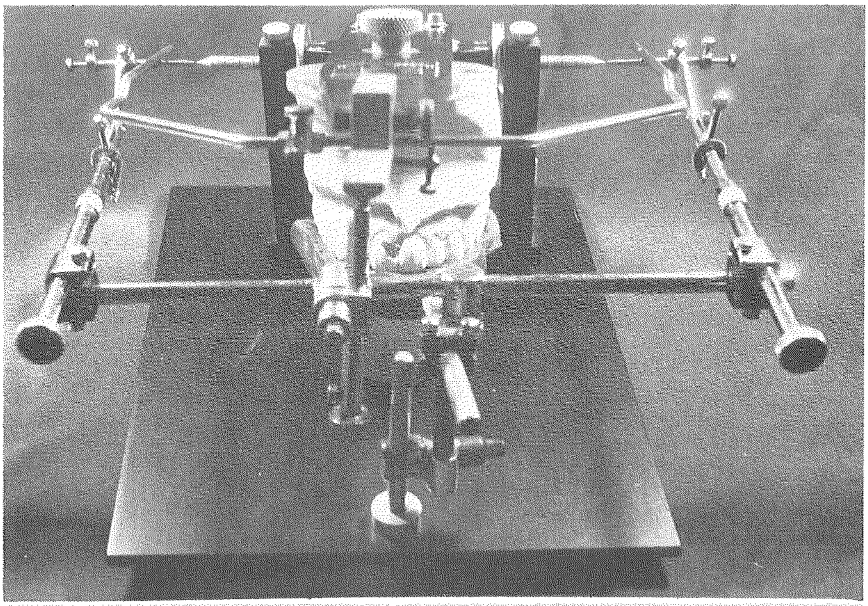
129 

Fig. 128. Transfer bow assembled on mounting frame.
Fig. 129. Intercondylar rods equidistant from styli tips and in line with them.

127). The face-bow or pantograph is attached by means of a clamp to the base of the mounting frame (Fig. 128), and the adjustable part of the mounting frame is positioned (with the upper bow) so that the telescoping rods are equidistant from and aligned with the tips of the stylus pins (Fig. 129). Adjustable screws on the movable part of the mounting frame permit accurate alignment of the two parts. A locking clamp holds this relationship until the upper bow is attached to the related part, whether a cast or the clutch of the pantograph (Fig. 130).

After this attachment is made, the upper bow (and the attached cast or pantograph) is removed from the mounting frame. The condyle path and holder



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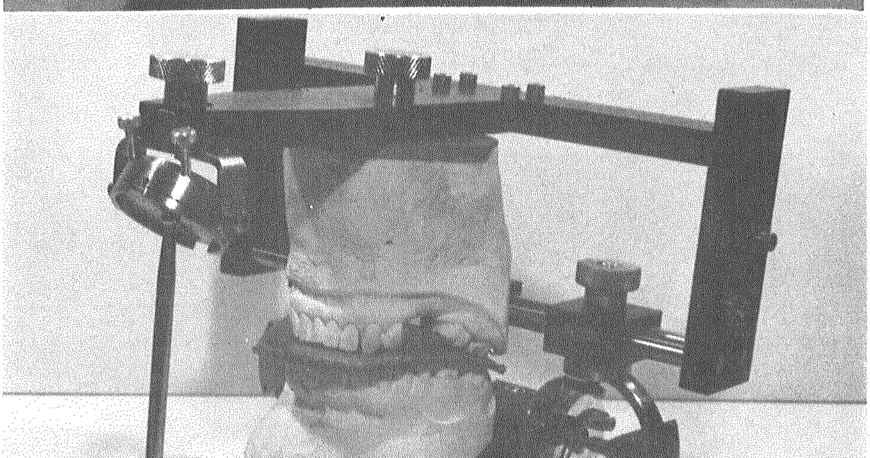

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Fig. 130. Upper cast attached to upper bow of articulator.
Fig. 131. Lower cast attached to lower bow of articulator as related by centric interocclusal record.

are replaced on each side of the upper bow, and the upper bow (with the attached cast or pantograph) is placed on the lower member of the articulator to complete the mounting (Fig. 131).

STUART SYSTEM

When Stuart's articulator* is used, the arrangement is somewhat different. The mounting table is simpler, and the articulator itself acts as the adjustable

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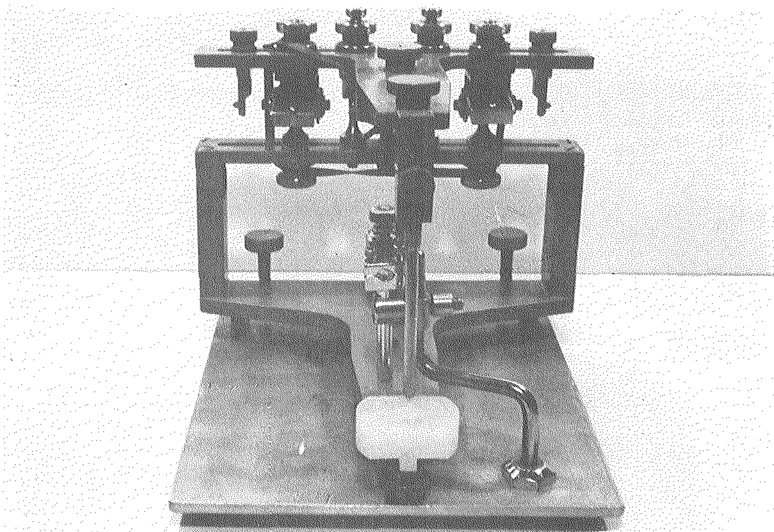

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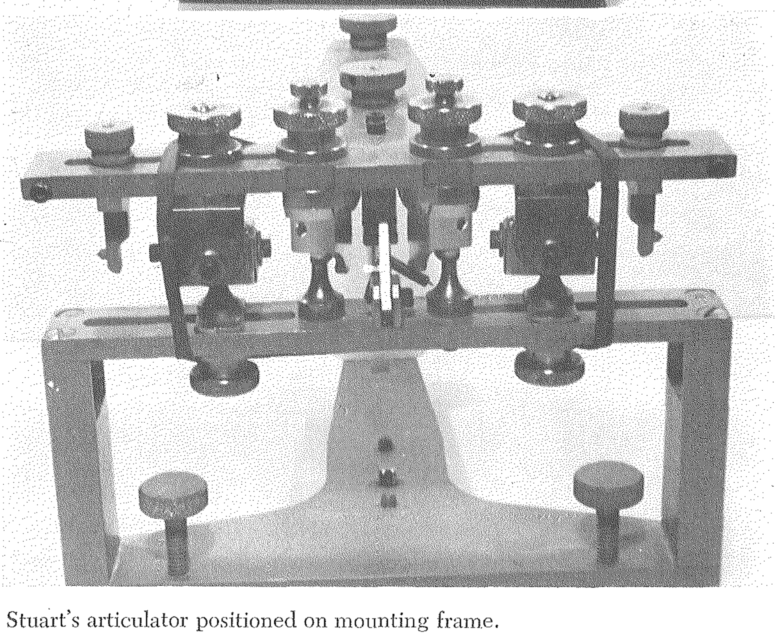
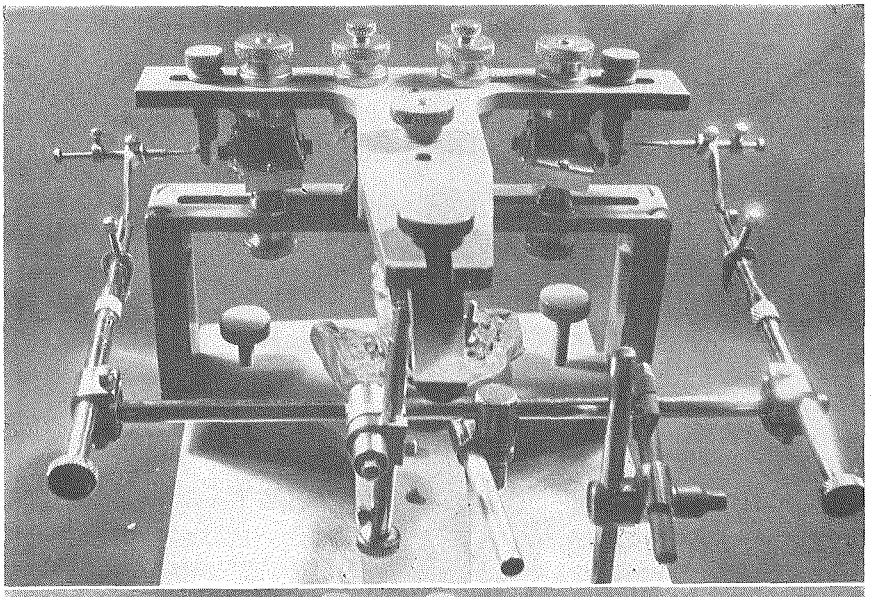


Fig. 132. Stuart's articulator positioned on mounting frame.
Fig. 133. Rear view of Stuart's articulator. Note adjustable intercondylar axis indicators.

*Dr. Charles E. Stuart, Ventura, Calif.



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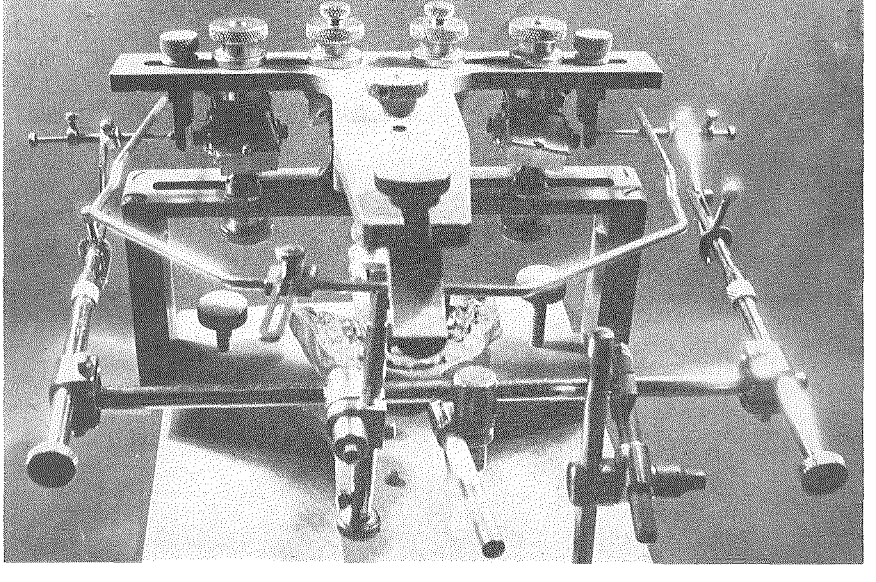

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Fig. 134. Transfer bow in position on mounting frame before complete alignment of intercondylar axis indicators with styli tips.
Fig. 135. Intercondylar axis indicators perfectly adjusted to styli tips of transfer bow.

part of the mounting frame (Fig. 132). The face-bow or pantograph is attached to the base of the mounting frame, and the entire articulator is placed on the frame. The upper bow of the articulator has two adjustable pins lined up with the axis of the articulator. The pins are set an equal number of calibrations on the upper bow so that the entire articulator is centered between the stylus pins of the face-bow or pantograph (Fig. 133). The tips of the pins are aligned with the tips of the face-bow (Fig. 134), thereby making the axis continuous. The lower member of the articulator has elevating thumbscrews which permit adjustment of the articulator to the face-bow (Fig. 135).

A locking device holds the articulator in this position on the mounting frame

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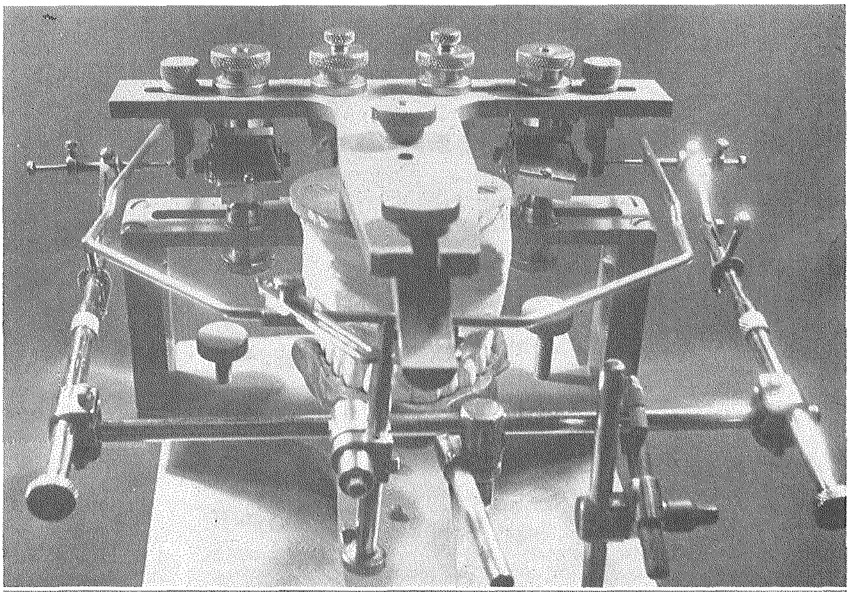

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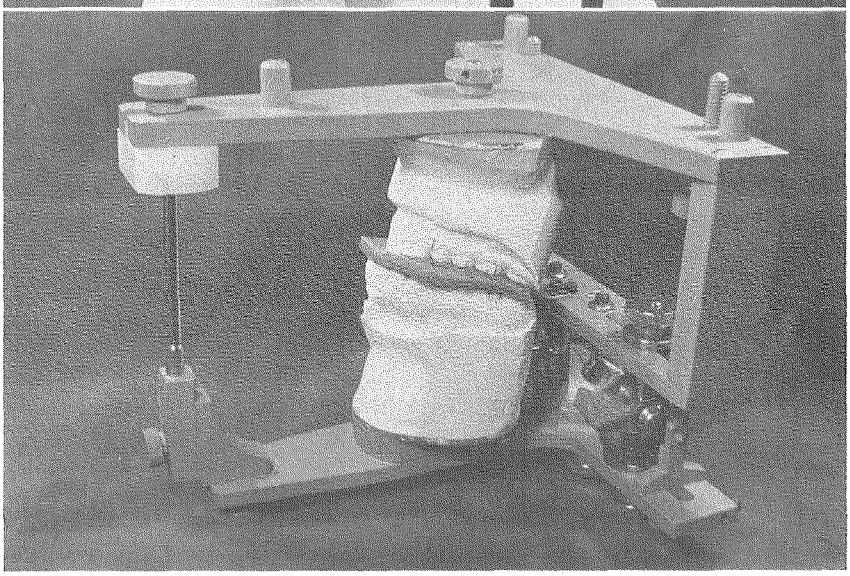

Fig. 136. Upper cast attached to upper bow of Stuart's articulator. Note leveling device to parallel upper bow to axis-orbital plane.
Fig. 137. Lower cast attached to lower bow of articulator as related by means of centric interocclusal record.

until the mounting to the upper bow is completed (Fig. 136). The attachment of the lower cast to the lower member is accomplished, as with the other articulators, by means of a centric interocclusal record and by inverting the instrument (Fig. 137).

The pantograph mounting is handled in a similar manner. The upper clutch cast is attached to the upper bow of the articulator after the pantograph styli are lined up to the intercondylar axis of the articulator. The articulator (with the pantograph attached to the upper base) is removed from the mounting frame, and the mounting is completed by attaching the lower clutch cast to the lower member of the articulator.

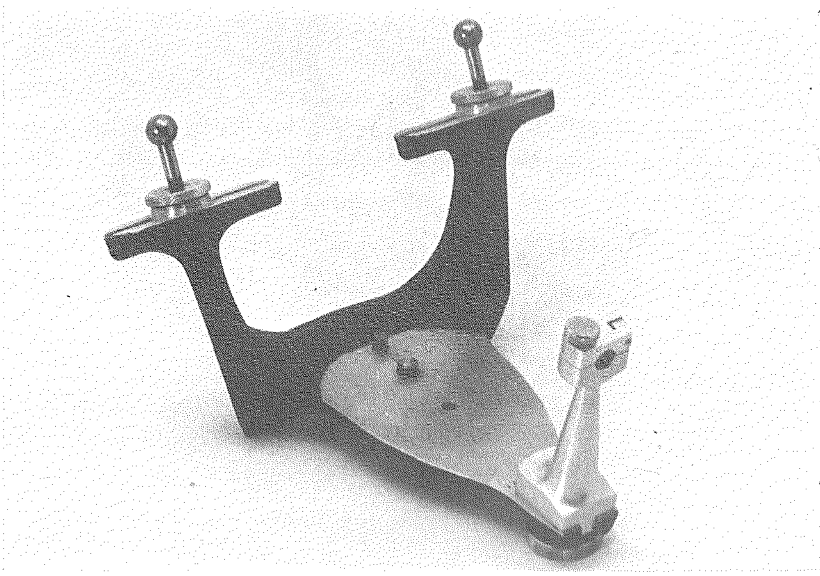

Fig. 138. De Pietro mounting post on the lower bow of the articulator.

DE PIETRO SYSTEM

In the De Pietro* system the mounting frame is replaced by a mounting post (Fig. 138). The mounting post is substituted for the incisal table, and the lower bow of the articulator becomes the base for the mounting post.

The transfer bow is placed on the mounting post in a convenient position (Fig. 139). After the distance between the pin tips of the transfer bow is measured (Fig. 140) and the intercondylar distance is set to this measurement, the upper bow of the articulator is put in place (Fig. 141). The properly related cast is now attached to the upper bow of the articulator. Note that there are

*J. M. Ney Co., Hartford, Conn.

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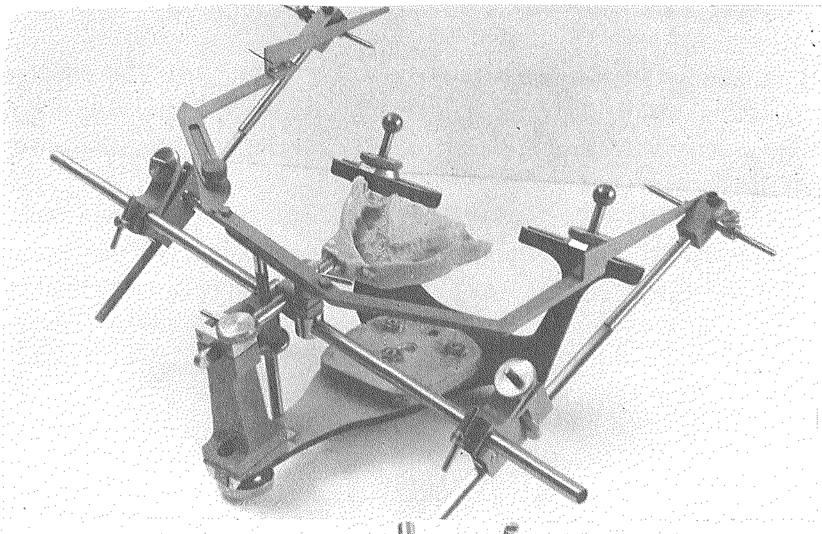

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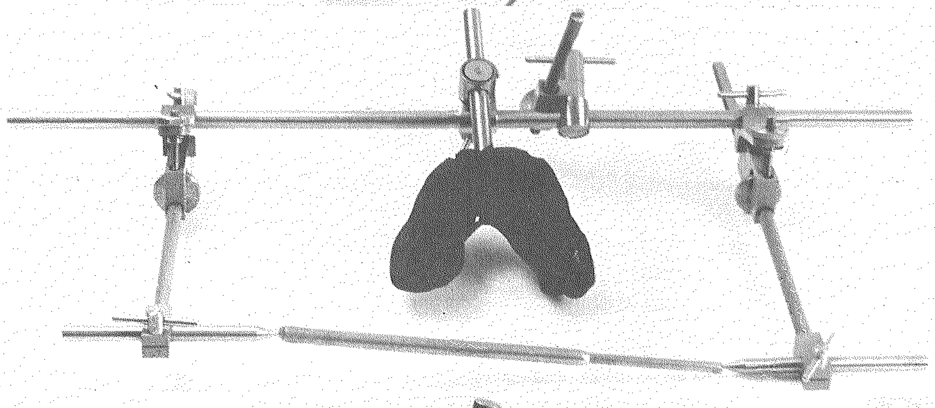

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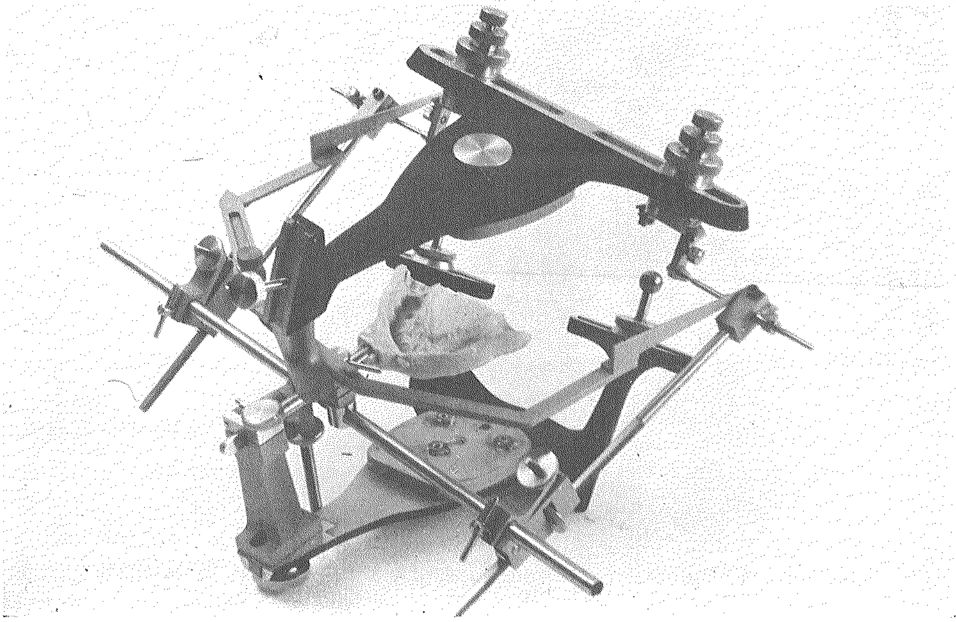

Fig. 139. Transfer bow conveniently positioned on the mounting post.
Fig. 140. Measuring the distance between the tips of the transfer bow pins.
Fig. 141. The upper bow of the articulator is placed on the transfer bow.

no fine adjustments necessary—it automatically perfectly relates the axis of the articulator to the axis of the transfer bow. In addition any slight movement of the transfer bow automatically carries the upper bow of the articulator with it because it is held by the transfer bow.

CHAPTER 7

Centric relation

Webster's *Collegiate Dictionary* defines "centric" as follows: "adj. 1. Placed in or at the center or middle; central. 2. Of, pertaining to, or characterized by, a center."

Perhaps our dental ancestors deserve more credit than we have given them. Unfortunately, their lessons were either not well taught or else not well received, for very few dentists indeed correlate a center with "centric" relation.

CONFUSION AS TO MEANING

Centric relation means many things to many men. To most, it means the contact of teeth after a jaw closure. To some, it means a closure in a particular position, the particular position having many interpretations varying from an habitual closure to a forced retrusion, or somewhere in-between. Others identify it as the most retruded position from which right and left lateral excursions can be made. Some men refer to centric relation when they are talking about the mandible, disregarding the teeth. Depending upon their belief and understanding, they decide that the mandible is in centric position, and that if the teeth occlude in this mandibular relation, then the teeth are in centric relation. Other men describe "mandibular centricity" as a mandible-to-maxillae relationship at a certain vertical dimension.

To all these men, centric relation has a definite meaning; yet the meaning is not the same to all of them. That this is so is unfortunate because it is hardly an exaggeration to say that no other phase of dentistry is so important as a clear understanding of centric relation. Obviously, it should have one and only one connotation to the dentist.

To understand centric relation and to appreciate its great importance, one must understand how the jaw functions and must set about to make restorations that will function normally in that jaw. They must neither interfere with nor force a particular action on the chewing mechanism. In other words, the restorations must fit into the pattern of jaw movements. They should follow, without any detrimental effects, the movements of the masticating mechanism. Because the teeth are secondary in importance to the mechanism relative to determining movement, because quite frequently they are missing, because we are often called upon to place restorations in the teeth, and because the teeth are only the instruments of mastication, we must direct our attention to that part of the mechanism which is responsible for the movements of the jaw. The means of motion have been described elsewhere in this book. The present concern is with the *type* of motion, how it takes place, and its bearing on the all-important subject of centric relation. This, of course, directs attention to the temporomandibular joint. For the moment, the other important structures—the muscles, tendons, ligaments, nerves, blood supply, and teeth—may be forgotten, and consideration may be confined to the action of the temporomandibular joint.

LOCATION OF THE CENTERS OF ROTATION

It is possible to demonstrate beyond any doubt that there exists a recordable center of vertical rotation in the condyles. An imaginary line joining these centers has been termed the hinge axis.

In practice, when the point on the side of the face for the hinge axis is located, what is actually being located is the hinge *action* in the facial plane (on the side of the face). This is not the true center of vertical motion, however, for that is located in the condyle. What is being located is a point on a line that has been extended from the centers of vertical motion. In other words, the point located on one side of the face is on the same line passing through the actual centers of vertical rotation in each condyle and through the point on the other side of the face. For this reason, when a transfer is made, the points of the stylus must not be moved in or out once the point of hinge action is located. In practice, there must be a means of transferring these hinge-action points to a suitable articulator, the intercondylar axis of which can be lined up with these points. This is accomplished with the mounting frame, which is discussed in detail in Chapter 6.

It should be obvious that these centers of hinge action can be located only when the condyle is in a position where it can repeatedly scribe these arcs, in short, when it is in the most retruded position in the glenoid fossa. Because patients normally do not execute a hinge action in the most retruded position of the mandible, they have to be educated to this movement. When this is considered, as well as the many habits patients can acquire over the years and the conditioned reflex action forced by habit and tooth relations, it is easy to understand why some patients reluctantly produce the hinge action during treatment.

This hinge action (and the imaginary line called the hinge axis) is constant to the mandible. In other words, the vertical motion of the mandible (and condyles) is produced by the action of the heads of the condyles on the undersurface of the meniscus. Thus, as the condyle and the meniscus translate—

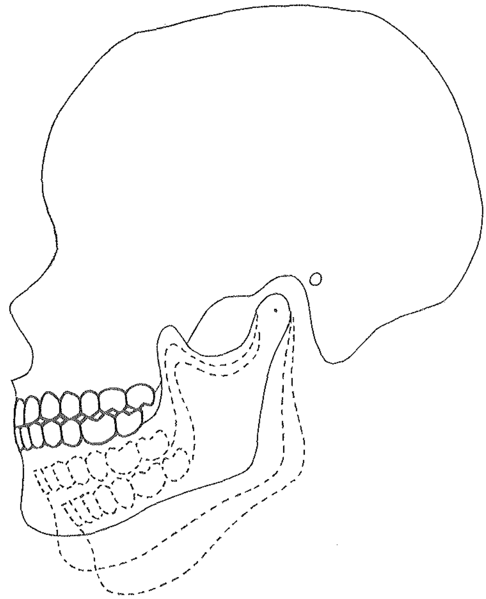

Fig. 142. Diagram showing that the hingelike action of the mandible can take place in any position.

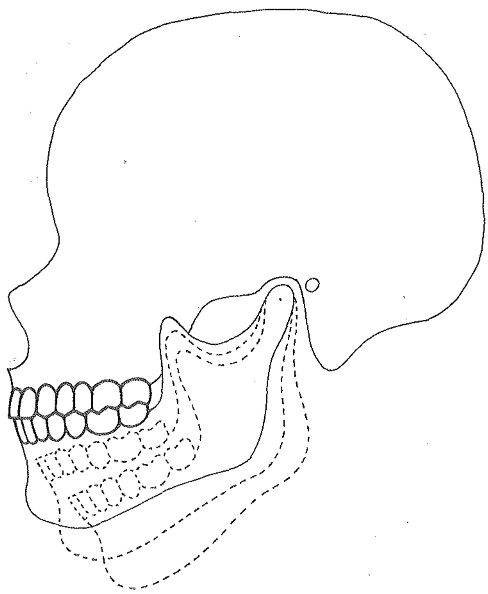

Fig. 143. Diagram of the mandible in the terminal hinge position.

move down the incline of the glenoid fossa or across the trough of the fossa in the Bennett movement—the mandible can produce this hingelike action in any position of the condyle (Fig. 142). In function, as a matter of fact, it will start to produce a hingelike action as it glides down or across the condyle path. It must be remembered that the hinge action is constant to the meniscus in any position it may find itself, but it is constant to the maxillae or fossae only in the most retruded position of the condyles. It is constant to the maxillae when the condyle is executing the hinge action in the terminal position. This has been called "centric relation" by many (Fig. 143); however, as we shall show, this does not go far enough.

In addition to the centers of vertical (opening and closing) motion of the mandible, there exist centers of lateral rotation. The patient can make pure lateral movements. These lateral movements have centers of rotation located in the condyles. At one time, there was considerable confusion about these centers because seldom are they stationary. In other words, the centers themselves move as the mandible (condyle) is making the movement. The path of these centers of lateral rotation on the rotating or working side is the Bennett path. The confusion arose because it was claimed that the center of lateral rotation was some place in back of each condyle or in the vicinity of the foramen magnum. The moving centers of lateral motion were called "loci." Actually, what was termed the center of lateral movement behind the condyles or "somewhere else" was the center of the locus. In short, the *center of the path* that the *center of lateral movement* was making on the working side was in fact the center of the Bennett path.

It is practical to locate the exact centers of lateral rotation by means of two Gothic arch tracings taken in the same plane in front of each condyle and on either side of the midline of the face (Fig. 144) and to reproduce their paths across the fossae. When this has been done in conjunction with the location

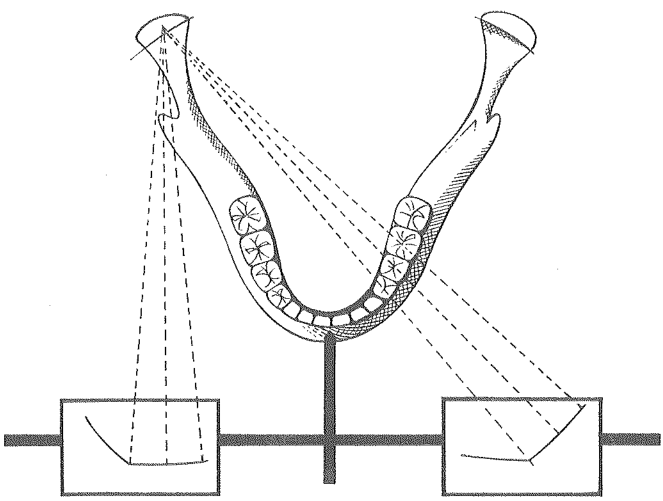

Fig. 144. Diagram showing the Gothic arches produced by the centers of lateral rotation.

of the centers of vertical rotation (hinge action), then we have truly found centric relation. The terminal hinge action is the vertical component of centric relation; the centers of lateral rotation are the lateral components of centric relation.

Why this is centric relation, we shall now attempt to explain. We shall also show why it is so important.

It might be stated categorically that unless the centers of rotation are located, centric relation is disregarded. This statement will immediately draw protests because, regardless of one's understanding of centric relation, all will agree that it is essential to the practice of dentistry and cannot be ignored.

Let us analyze what really happens.

In the course of constructing occlusal surfaces for dentures, bridges, or natural teeth, a centric interocclusal record is taken, using the material of choice. The casts on which the restorations are going to be fabricated are mounted on some sort of instrument and the restoration constructed.

Now in order for a centric interocclusal record to be useful, it must register the maxillomandibular relationship without any tooth contact or tooth penetration of the recording medium. If tooth surfaces contact through the recording medium, one can be sure that the proprioceptive reflexes have come into play and caused an improper relationship to be recorded.

It is apparent that one of two things must be done even to begin to get an accurate interocclusal record. Either it must be secured at the exact level of vertical dimension without tooth contact (a nice trick if it can be accomplished), or else the casts must be mounted on the articulator to the same opening axis which the mandible has to the maxillae of the patient. If the latter is done, then the centric interocclusal record can be secured in an open position to

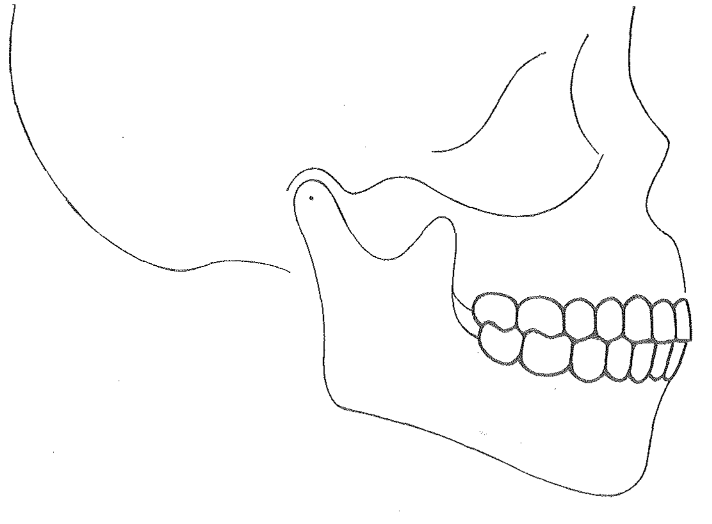

Fig. 145. Diagram showing the apposition of the cusps after the recording medium has been removed.

clear the tooth contacts, and when the registering medium is removed, the teeth on the casts can be approximated as they are in the mouth (Fig. 145).

It is also most desirable that the centric mounting be checked because on this relationship will depend many hours of laboratory work. Except by pure accident, it is utterly impossible to check a centric interocclusal record accurately unless hinge axis procedures and transfers have been used!

In order to check a centric interocclusal record, it is necessary to take a second record—and with all the care used to take the first one. It would be pure chance if the second record were of the exact thickness as the first. The wax might be softer, or the patient might close the mouth further. Whatever the reason, chances are against getting records of exact thickness. Yet, unless the second record were on the same arc of closure on the articulator as in the mouth, the thickness of the two records would have to be absolutely identical.

The seating of a wax interocclusal record on casts can be quite deceiving. The second record might appear to fit between the casts without causing any malposition of the articulator parts. However, if one really wants to determine whether the two centric interocclusal records are identical, he must resort to the following procedure, which is frequently demonstrated in the clinics of Dr. Arne Lauritzen.

Split cast technique

Before the upper cast is mounted on an articulator, a second section (the split cast) is carefully prepared. First, it is very important that the upper cast be poured with extreme accuracy, care being taken to avoid any bubble formation. The mounting side of the upper cast is trued up on a model trimmer. V notches are cut on the edges of the mounting side of the upper cast—one in

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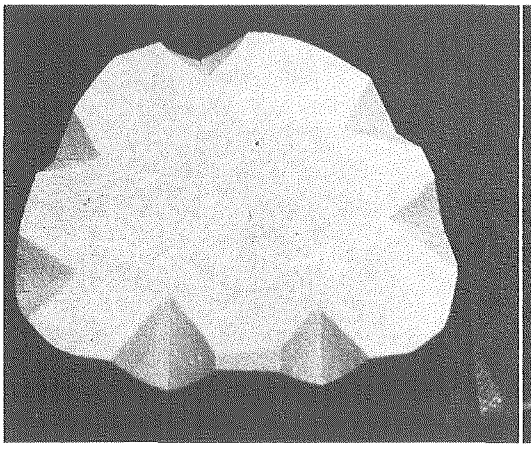

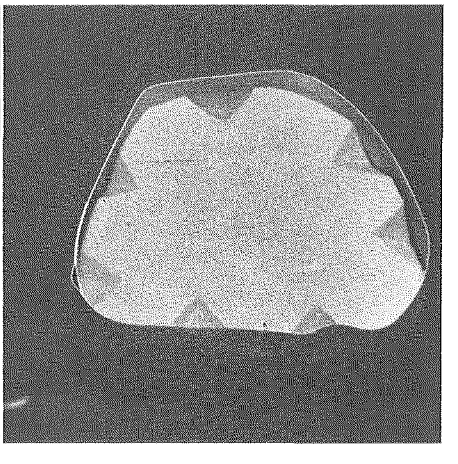

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Fig. 146. Upper cast prepared for construction of the split cast.
Fig. 147. Tape wrapped around prepared cast produces a form into which the carefully mixed stone is poured for the split cast.

front, two on the sides, and two in the posterior region (Fig. 146). These notches are carefully made so that they are truly wedge-shaped. A piece of electrician's paper tape is wrapped around the periphery of the cast, producing a form into which the second section of the split cast is poured (Fig. 147). Prior to this pour, the cast has been carefully lubricated with Kerr separating medium.* Three knobs of stone are placed on top of the pour to serve as handles in the separation of the disc from the original cast (Fig. 148). In pouring the disc, it is extremely important to prevent any bubbles from forming. When the disc pour has hardened, the cast is separated from the disc by removing the electrician's tape and using the stone knobs on the disc as a handle. Immediately after separation, the two parts are reassembled to prevent any dust or loose fragments of stone from adhering to the contacting surfaces. The knobs are now cut down with a model trimmer, just enough of them being left to engage the new mix of stone that will be used to fasten the disc and cast to the upper bow of the articulator (Fig. 149).

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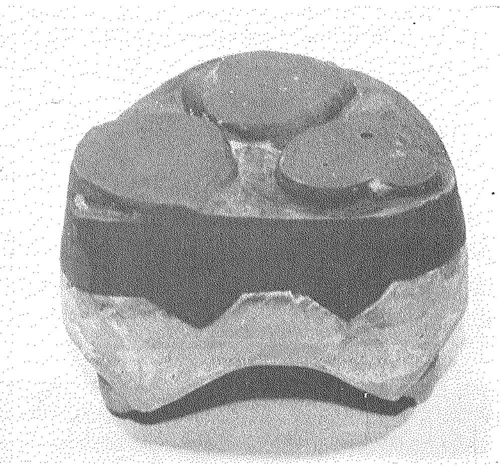
 149

Fig. 148. Knobs of stone facilitate separation of the disc from the cast.
Fig. 149. Knobs cut down prior to articulator mounting.

By means of a face-bow transfer, the upper cast and disc are accurately attached to the upper bow of the articulator. By means of the centric interocclusal record, the lower cast is next attached to the lower bow of the articulator. This completes the mounting of the split cast, and the lower cast is in what is believed to be centric relation (Fig. 150).

If one now opens the articulator, separates the disc from the upper cast, presses the upper cast into the centric interocclusal record to be sure it is accurately seated in place (Fig. 151), and then attempts to close the upper bow

*Kerr Manufacturing Co., Detroit, Mich.

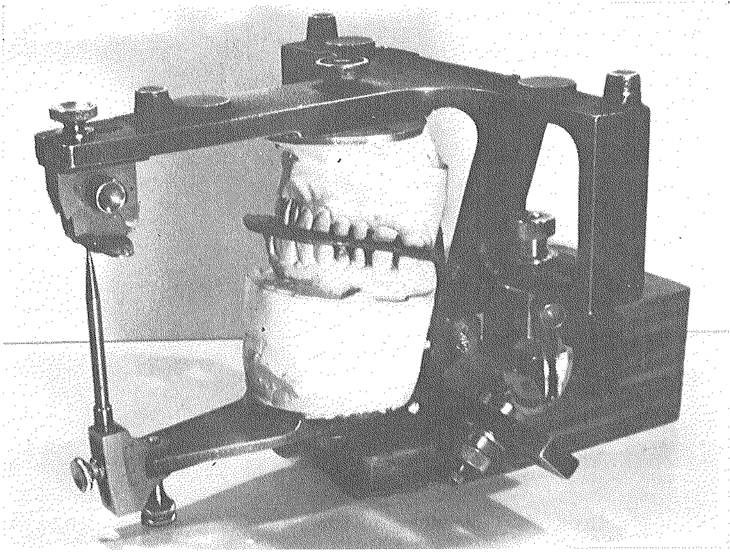


Fig. 150. Completed mounting of upper cast, split disc, and lower cast.

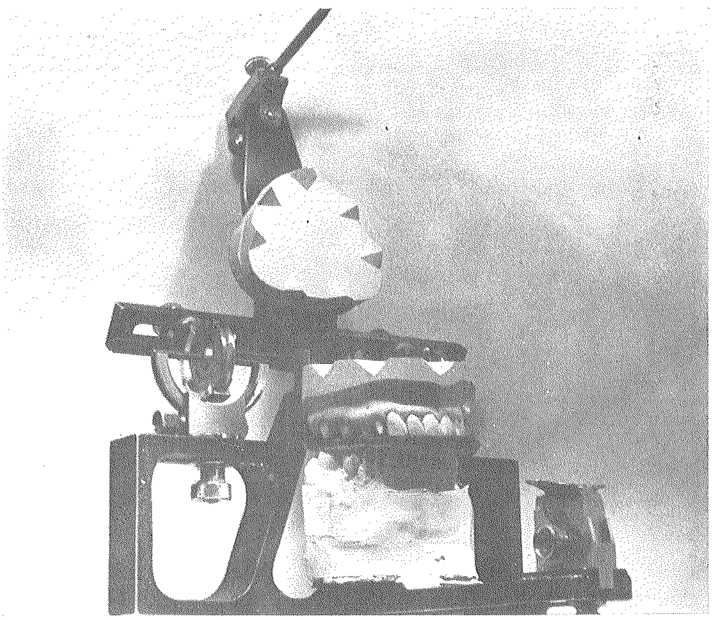


Fig. 151. Upper cast seated into centric interocclusal record.

and disc into the V notches on the upper cast, he will soon find out whether the mounting was accurate (Fig. 152). If it is satisfactory, this mounting and interocclusal record are checked with the second record. The first wax record is replaced by the second one (Fig. 153); the upper cast is seated into the indentations; and again an attempt is made to close the disc into the V notches of the upper cast (Fig. 154). It is amazing how often an apparently acceptable interocclusal record is a great deal off. This technique should be ample proof that a centric interocclusal record cannot be accurately checked unless the hinge axis and hinge transfer procedures are used.

If these procedures are as far as we go, the restorations constructed on such casts will come together accurately in centric closure. If one more step is added

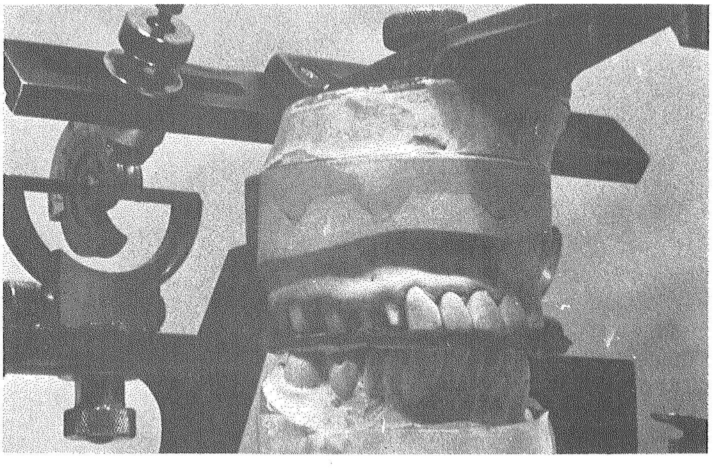


Fig. 152. Upper bow with upper disc closed into upper cast held in position by centric interocclusal record.

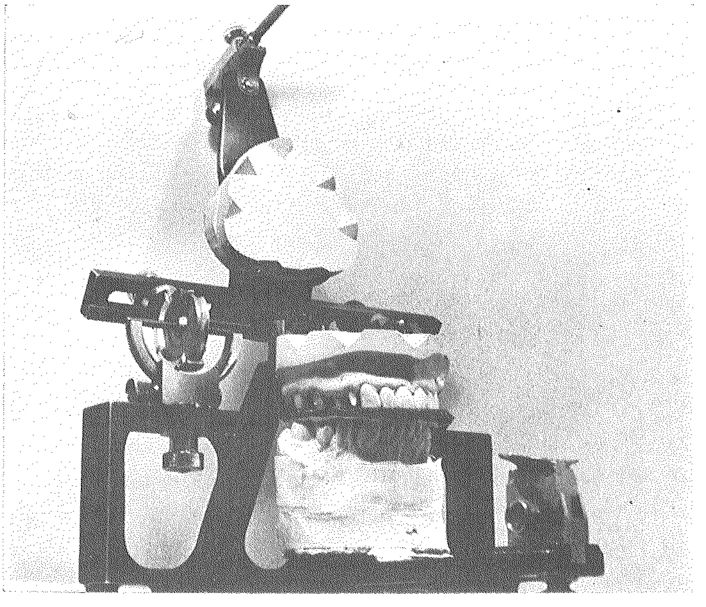


Fig. 153. First centric interocclusal record replaced with second record to check similarity of one to the other.

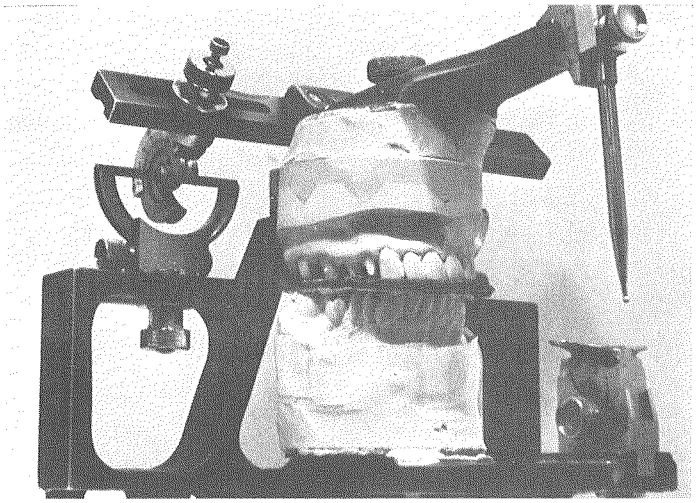


Fig. 154. Upper bow with upper disc closed into upper cast held in position by centric interocclusal record. Checks out.

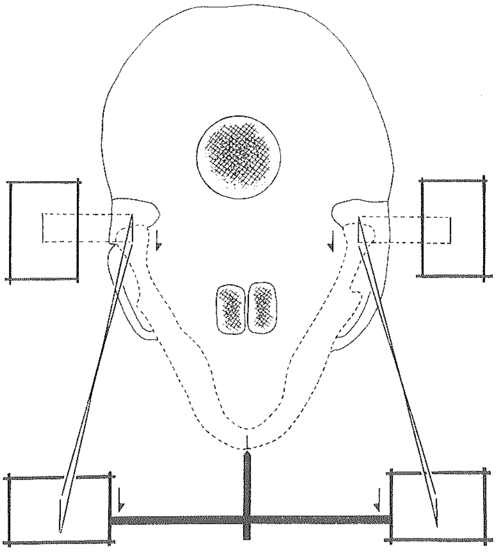
and a protrusive path with a protrusive record is produced, it is possible to have proper contacts in both the centric and protrusive relationships. Unfortunately, though, patients do not chew in these positions alone.

How does a dentist manage without using the axis and a protrusive record? Like the man who simply takes a static closure, he does a great deal of work in the mouth, grinding here and there until some surfaces come together. Considerable work is involved for an inferior result.

The man who takes a hinge-closure record, relating it properly to an instrument by means of a face-bow, and then takes a protrusive record is only slightly better off. He still has all the lateral excursions with which to contend. Whether one believes that the patient uses the lateral excursions, the fact is that he will use them if he is permitted to. The apparent short cuts—not locating an axis, not reproducing all of the patient's movements—are responsible for the creation of flat, useless occlusions.

If these headaches are to be avoided, *the centers of rotation must be located.* In addition to locating the hinge axis and obtaining a proper centric interocclusal record, the centers of lateral rotation must also be located. This is accomplished by means of the twin Gothic arch tracings (Fig. 144). Moreover, the paths of these centers of lateral rotation must be traced. This is done with an extraoral tracing device, the pantograph, which is fully described in Chapter 8. With the pantograph, the protrusive paths of the centers of rotation can be traced (Fig. 155), as well as the right and left lateral paths (Figs. 156 and 157).* From the pantograph tracings made by the path of travel of the centers of rotation, the procedure can be reversed, and the centers and their paths can

*The pantograph is the only practical present-day means of accomplishing this.



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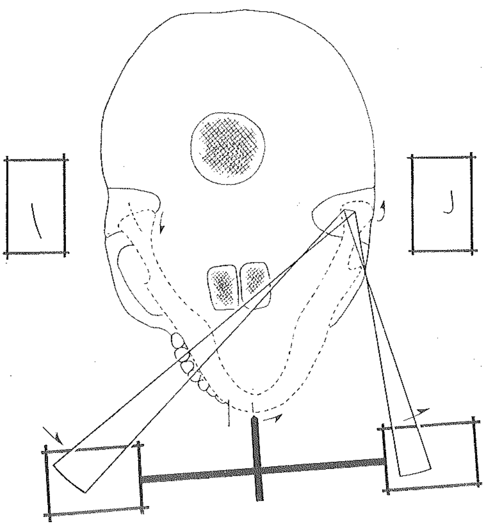

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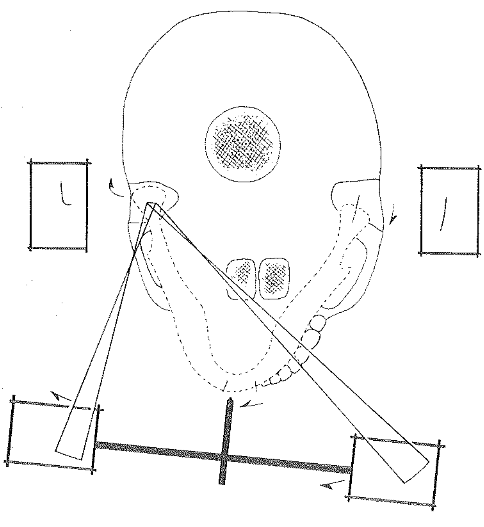

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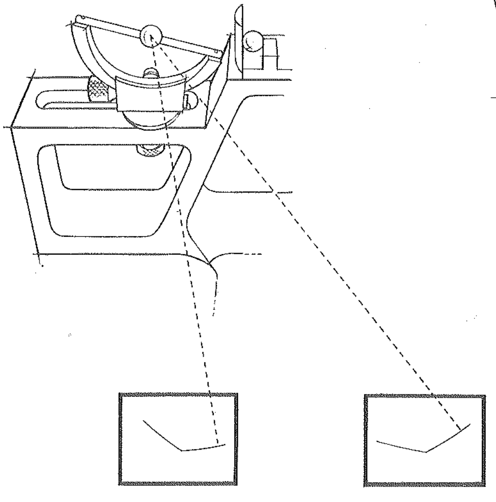
Fig. 155. Diagram of the pantographic tracings of a protrusive movement viewed from below. Note posterior tracings travel with the center of rotation, whereas the anterior tracings seem to go backward. This is because the anterior slides (on which the tracings are made) are attached to the mandibular part of the pantograph, whereas the posterior slides are attached to the maxillary part.
Fig. 156. Diagram of the pantographic tracing of a right lateral excursion. Note the side shift of the pivoting condyle.
Fig. 157. Diagram of the pantographic tracing of a left lateral excursion. Note correlation of the two sides and compare with Fig. 156.

be duplicated on an articulator capable of full adjustment (Figs. 158 to 160). Now when the restorations are constructed and placed in the mouth, they will be in harmony with the patient's movements. It will not be necessary to grind them, with resultant destruction of proper function (Fig. 161).



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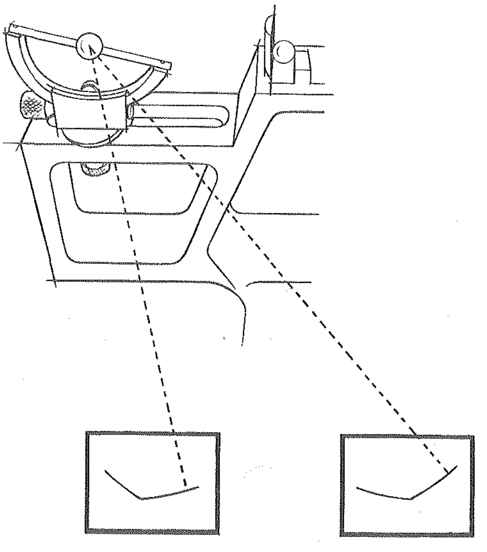

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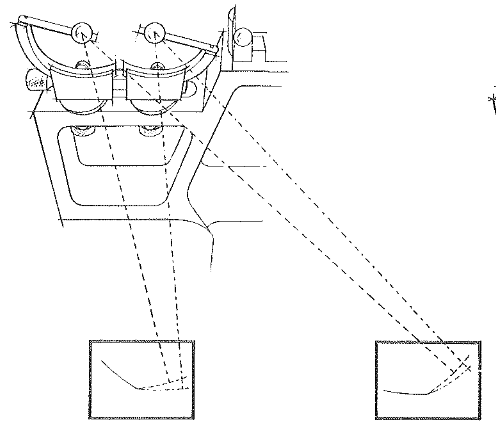

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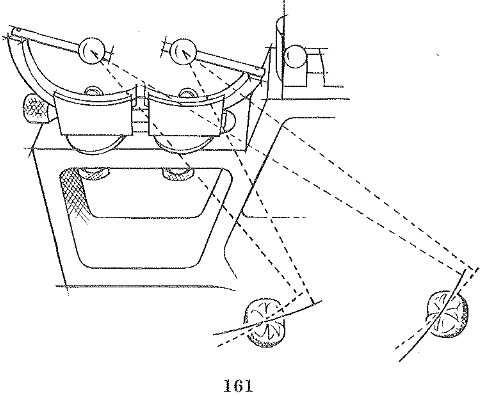

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Fig. 158. Diagram showing how projections from the wings of the Gothic arch tracings determine the center of rotation on an adjustable articulator.
Fig. 159. Diagram showing a variation in the Gothic arch wings which locates another center of rotation.
Fig. 160. Composite diagrams of Figs. 158 and 159 to show how the wings of the Gothic arches determine the correct centers of rotation for each patient.
Fig. 161. Diagram showing the paths of travel of an upper cusp in the molar area dictated by two different centers of lateral rotation. The centers of lateral rotation are individual to each patient.

In summary, a thorough understanding of centric relation is essential to the proper practice of dentistry. However, unless the centers of rotation are located, centric relation is disregarded, which entails the following:

1. Location of the hinge axis
2. Location of the centers of lateral rotation
3. Transference of the casts to the axis: (a) face-bow transfer of the upper cast to the axis; (b) relation of the lower cast to the upper by a correct centric interocclusal record

OBTAINING CENTRIC RELATION—VARIOUS MATERIALS FOR VARIOUS SITUATIONS

The technique of obtaining a centric relation is secondary to an understanding of the phenomena. Various materials will produce acceptable results, but the important thing is to know what we have to get and to be aware that we have what we want.

From the preceding discussion, we know that the centers of rotation must be located. By means of the two Gothic arch tracings we are able to locate the centers of lateral rotation. By means of the hinge axis location the centers of vertical rotation are located. The practical problem now is to couple these two centers of rotation into *the* center of rotation. To do this, the lower jaw has to be related to the fixed member, the upper jaw. After the upper jaw

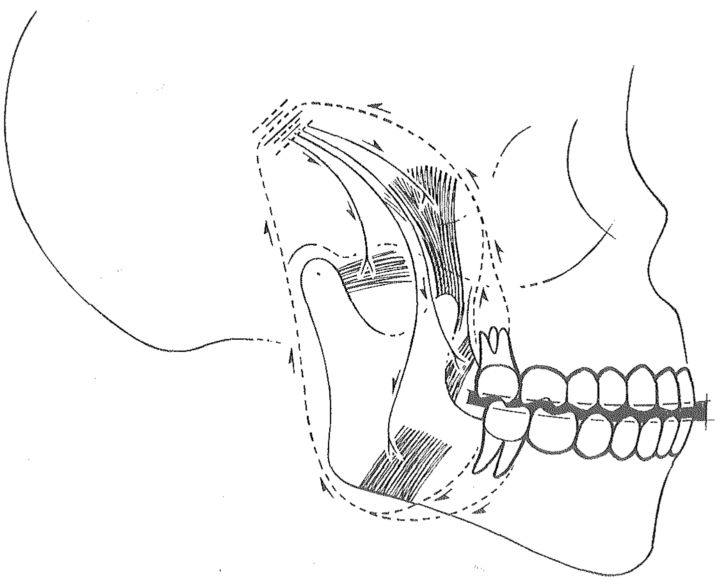
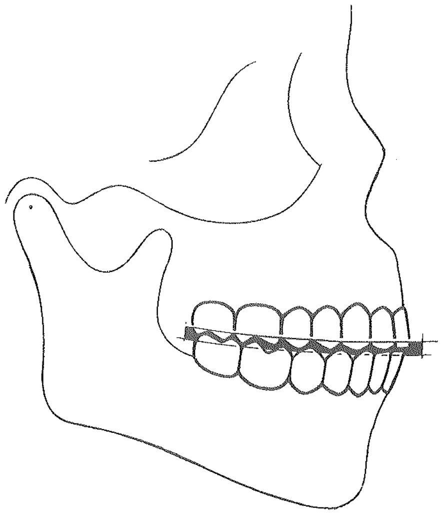


Fig. 162. Schematic drawing showing the path of travel of a proprioceptive impulse from the periodontal membrane to the motor cortex, which in turn sends an impulse to the muscles to move the mandible in a different path to avoid the deflective occlusal contact (in this case, penetration of the wax wafer and contact with the premature cusp).



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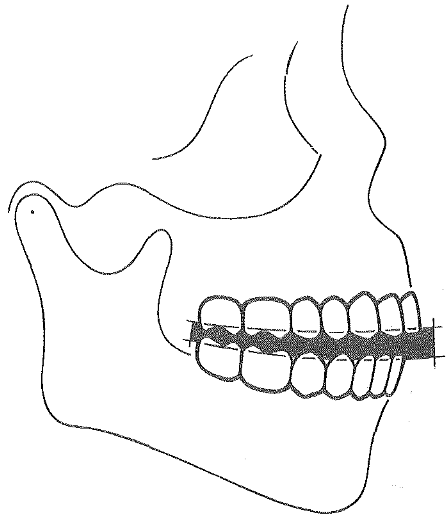

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Fig. 163. Diagram showing the use of a thin wax wafer to record centric relation. This is possible if there are no deflective occlusal contacts.
Fig. 164. Diagram showing the use of a thick wafer for a centric interocclusal recording. This may be necessary to block out any proprioception of the teeth. In turn, this necessitates a hinge axis mounting so that the cusps will approach each other as they do in the mouth.

(cast) is related to the center of vertical rotation by means of the face-bow and the articulator is set for the centers of lateral rotation, it now remains to orient the lower jaw (cast) to these centers.

This is accomplished by freezing the lower jaw (cast) in the terminal hinge closure at a convenient vertical dimension. This is the problem of obtaining centric relation. There are many factors which complicate this procedure, and patience and experience are required to complete the task satisfactorily. Among the complicating factors are the patient's reluctance to make a pure hinge closure, the patient's neuromuscular pattern which may have developed around a deflective occlusal contact (Fig. 162), the natural tendency of many patients to go into a physiological rest position at the completion of any jaw movement, and the natural tendency of a patient to exercise the prehensile reflex whenever anything is placed between the teeth.

Certain procedures and materials are required to overcome these factors. The very first procedure is to practice with the patient until he is able to execute a pure hinge closure. Second, some of the neuromuscular reflexes must be blocked out by preventing the teeth from coming together (Figs. 163 and 164). This can be accomplished by using the thumbnail as a controllable anterior stop. Third, the patient's jaw must be kept in function, swinging up and down so that he cannot go into physiological rest. As long as the jaw is functioning, its bracing position is maintained. The natural prehensile reflex can be minimized if the patient closes his eyes during these procedures. If he sees the wax wafer (the recording medium) approach his mouth, he will automatically begin to reach out to grasp it with his teeth, and this is not a centric closure.

Care must be exercised not to violate these precautionary procedures as the recording is made. This presents quite a problem because what is really needed is a magic material—a material that by its lack of resistance will not cause any unequal displacement of the joint or teeth, a material that will remain sufficiently soft long enough to ensure a dynamic registration but will freeze just as soon as all the procedures are completed.

Two-stage registration

One method that has proved acceptable is a two-stage registration. A wafer is made of one sheet of Sure-Set* wax and one sheet of Tenax† wax (Fig. 165).

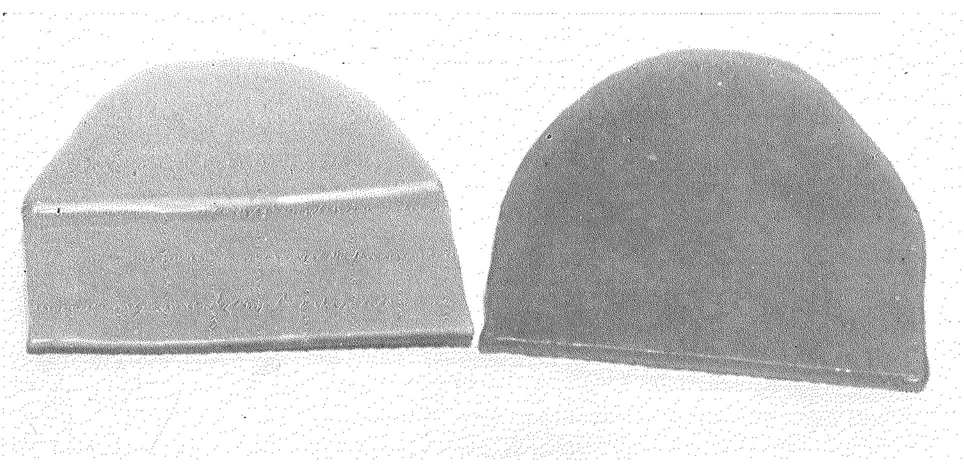

Fig. 165. Photograph of wax wafers used to record centric relation.

These are luted together. The reason for using two kinds of wax is to permit an easy indentation on one side and to provide a stiffer side which will act as a carrier. The wafer is placed vertically in a water bath at 130° F. (Fig. 166). The anterior part is kept out of the water so that it will remain stiffer and offer some resistance anteriorly, thus ensuring the bracing position of the condyles.

Use of trainer. While the wax is softening, the patient is rehearsed in the terminal hinge closure. One device that will help the patient learn how to execute a hinge closure is the trainer designed by Dr. Raymond Cohen, which is an

*Kerr Manufacturing Co., Detroit, Mich.
†S. S. White Dental Manufacturing Co., Philadelphia, Pa.

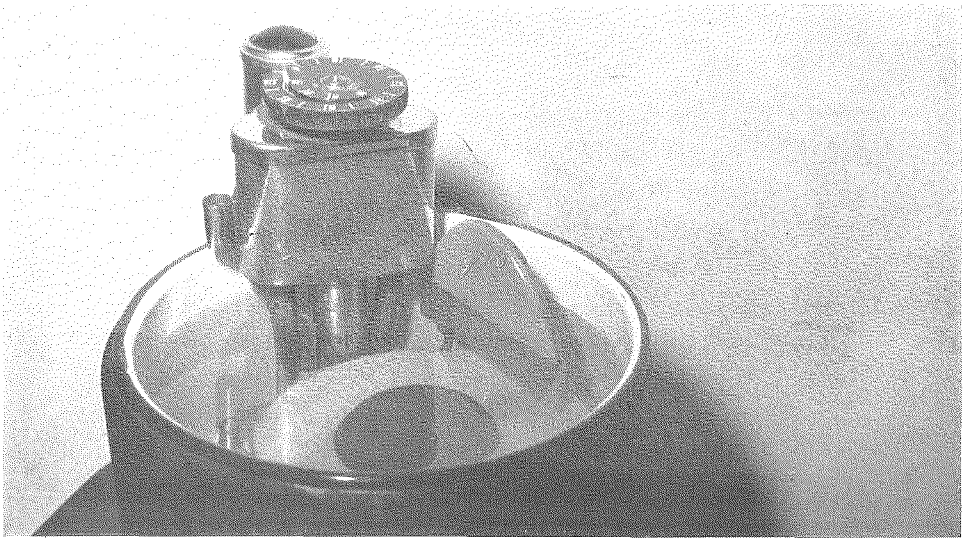

Fig. 166. Wax wafer is softened in water bath at 130° F.

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Fig. 167. Trainer on patient to aid in learning the hinge closure (closed-jaw position).
Fig. 168. Opened-jaw position.

improvement of the Hickok* retruder. It consists of a piece that fits over the patient's shoulders, a headband that secures it to place, and a chin cup which is fastened by adjustable rubber straps to a crossbar attached in back of the headband. The rubber strap exerts an upward and backward pull on the chin cup, and thus the opening and closing, or hinge action, of the mandible is aided at the same time that it tends to overcome the translating contractions

*Hickok Specialties Co., Grand Rapids, Mich.

of the external pterygoid muscle. The patient is instructed to open and close the jaw without clenching the teeth together. By avoiding the tooth contacts the patient does not receive the periodontal proprioception which could cause an abnormal reflex closure. This is what we are trying to avoid. What is desired is a pure hinge closure free of any acquired malpositions. This procedure will help the patient to execute a pure hinge closure. It permits the temporomandibular ligament to be stretched to its normal position. It trains the patient to separate the rotation from the natural combination of rotation and translation that makes up all functional movements.

The trainer is placed in position on the patient, who is instructed to open and close the mouth repeatedly (Figs. 167 and 168). In about five or six minutes the device is removed, and before the patient can bring the teeth together, a centric interocclusal record is taken.

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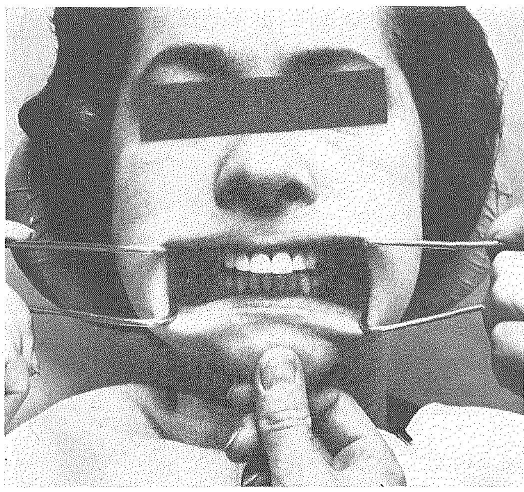
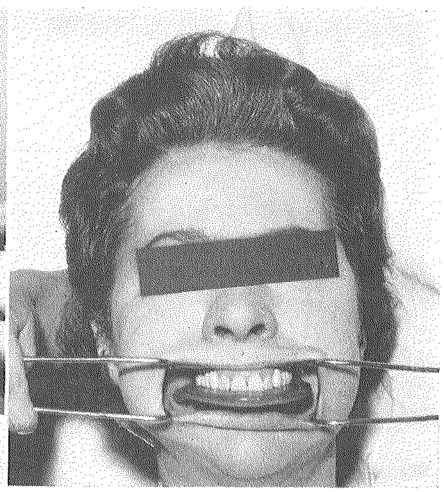
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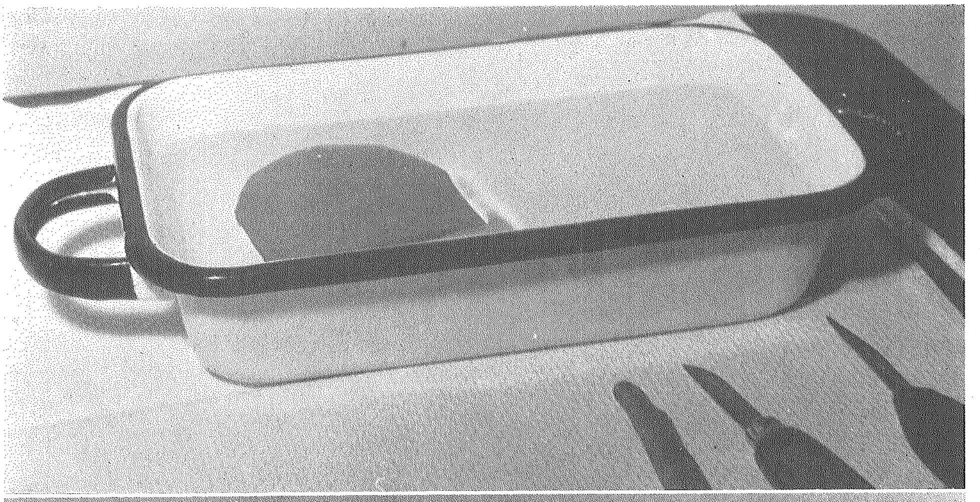
Fig. 169. Patient is rehearsed in terminal hinge closure.
Fig. 170. Wax wafer between patient's teeth.

When a trainer is not used, the patient is rehearsed in the terminal hinge closure while the cheek retractors are in place (Fig. 169). These conditions will simulate the actual taking of an interocclusal record. The patient is instructed to close the eyes, and when the wax wafer is sufficiently soft on the Tenax side, it is inserted into the mouth, with the Tenax side against the upper teeth. The patient is told to swing the jaw several times without closing on the wax, and then when the terminal hinge closure is "felt," he is instructed to close lightly against the wafer (Fig. 170). At this stage the interest is chiefly in getting an accurate imprint of the upper teeth in the Tenax wax.

The wafer is removed from the mouth and placed in water of *room temperature* (Fig. 171). After partial chilling, it is trimmed to the outside edges of the



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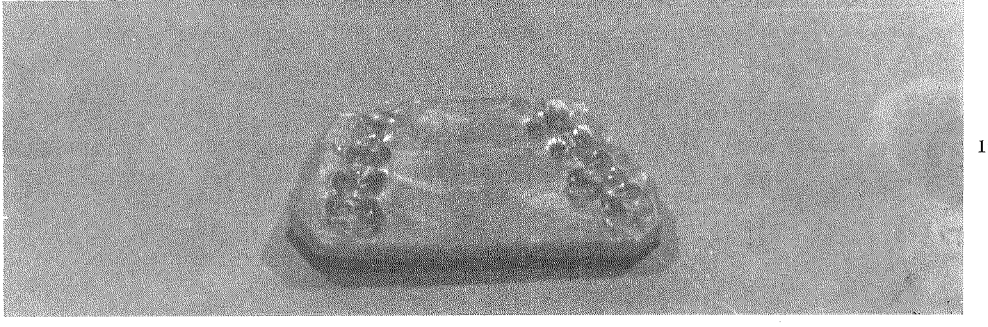

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Fig. 171. Wax wafer is removed and placed in water of room temperature.
Fig. 172. Wax wafer trimmed to outer edges of indentations and anterior section removed.

tooth indentations to remove the bulk. The anterior portion is also removed, cut off across the center of the cuspids (Fig. 172). There is a twofold reason for removing this part of the wafer. First, with the anterior teeth exposed, the thumbnail can be used as the anterior resistance. Second, without the anterior portion, there is that much less area to seat against the casts when the mounting is made. Consequently, should there be a slight discrepancy in the anterior part of the casts, it will not cause their malrelationship. In short, the only concern will be with the posterior areas.

The wax wafer is now replaced on the upper teeth and held in place with the thumb and forefinger of the left hand. It must be evenly seated against the upper teeth. The patient is instructed to close the mouth into it again to correct any warpage (Fig. 173). The wafer is then removed, and with a Bard-Parker* knife the excess wax around the indentations on the Tenax side is trimmed away, leaving only the cusp tip indentations so that the cast may be accurately

*Bard-Parker Co., Danbury, Conn.

Fig. 173. Trimmed wafer is returned to mouth for correction of any warpage.

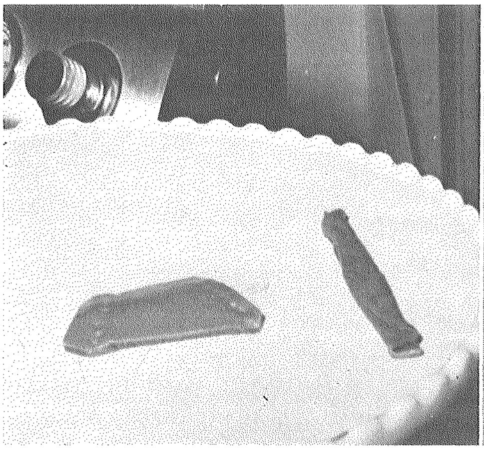
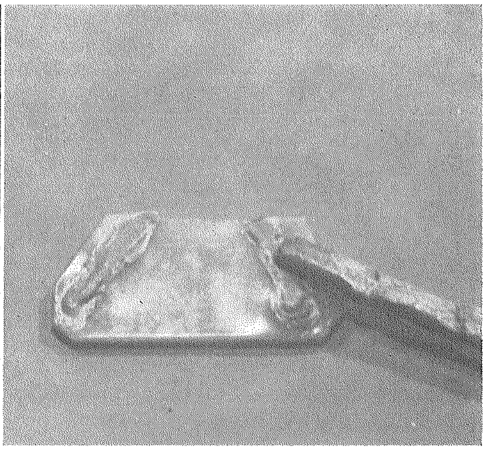
174   175

Fig. 174. Aluwax is applied to mandibular side of wax wafer with Aluwax "pencil."
Fig. 175. Wax wafer with Aluwax application.

seated when the mounting is made. It is again seated on the upper teeth, and the patient closes the mouth once more to eliminate any warpage that may have resulted from the trimming process. When it is certain that the seating of the wafer against the upper teeth is accurate, taking of the interocclusal record is completed.

Remove the wafer and dry it with a blast of compressed air. Taking a sheet of Aluwax,* form a "pencil," melt it, and apply the softened wax to the underside (Sure-Set side) of the wafer (Figs. 174 and 175), dripping it on as though using a candle. Aluwax melts at a lower temperature than Sure-Set or Tenax and

*Hickok Specialties Co., Grand Rapids, Mich.

thus provides a soft surface that can be easily carried to the mouth without warping the wafer. The wafer is placed on the upper teeth and held in place with the left thumb and forefinger (Fig. 176). With the right thumb on the patient's chin, the operator *guides* the patient into the terminal hinge closure. During this procedure the patient's eyes are closed. He executes the terminal hinge closure (Fig. 177), but does not contact the softened Aluwax until the

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Fig. 176. Wax wafer, with Aluwax lining the mandibular surface, in patient's mouth.
Fig. 177. Patient swings jaw in terminal hinge closure.
Fig. 178. Patient closes teeth into soft wax while guided into terminal hinge closure.

"swing" is correct. Gradually, he closes the mouth more and more after each swing until the Aluwax is contacted (Fig. 178). It may be necessary to add wax several times before an acceptable interocclusal record is obtained.

Tests of an accurate interocclusal record

There are several ways of determining whether an interocclusal record is accurate.

1. Hold the wax wafer up to the light to see whether there is any penetration. If there is, it will not be correct. Likewise, if there are one or two thin spots, the chances are that it is incorrect. Areas of penetration or thin areas are liable to cause a slight deviation of the mandible—so slight that one may be unaware of it. Variations of thick and thin spots will offer variations in resistance and may cause as much inaccuracy as a penetration.

2. If the thickness is satisfactory, place the wafer on the upper teeth and carefully examine it to determine whether the seat is accurate. There must not be any give in any area.

3. Have the patient close the teeth into the wafer, first guiding him as during the taking of the interocclusal record and then allowing him to close the mouth by his own muscular force. If there is any *hesitation* in finding the indentations, the interocclusal record is probably inaccurate.

4. If the foregoing requirements are satisfied, there is one final test to make. Have the patient close the teeth into the wafer and hold it firmly. Then examine the posterior portion for any play between the teeth. Both sides should be examined carefully.

If the interocclusal record meets all these tests, one is justified in accepting it as correct (Fig. 179).

This may seem to be a long and tedious procedure—and it is! However, let us bear in mind that everything that has been done previously and everything that is done subsequently will depend absolutely upon this one procedure. An error in some other part of the operation may be tolerated, but an error here is disastrous.

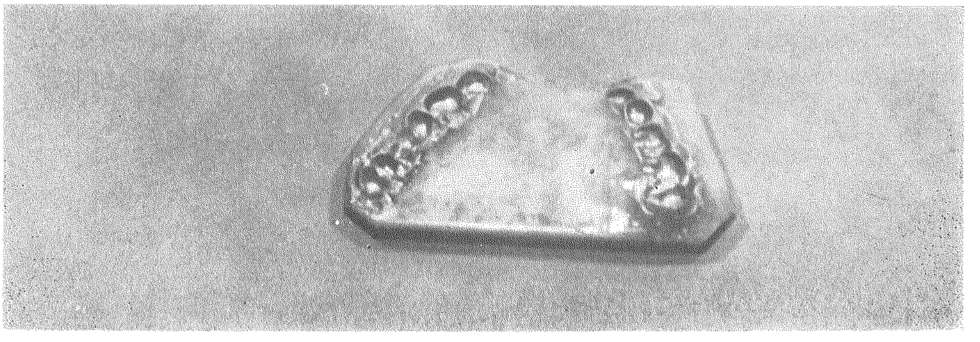


Fig. 179. The completed centric interocclusal record.

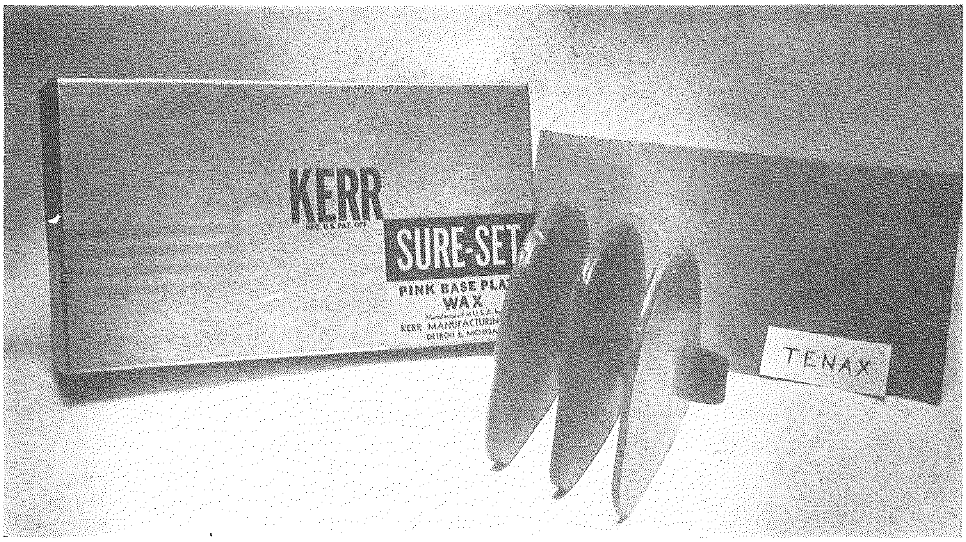


Fig. 180. Wax wafers of various thicknesses to be used according to intermaxillary space created by tooth preparations.

Obtaining an interocclusal record for mounting of working casts

Here, the same procedure is followed, with one exception. Because of the interdental space created by the preparation of the teeth, it is necessary to use a much thicker wafer. Two layers of Sure-Set (hard) wax and two or three layers of Tenax are used, depending upon the restoration (Fig. 180). Even more care is required because of the thickness of the wafer and because many hours of laboratory work will depend upon an accurate relationship at this stage.

The thick wax wafer is softened in water at 130° F. The cheeks are retracted, and the patient is trained and rehearsed in the terminal hinge closure. While the patient's eyes are closed, the softened wax wafer is placed in his mouth, and he is guided into the terminal hinge closure. The wax wafer is then removed, partially cooled, and trimmed with a pair of shears so that all the excess bulk is removed from the sides. About one-fourth inch is left lateral to the tooth indentations, and the anterior portion of the wafer—through the cuspid areas—is cut off. The trimmed wafer is replaced on the upper teeth, and the patient is instructed to close the jaw several times to eliminate any possible warpage. Remove the wafer, chill it thoroughly, and with a sharp Bard-Parker knife carefully remove the sides of the imprints of the upper preparations, leaving only the *tips*. When this has been done, replace the wafer on the upper teeth and again have the patient close the mouth firmly against it. This will eliminate any possible bending or curling of the wax edges around the preparations.

Taking of the interocclusal record is now completed by relining the *mandibular* side of the wafer. This is done by dripping melted wax from the Aluwax pencil wherever there are preparation imprints. Quickly moving the dripping pencil from one indentation to the other will ensure an even degree of softness to the Aluwax, and this is most important. As soon as the added Aluwax has lost its shine and taken on a dull sheen, the wafer is replaced on the upper teeth. Carefully guide the patient into the terminal hinge closure, but do not allow the lower teeth to contact the softened Aluwax until you are certain of the swing. Then, have him close the mouth more and more after each swing until indentations are made in the Aluwax. He should contact the wax several times, always being sure to execute a terminal hinge closure.

The wafer is removed and chilled thoroughly in water of room temperature. If the indentations are even and definite, any edges that have formed over the preparations are trimmed away very carefully. If the indentations are not even or if some areas show no indentations, more softened Aluwax is added. Whenever additions are made, the new wax must be appplied over all the surfaces. In other words, missing areas are built up, and a thin coating is applied over the rest of the wafer. This will ensure even pressure throughout. The wafer is replaced on the upper teeth, and the patient is guided into the terminal hinge closure. Once again, do not allow the lower teeth to contact the softened wax until you are certain of the swing. The wafer is removed and chilled, and the sides of the indentations are trimmed away. Again the wafer is chilled and placed in position, and the patient is instructed to close the mouth repeatedly into it. First guide the patient so that any trimming discrepancies will be eliminated; then allow him to close the mouth without guidance into the lower indentations. If he does not close immediately and without hesitation into these indentations, the interocclusal record is not correct! With or without guidance, the patient must be able to close the mouth unerringly in the same place.

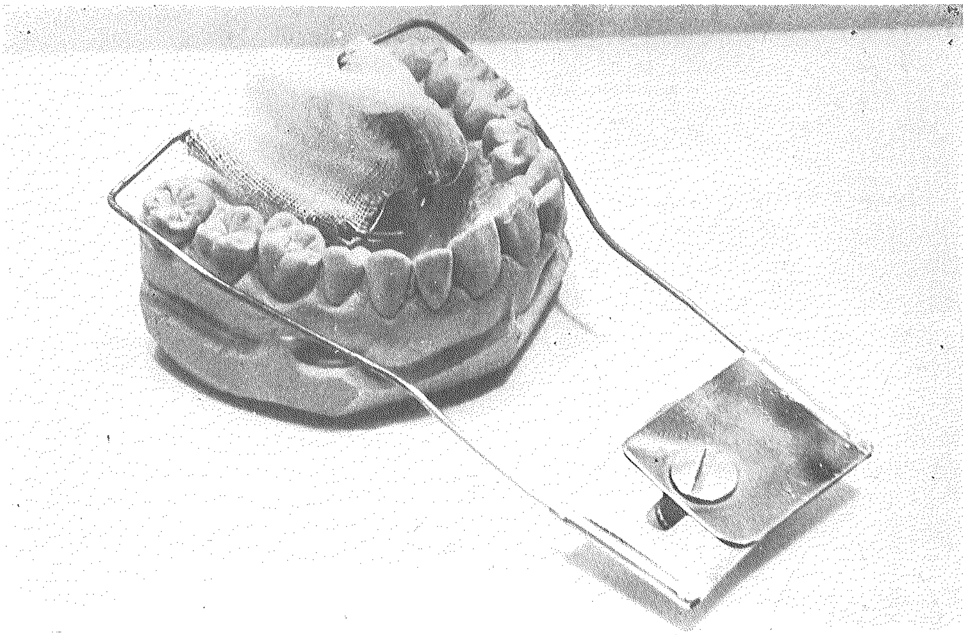
Obtaining an interocclusal record for remount

Another very exact method of taking an interocclusal record is employed when the finished castings are related for final adjustment. This particular record can be used only when the restorations themselves are available to fit into it.

A zinc oxide eugenol record is taken in a gauze "sandwich." This is a rather tricky but extremely accurate procedure. A Jones adjustable bite frame* is used to carry gauze strips. These are glued to a thin wire insulation known as "spaghetti" in the radio trade. The insulation tubes with the gauze strips attached are cut into lengths about an inch and a half long. These are slipped on the wire frame, which is adjusted according to the size of the patient's upper jaw. This is best done on a cast of the upper jaw (Fig. 181).

A zinc oxide and eugenol paste, such as Opotow's mandibular paste* or Kerr's registration paste,† is used (Fig. 182). The mixed paste is placed on the sur-

*Interstate Dental Co., Inc., New York, N. Y.
†Kerr Manufacturing Co., Detroit, Mich.



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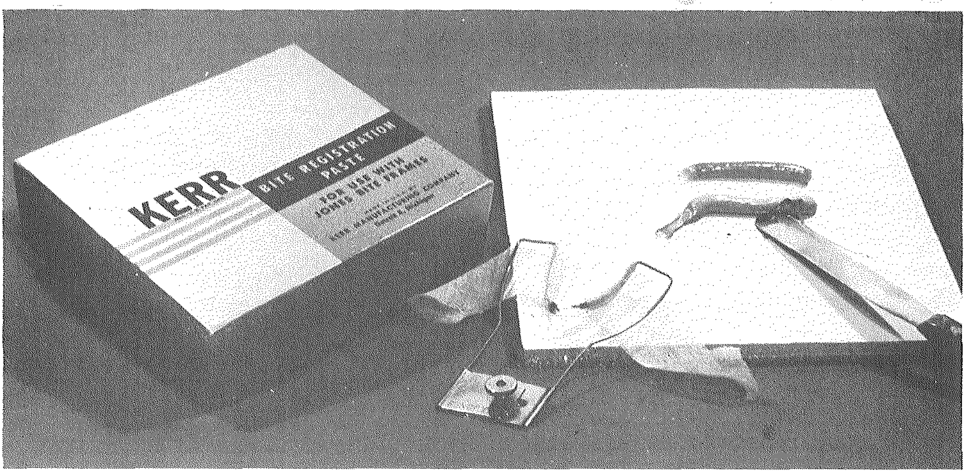

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Fig. 181. The Jones adjustable bite frame is adjusted on a maxillary cast.
Fig. 182. Kerr's registration paste ready to be mixed and applied to the gauze on the frame to make a sandwich.

face of the gauze, and the gauze, which is about 3 inches long, is wrapped around the outside wire of the frame and then around the inside one again until there is no loose end. In other words, the gauze, with paste on its surface, is wrapped around the buccal and lingual wires of the frame. This neatly wraps the paste between the gauze and between the buccal and lingual wires. A slight amount of paste may be applied on the upper and lower surface of this roll, on

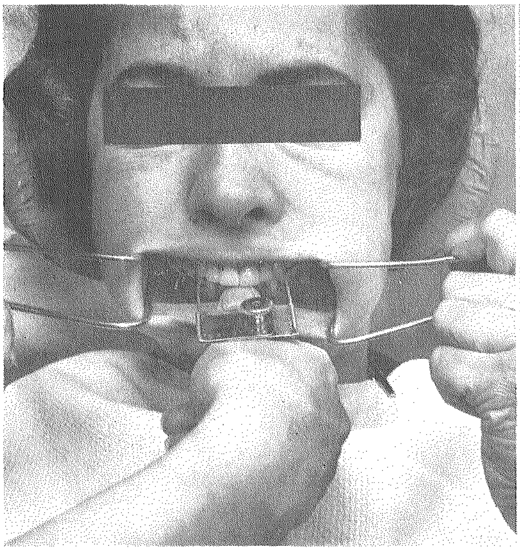
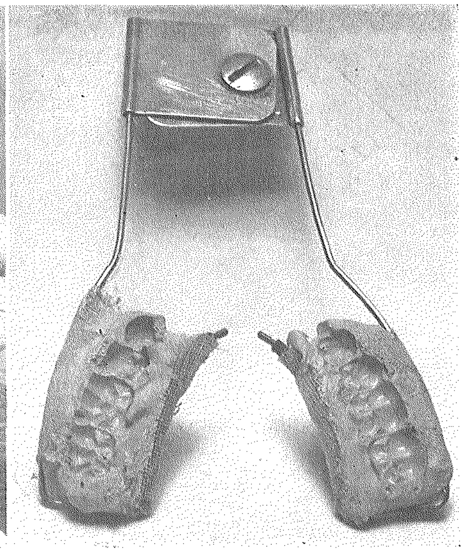
183   184

Fig. 183. The gauze sandwich in place. The lower teeth are braced against the thumb stop while the patient is in the terminal hinge position.
Fig. 184. The zinc oxide and eugenol record on the Jones frame.

both sides of the frame. It will take a little practice to learn to manipulate the paste without becoming entangled in it.

The patient is handled as previously described—eyes closed, retractors in place—and rehearsed in the terminal hinge closure. The wire frame carrying the gauze and paste is placed between the teeth (restorations in teeth), and the patient is instructed to open and close the mouth in the terminal hinge position. The right thumb is used as a stop between the anterior teeth, and as the patient produces the terminal hinge closure, gradually reduce the interdental space by retracting the thumb. When the patient has closed sufficiently into the gauze and paste sandwich, we stop retracting the thumb and, after several closures, allow the patient to remain in the closed position with the lower anterior teeth braced against the thumb (Fig. 183). By this time, the paste will have begun to set. Here lies the only risk in using this material and technique. If the paste does not set quickly enough, the patient may drift out of the terminal hinge position.

The indentations in a centric interocclusal record taken in this manner are so accurate that only the actual restorations will fit to place (Fig. 184). After the remount casts are made, they can be precisely related, and the final correction of the articulation is accomplished.

Thomas's centric interocclusal record method

Another very accurate method of obtaining a centric relation record was demonstrated to me by Dr. Peter K. Thomas of Los Angeles.

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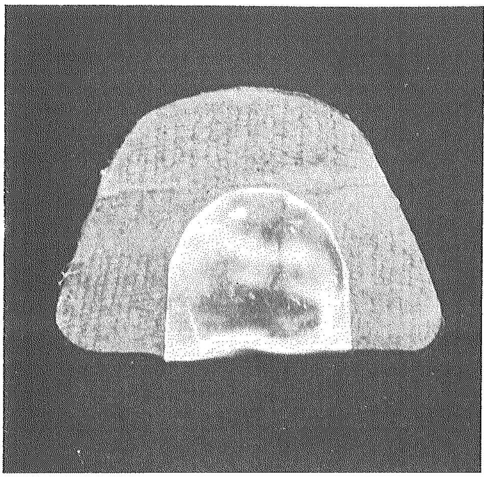

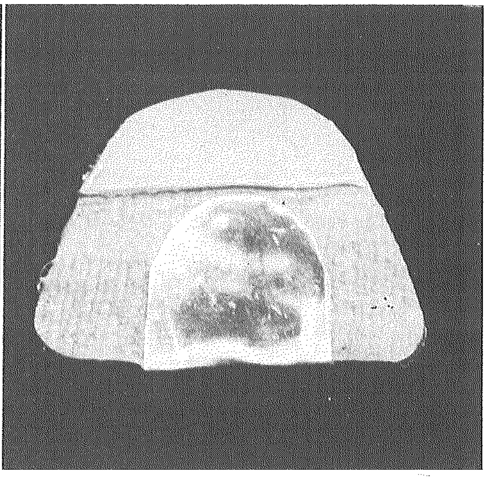

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Fig. 185. Ash's No. 7 relief metal used as a reinforcement to the Aluwax wafer.
Fig. 186. Truwax or Sure-Set wax added to anterior region of mandibular side of wafer.

An Aluwax wafer is reinforced through its center by a piece of No. 7 Ash's relief metal.* The metal is cut so that it will occupy only the center of the wafer and not interfere with the areas into which the tooth indentations will be made (Fig. 185). The metal is doubled over the posterior end of the wax wafer so that the wax is sandwiched between it. A piece of hard Truwax† or Sure-Set is added on one side of the anterior portion of the wafer (Fig. 186). The lower anterior teeth close into this portion of the wafer, thus permitting a seating of the condyles in their bracing position. This hard wax further prevents the posterior teeth from forcibly contacting the Aluwax in the posterior region.

This specially prepared wafer is softened in a water bath of about 120° F., after which it is placed in the mouth with the Truwax section over the lower anterior teeth. The lower jaw is firmly jiggled and guided into the terminal hinge closure (Fig. 187). This may be repeated several times. The wax wafer is then held in place until it is hard and chilled with a syringe of ice water (Fig. 188). The wafer is marked to indicate the outer edges of the teeth, whereupon it is removed, trimmed where necessary, and reinserted in the mouth. An examination is made to determine where there is light contact in the posterior region. If there are any areas without contact, the wafer is removed, and a very small strip of Tenax is added in such areas. If there is an edentulous area, a small cone of Tenax is added which will just contact the ridge in a very small area. The wax wafer is removed and carefully examined. Any wax having a deep imprint is removed with a Bard-Parker knife. Only the *cusp tip* indentations are

*Claudius Ash & Sons, Niagara Falls, N. Y.
†The Dentists' Supply Co. of New York, York, Pa.

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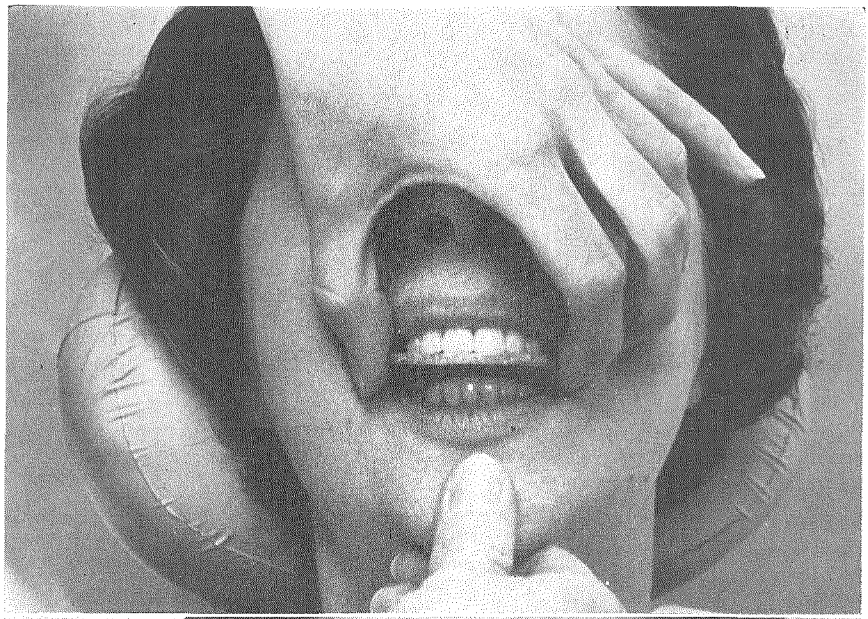

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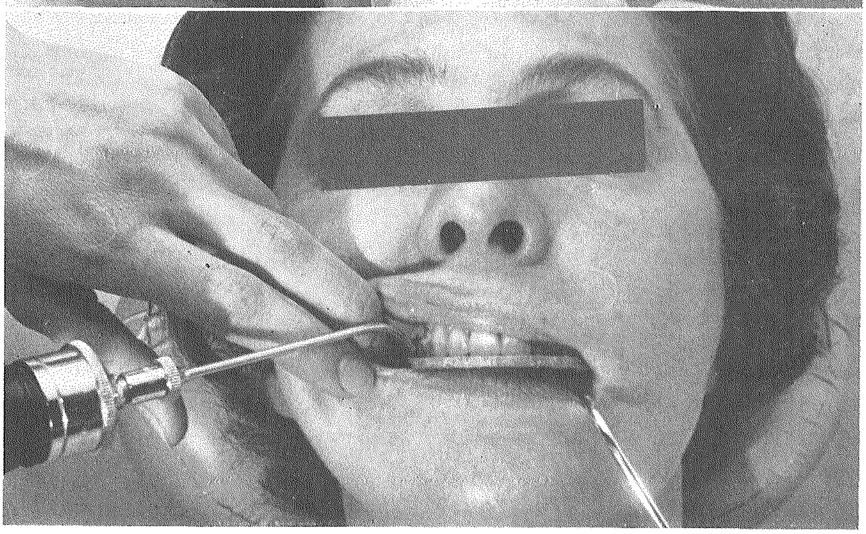

Fig. 187. Patient guided into terminal hinge closure.
Fig. 188. Syringe of ice-cold water to chill wax wafer.

left (Fig. 189). The wax wafer at this point should have definite contact in the anterior region and only very slight contact in the posterior region.

The wafer is now ready to be corrected.

The upper and lower teeth are lubricated with Mucolube[*] or petrolatum. A very small amount of a zinc oxide and eugenol paste, such as Kydac[†], Acker-

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*Cosmos Dental Products, Inc., Long Island City, N. Y.
†The Motloid Co., Inc., Chicago, Ill.

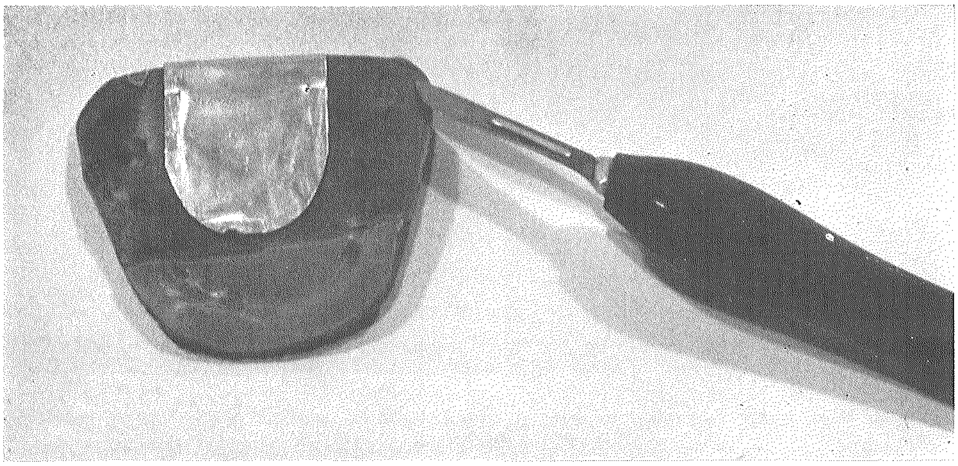

Fig. 189. Only cusp tip indentations left on wafer.

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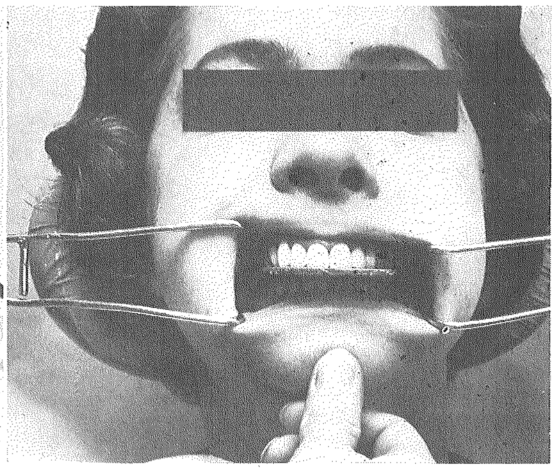

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Fig. 190. Small amounts of registration paste are applied to wafer.
Fig. 191. Patient guided into terminal hinge closure.

man's,* or Luralites,† is mixed. The setting time is hastened by adding a drop of water after the mix is completed. With a cement spatula *small* amounts of the paste are placed in the tip indentations on the wax wafer (Fig. 190). The wafer is placed in the mouth and seated on the teeth, and the patient's jaw is again jiggled and guided into the terminal hinge closure (Fig. 191). The chin is held until the paste sets firmly. This usually takes only a few seconds. The corrected wafer is now very carefully removed by having the patient open the mouth

*Ackerman Dental Co., Santa Monica, Calif.
†Kerr Manufacturing Co., Detroit, Mich.

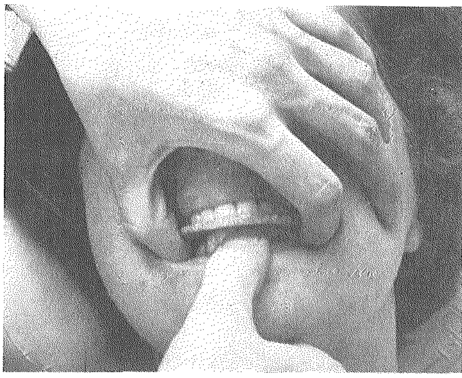
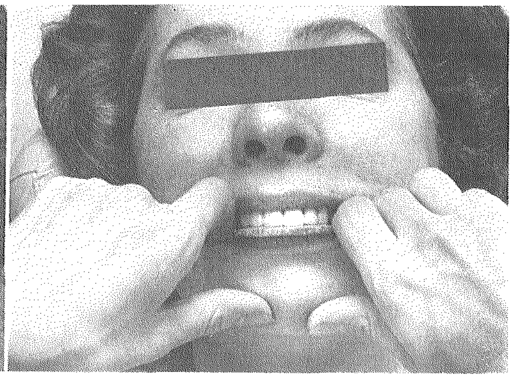
192   193

Fig. 192. Wax wafer is supported against upper teeth as patient gently opens jaw very slight degree.
Fig. 193. Wafer is supported against lower teeth as patient very gently opens jaw slightly.

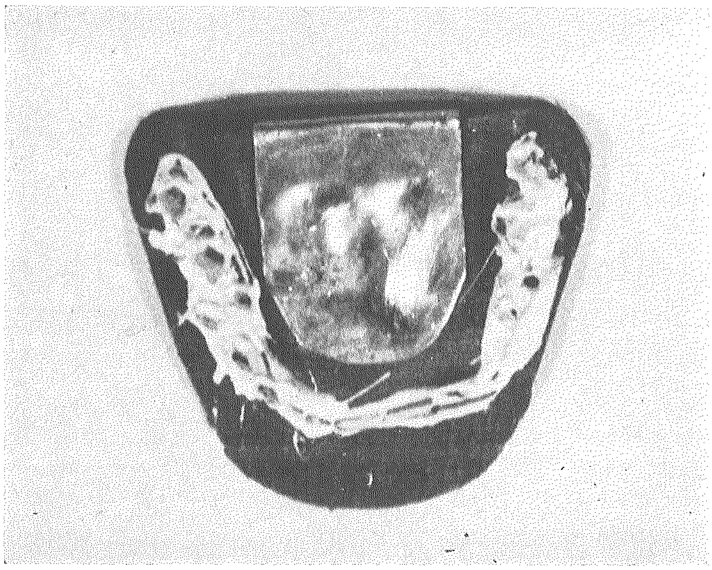


Fig. 194. Completed centric interocclusal record obtained by Thomas's method.

gently while the wafer is supported with the fingers. First, the wafer is supported against the upper teeth as the patient opens the jaw (Fig. 192). The patient is instructed to close. Then as he again opens the jaw, the wafer is supported against the lower teeth (Fig. 193). This procedure reduces the possibility of warpage. After the corrected wafer is carefully removed, any thin edges of the zinc oxide and eugenol paste are trimmed (Fig. 194). Again the wafer is seated to place, and the patient guided into the terminal hinge closure. The lower teeth should fit very accurately into the imprints.

Two such wax records are obtained. One is used to mount the lower cast; the other is used to check the first one. Until two wax records that check out are obtained, we must not proceed.

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3. Lucia, Victor O.: The Fundaments of Oral Physiology and Their Practical Application in the Securing and Reproducing of Records to be Used in Restorative Dentistry, J. Pros. Den. **3**:213-231, 1953.
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CHAPTER 8

Setting the McCollum gnathoscope

The basic procedure of setting any fully adjustable articulator is quite similar. Therefore, before considering a specific instrument such as the gnathoscope,* let us first concentrate on the features common to most articulators, making use of diagrammatic illustrations to demonstrate the principles involved.

FEATURES COMMON TO MOST FULLY ADJUSTABLE ARTICULATORS

We shall describe the setting of an instrument from graphic tracings since they are the most accurate.

The inclination of the angle of a condyle path is set by rotating the condyle disc of the articulator. From the gnathograph† (a tracing apparatus used to record the patient's movements), the inclination on the articulator is set so that it follows the same inclination as the tracing. The angle of the path is related to a fixed plane—the axis-orbital plane. The casts of the mouth are related to this same plane. The angle of the tracing, the angle of the articulator disc, and the angle of the patient's articulator eminence are all the same since they are measured from a fixed plane and are parallel to each other.

Fig. 195 shows diagrammatically how the disc rotation permits adjustments so that the articulator will follow the path given by the patient.

The two Gothic arch tracings taken in front of the patient depict the action of projections from the centers of lateral rotation (Fig. 196). In locating the centers of rotation on an instrument, one would have to project the radii of these tracings, and where they intersected would be the centers of rotation. This is not practical. So, by a process of trial and error, the centers of rotation on the instrument are moved in or out until they exactly duplicate the tracings made by the patient. Fig. 197 shows the effect of changing the center of rotation on an instrument until it follows the path made by the patient on the gnathograph.

As a rule, of course, the patient does not pivot as shown in Fig. 196. Rather,

*Dr. B. B. McCollum, Sepulveda, Calif.

†H. D. Justi & Son, Inc., Philadelphia, Pa.

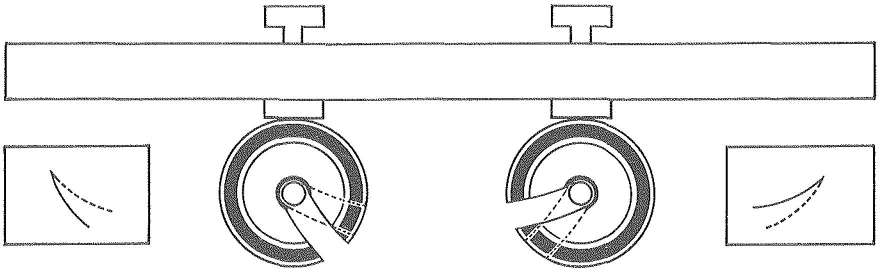


Fig. 195. Schematic drawing shows how the condyle disc rotation (changing inclination) permits the articulator to follow the pantographic tracing made by the patient.

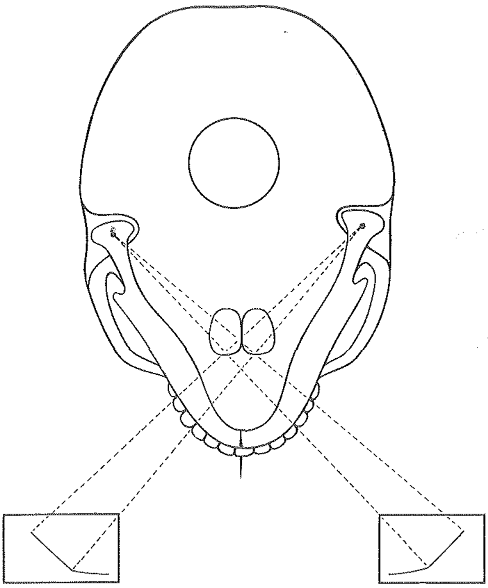


Fig. 196. Schematic drawing shows the relation of the Gothic arch tracings to the centers of lateral rotation.

the center moves as it pivots, and this produces the Bennett path or side shift of the mandible. The registration of the side shift of the centers (and mandible) is recorded on two horizontal tracings near the action (alongside the temporomandibular joint). In the center of the instrument is an adjustable guide which can be set to provide the amount of side shift necessary in order to duplicate that of the patient. By changing the angle of the limiting side of the Bennett guide, we can make the articulator duplicate the general direction of the patient's tracing as recorded on the gnathograph. By grinding the surface of the limiting side of the Bennett guide, we can accurately duplicate the exact curvature (if present). The relation of the gnathograph tracings and the articulator adjustment is diagrammatically shown in Fig. 198.

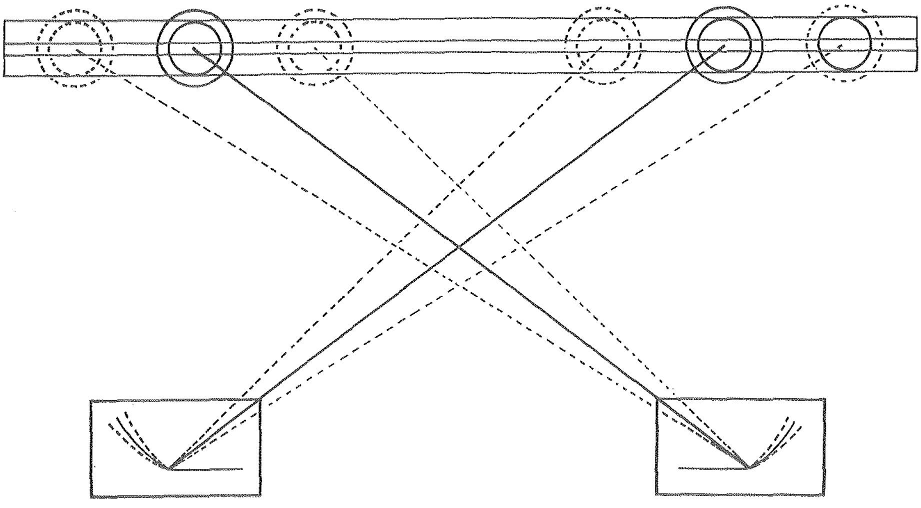


Fig. 197. Schematic drawing shows how variations in the outerwing of the Gothic arch tracing determine various locations of the centers of lateral rotation.

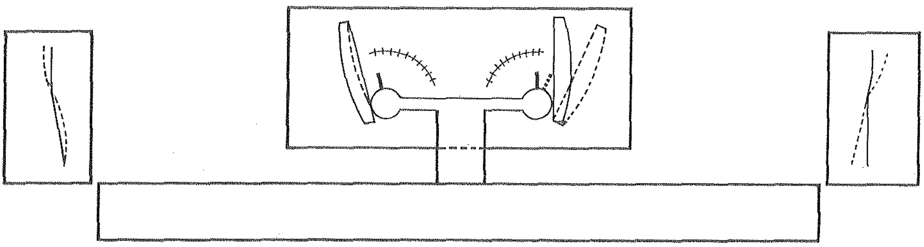


Fig. 198. Schematic drawing shows how adjusting the Bennett guide on the articulator permits duplication of the Bennett shift recorded on the pantograph. Note on the left side that grinding of the Bennett guide permits duplication of the curve in this Bennett path.

Since the tracings are made some distance from the actual centers of motion, some of them seem to give abnormal direction to the movements. This is so because the tracings are projected from the centers. The working occlusion tracings depict this phenomenon. The condyles appear to move upward and backward. Actually, they do no such thing. The tracings do this, however. The centers of lateral motion move along an axis. From the working occlusion tracings (the "reciprocals") the tilt of the axis on the articulator can be adjusted so that the centers of lateral motion follow the same path as recorded by the patient. As the center of lateral motion travels inward, it may go upward or downward (Fig. 199).

At the same time, the center of lateral motion may travel forward or backward as it goes up or down. The registration that permits the best setting for this direction is recorded in the inside wing of the anterior Gothic arches. By rotation of the axis on the articulator, the inner wing of the Gothic arch as recorded on the gnathograph can be faithfully duplicated. The diagram in Fig. 200 shows how this takes place.

In addition to having a certain inclination, the condyle path has a particular curvature. The duplication of this curvature is made possible by an assortment of discs with varying curvatures which may be selected for the articulator. In one instrument (Stuart's) an individual curvature is ground for each patient. The disc with the correct curvature is selected by reference to the protrusive path recorded on the gnathograph by the patient. If, in making a selection, one finds that the stylus of the gnathograph cuts across the path, one knows that the disc in the articulator has too little curvature. Consequently, one with more curvature must be selected. On the other hand, if the stylus cuts below the patient's

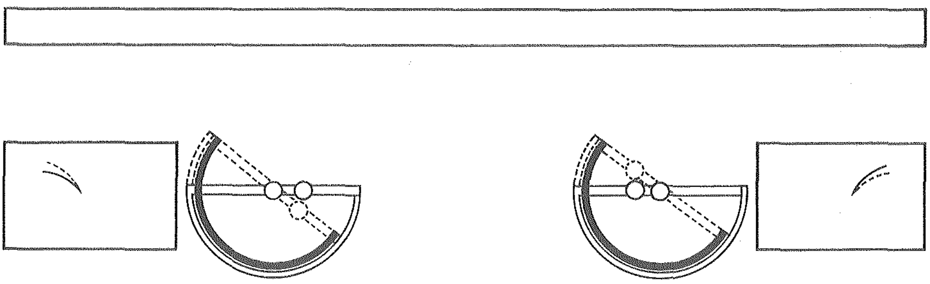


Fig. 199. Schematic drawing shows how tilting the axis of the articulator permits duplication of the vertical component of the Bennett movement. This is recorded on the working or pivoting side and is also known as the backlash or reciprocal movement.

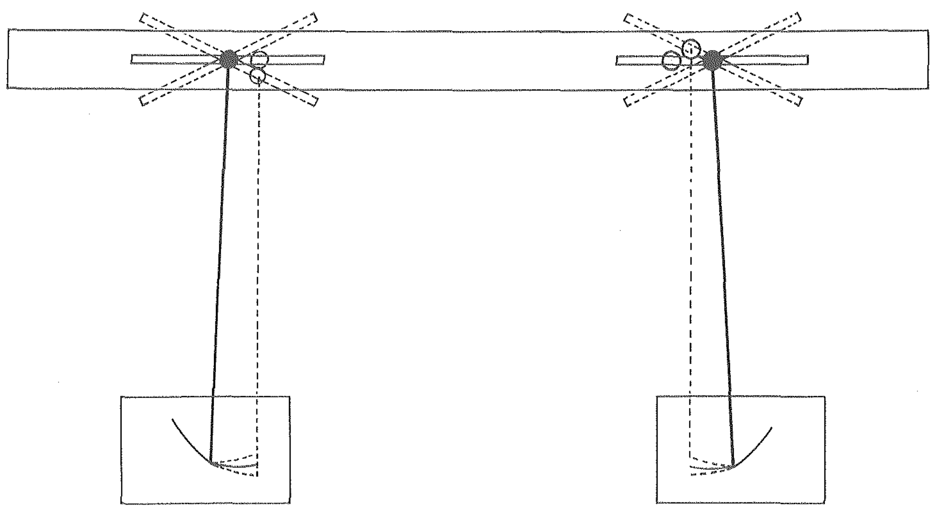


Fig. 200. Schematic drawing shows the relationship of the inner wing of the Gothic arch tracing to the rotation of the axis on the same side.

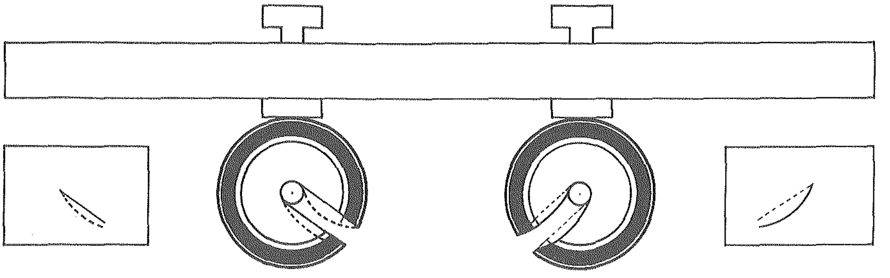


Fig. 201. Schematic drawing shows how the selection of the correct *curvature* of the condyle path permits duplication of the patient's path in every detail. If the stylus of the pantograph on the articulator cuts across the patient's path (as on the right), the disc has too little curvature. On the left, the stylus cuts below the patient's path, indicating the disc has too much curvature.

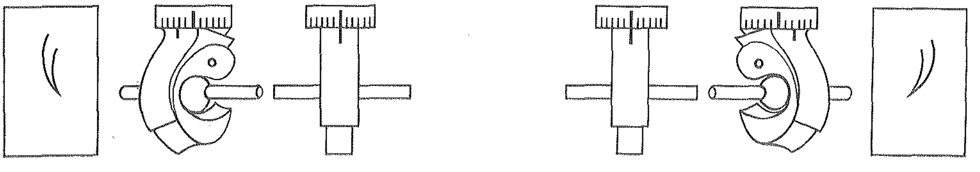


Fig. 202. Schematic drawing shows how rotation of the condyle disc permits adjustment to the protrusive and lateral paths with one setting of the instrument.

path, then the disc has too much curvature, and one with less curvature (Fig. 201) is selected.

In addition to the protrusive path, a pure lateral path has been recorded. This is actually a tracing of the articular eminence medial to the tracing made in protrusive relation. In order to have the instrument fully set to duplicate all the excursions of the patient, one must be able to follow both of these paths. By rotation of the disc previously selected for the protrusive tracing, both recordings can be followed. However, because of the rotation of the path and depending upon the tilt of the axis, the inclination of the disc may have to be reset to reproduce the protrusive tracings. Sometimes it may be necessary to reselect the curvature as well. One must find the combination of curvature, inclination, and disc rotation which will permit the instrument to follow both the protrusive and lateral paths with one setting (Fig. 202).

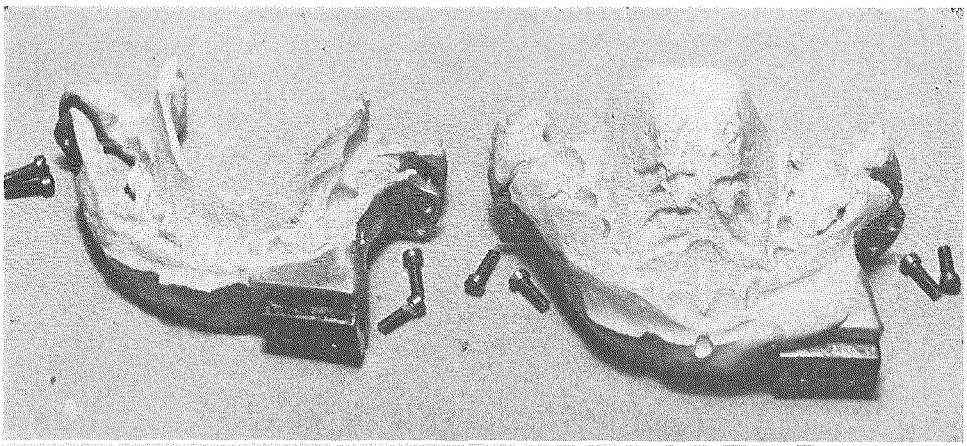
Let us now examine in detail the use of the gnathoscope in duplicating the registrations.

ADJUSTING THE GNATHOSCOPE BY MEANS OF AN EXTRAORAL TRACING DEVICE

After the registrations have been obtained and the clutches removed, the three points of reference are permanently marked on the patient.

Assembly of gnathoscope and writing apparatus

In the laboratory the clutches are reassembled (Fig. 203), and the writing apparatus, locked together by the vise grips (Fig. 204), is ready to be mounted on the articulator. By means of the mounting frame (Fig. 205), the upper bow of the gnathoscope is attached to the writing apparatus. The upper bow and writing apparatus are then transferred to the lower member of the gnathoscope. The writing apparatus is attached to the lower bow (Fig. 206) in such a way that the upper and lower members of the gnathoscope are in centric relation to each other. Note that the axis pins of the gnathograph and the axis-orbital indicator and support have been removed. The axis-orbital rest has been replaced with the incisal pin.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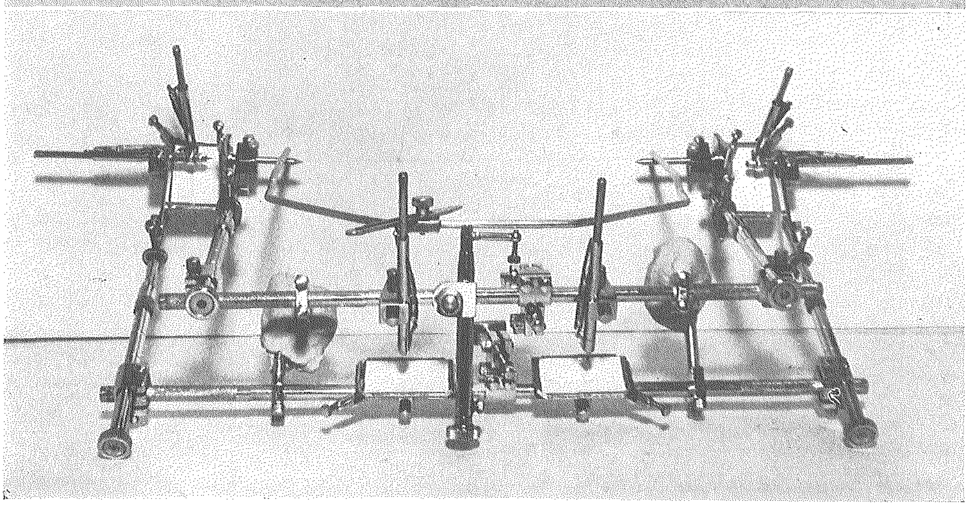
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Fig. 203. The separated clutches as they are removed from the mouth.
Fig. 204. The pantograph, locked in centric relation, as removed from the patient.

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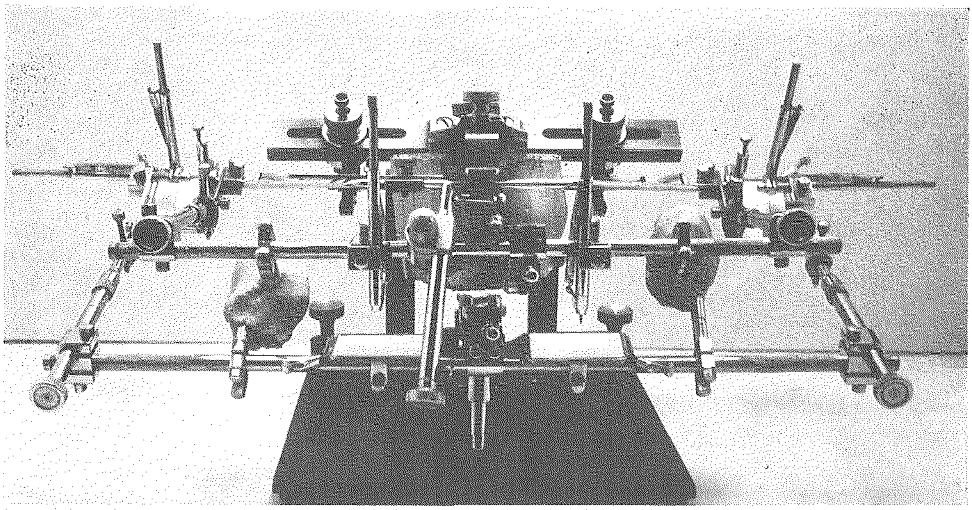

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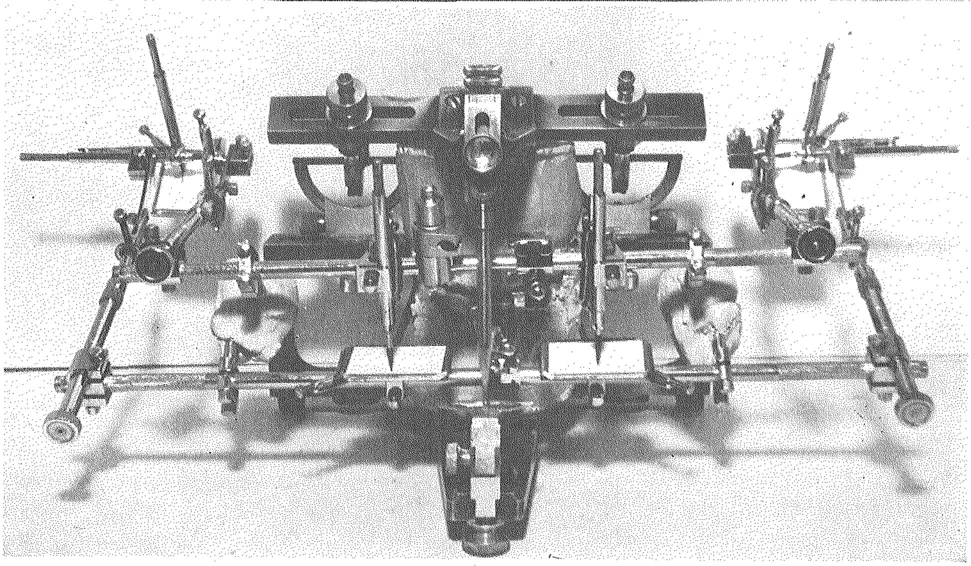

Fig. 205. The pantograph attached to the upper bow of the articulator. The mounting frame maintains the relationship of the pantograph to the upper bow while the attachment is made.
Fig. 206. The pantograph, attached to the upper bow, is assembled on the lower frame of the articulator and attached. The articulator must be in centric relation; i.e., the centers of rotation of the upper bow must be identical with those of the lower frame, and the condyle slots must be *seated against* the condyle balls.

When the stone has completely set, the vise grips are removed (Fig. 207), and the gnathoscope is ready to be adjusted.*

*Bear in mind that an adjustment of any articulator control will affect all the other settings. Once a control is set, it does not follow that it will not have to be reset later as the adjustment proceeds. The settings are *refined* as the adjustment progresses.

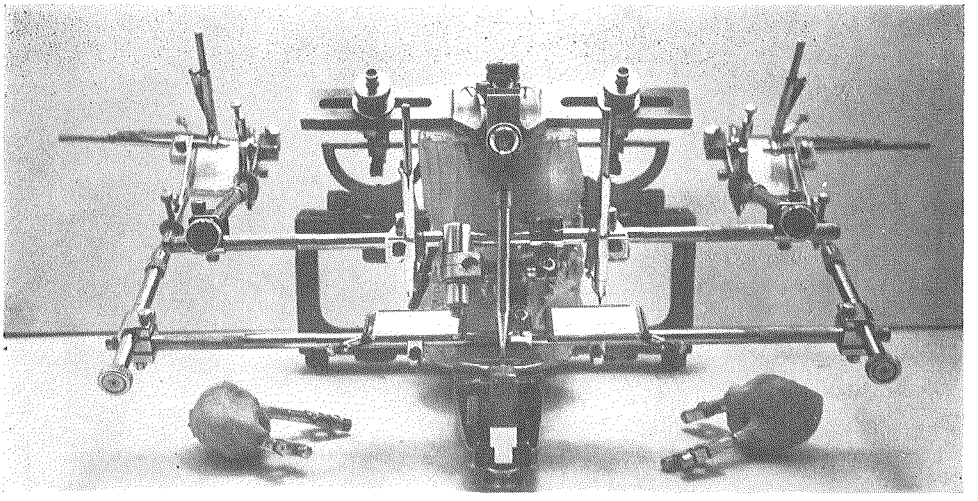

Fig. 207. The vise grips have been removed, and the articulator and pantograph can be moved into the eccentric position for adjustment of the articulator.

Approximate adjustment of condyle paths

Examine the condyle tracings by moving the articulator in the lateral movements (Fig. 208) and approximately adjust the condyle paths (Fig. 209) until the tracing is followed, as in Fig. 210. This procedure is repeated for the other side (Figs. 211 to 213).

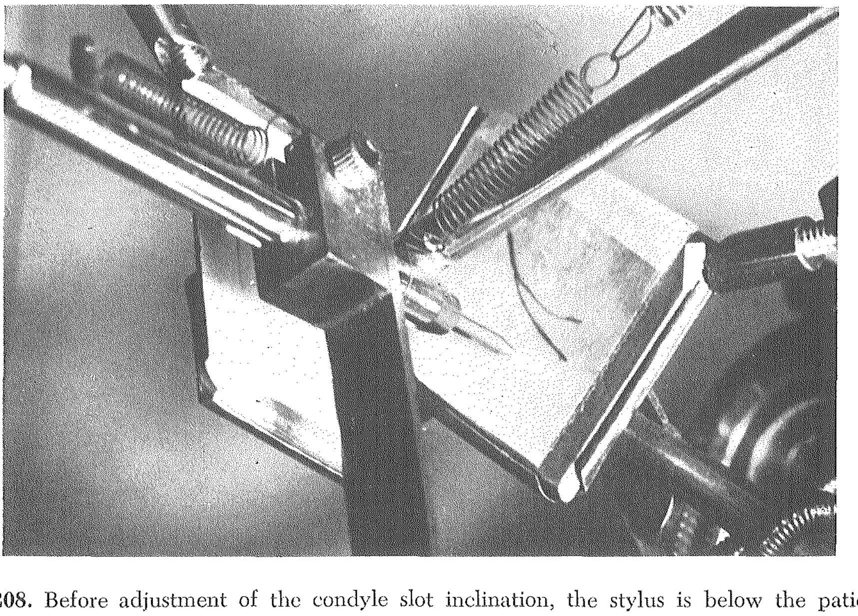

Fig. 208. Before adjustment of the condyle slot inclination, the stylus is below the patient's tracing (patient's right side).

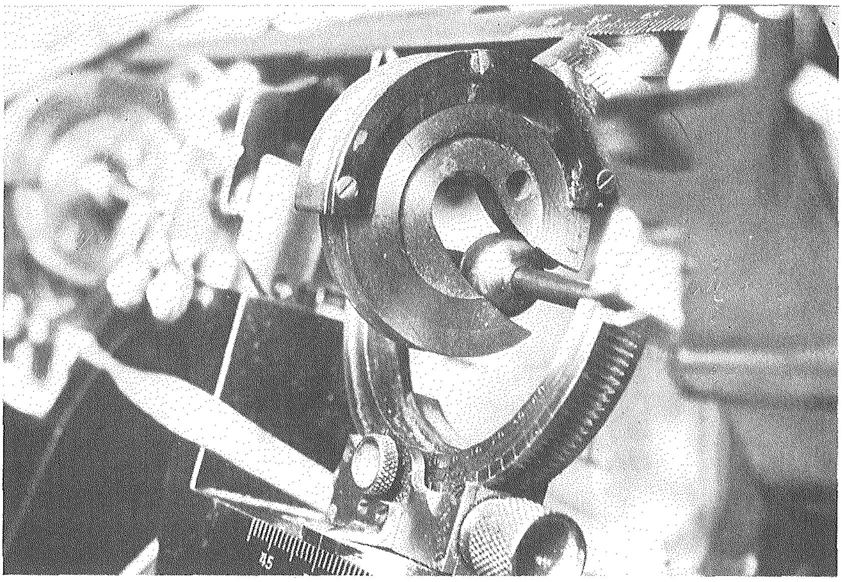

Fig. 209. Adjustment of the condyle slot inclination.

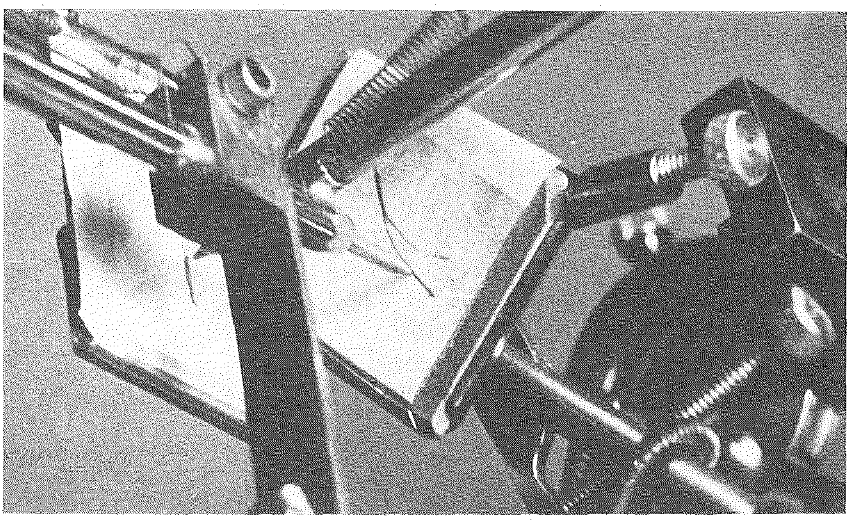

Fig. 210. The stylus of the pantograph on the articulator follows the patient's tracing after the condyle slot is properly adjusted.

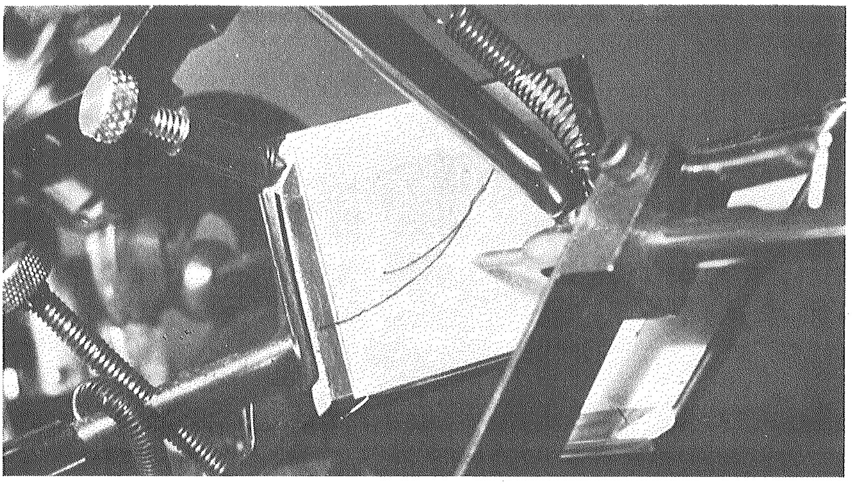

Fig. 211. On the left side, the stylus of the pantograph on the articulator is below the patient's tracing.

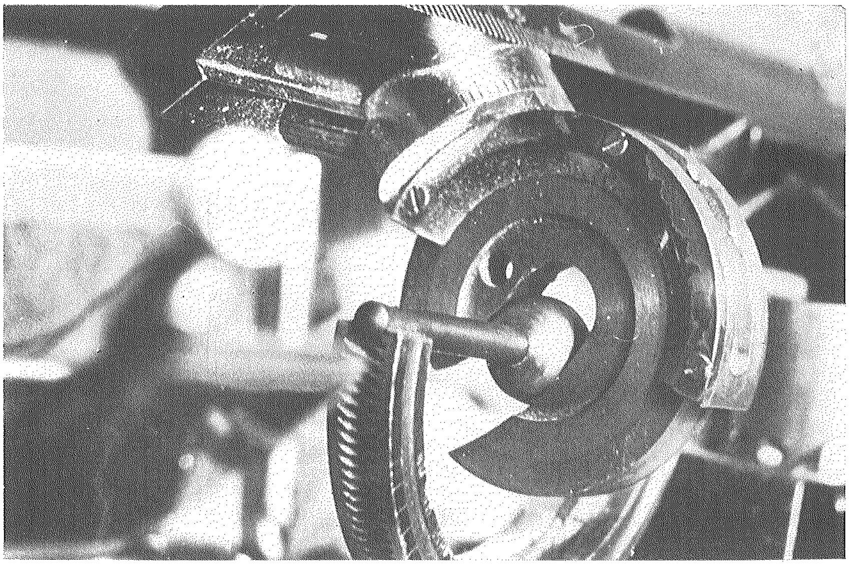

Fig. 212. Adjustment of the condyle slot inclination.

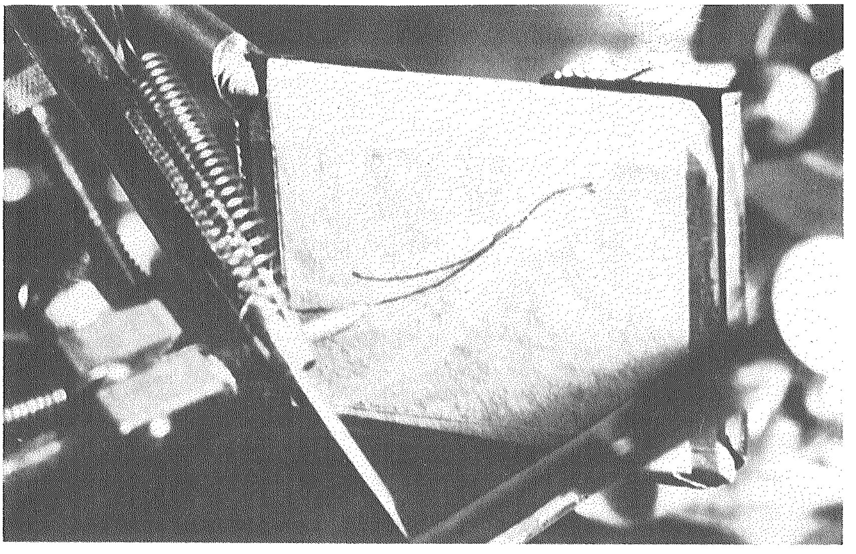

Fig. 213. The stylus of the pantograph on the articulator follows the patient's path after adjustment of the condyle slot of the articulator (left side).

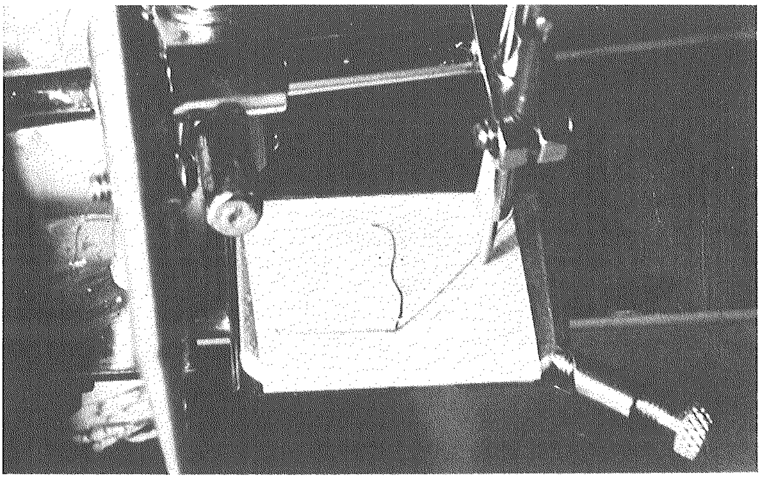

Fig. 214. The stylus of the pantograph on the articulator is outside the outer wing of the Gothic arch tracing made by the patient (left side).

Location of centers of rotation

Fig. 214 shows the stylus pin in relation to the outside wing of the Gothic arch on the left side.* Note that the stylus is outside the tracing. In order to have the stylus follow the outside wing, it will be necessary to change the center of rotation of the articulator on the opposite side. In other words, it will be necessary

*Such references are to the *patient's* right or left side.

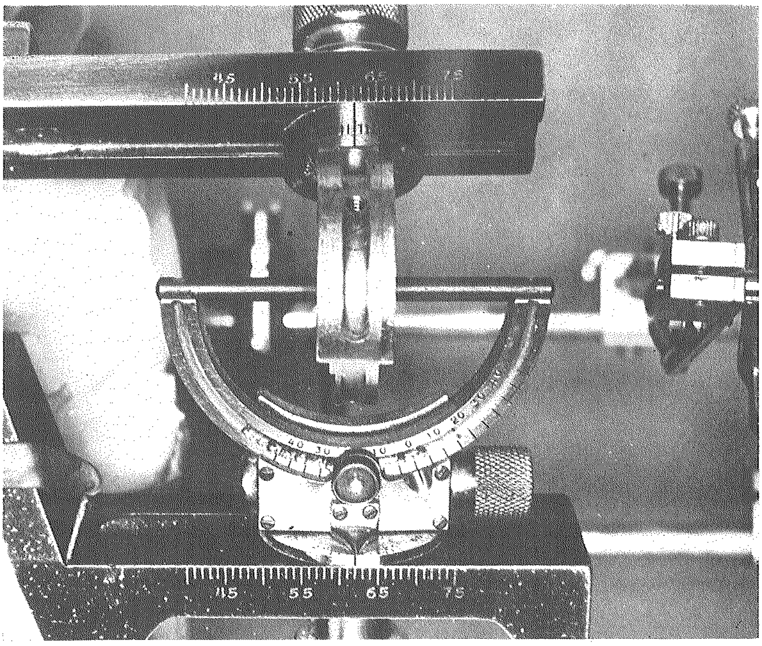

Fig. 215. The center of lateral rotation on the opposite side moved out to increase the length of the imaginary compass arm.

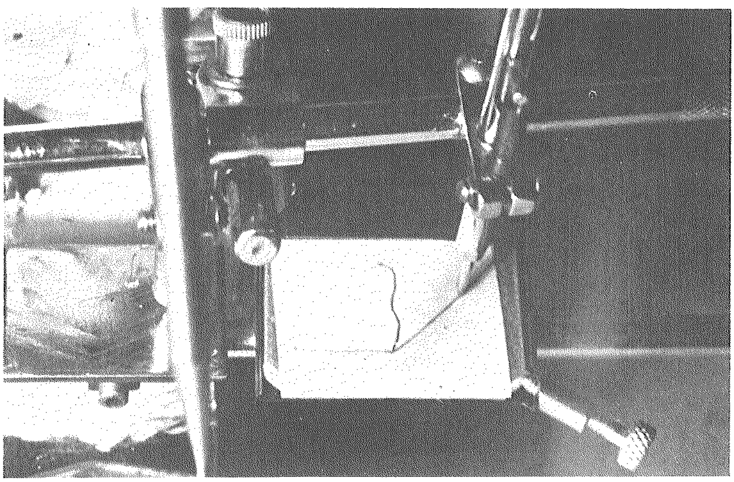

Fig. 216. The stylus on the left side after proper location of the center of lateral rotation is on the outer wing of the Gothic arch and at its end.

to move the center of the imaginary compass outward. Fig. 215 shows the center of rotation moved from the neutral setting of 55 (where it was in Fig. 214) to 62. Now it will be noticed that in Fig. 216 the stylus remains on the outside wing of the Gothic arch tracing and at its end.

On the other side of this patient, note that the stylus cuts inside the

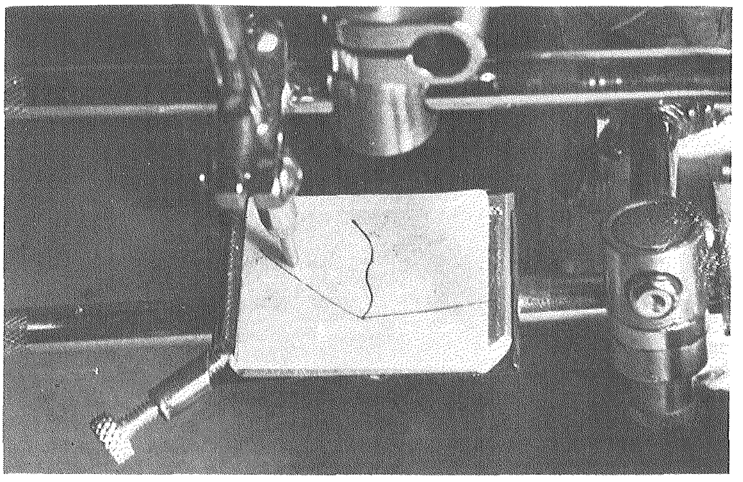

Fig. 217. The stylus of the pantograph on the articulator is inside the outer wing of the Gothic arch tracing made by the patient on the right side. The imaginary compass arm has to be shortened.

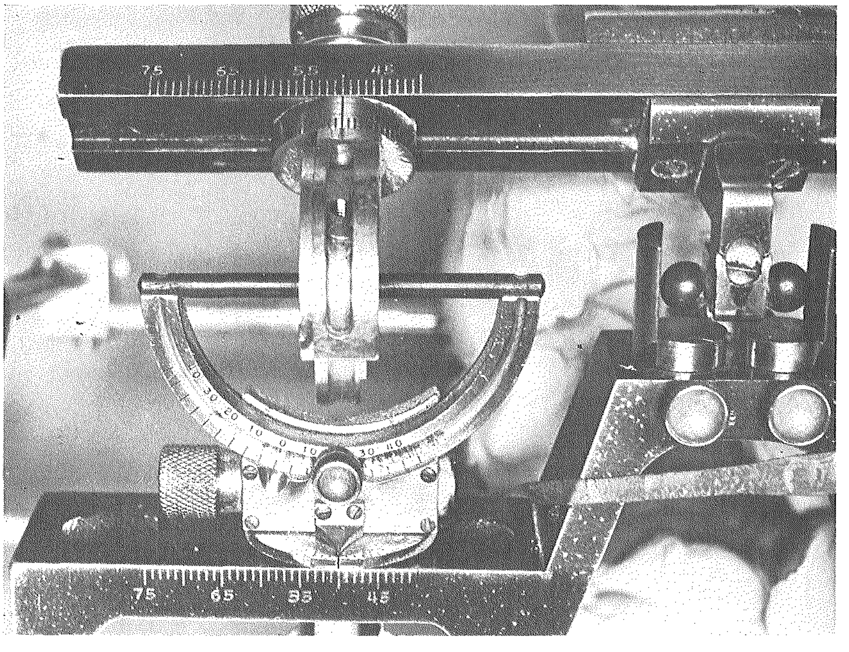

Fig. 218. The center of lateral rotation on the opposite side is moved inward to shorten the imaginary compass arm.

outer wing of the Gothic arch tracing (Fig. 217). The center of rotation on the opposite side of this particular tracing will have to be moved inward, as in Fig. 218, from the setting of 55 to 50. Now the stylus follows the line, as in Fig. 219, and is on the end of the line.

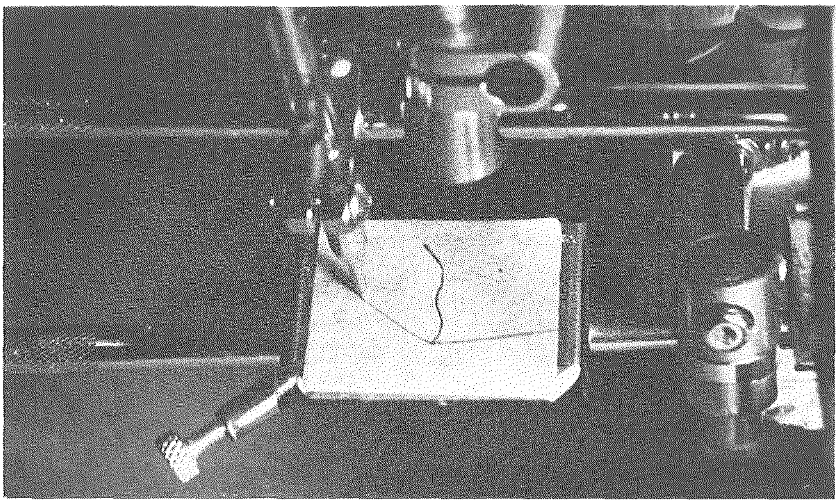

Fig. 219. After proper location of the center of lateral rotation, the stylus of the pantograph on the articulator is on the outer wing and at the end of the Gothic arch tracing made by the patient (right side).

At this point, the styli may not follow the lines in their entirety, i.e., they may miss from the beginning of the tracing (the apex of the Gothic arch) to the end. This is due to a curvature in the Bennett movement or side shift. This will be considered shortly. Meanwhile, at this stage of the articulator adjustment, the important point is that the styli are on the lines at their termination.

Bennett adjustment

The articulator (and writing apparatus) is moved to the left lateral excursion, and the tracing of the horizontal posterior slide (Fig. 220) is now ex-

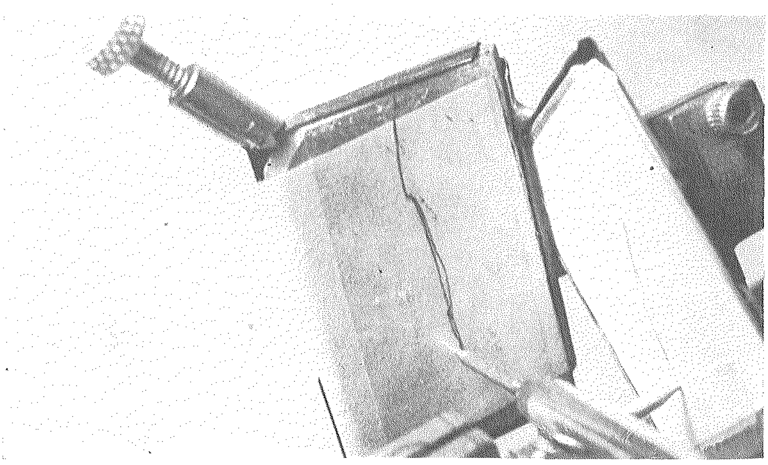

Fig. 220. The stylus of the pantograph on the articulator is not on the Bennett tracing made by the patient on the horizontal posterior slide of the right side.

amined. This is the balancing side. The end of the line of the lateral tracing (the other is the protrusive tracing) determines the amount of Bennett movement of the jaw. Fig. 221 shows the controls that limit this movement. The Bennett guide (Fig. 221) on the right side is adjusted so that the stylus is on the end of the lateral tracing when the Bennett ball is against the Bennett guide. If several lateral excursions are now made with the articulator and writing apparatus

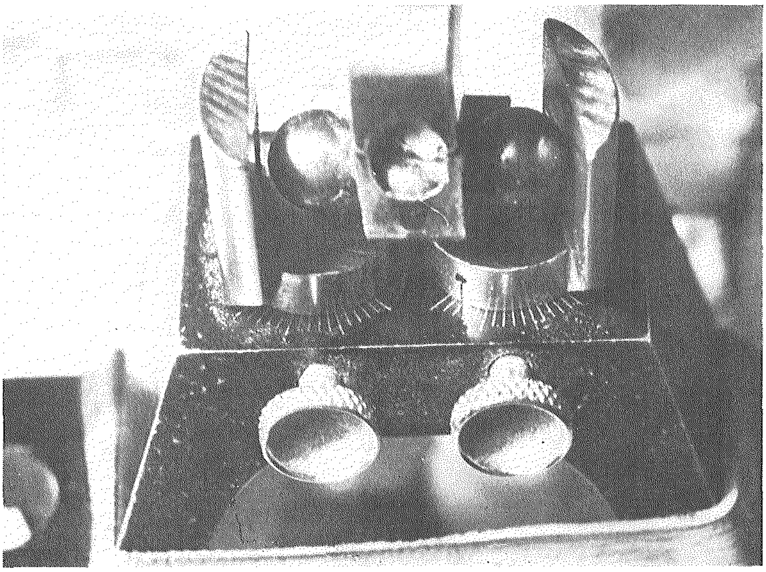

Fig. 221. The Bennett guide, which limits the amount of side shift on the articulator, is set to allow the proper angle.

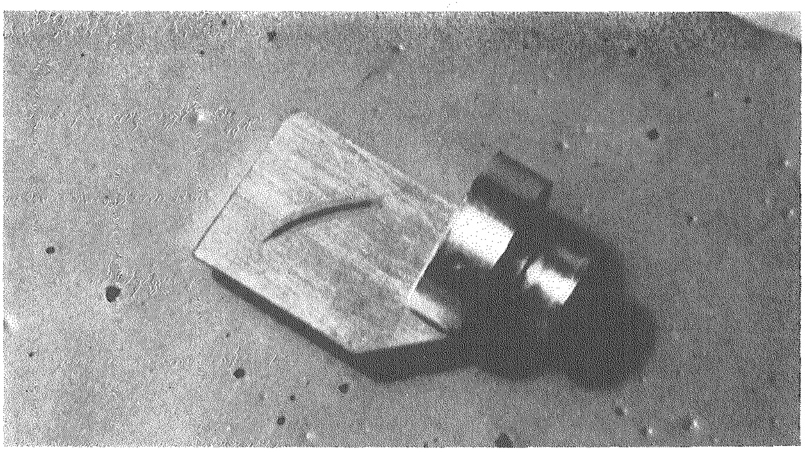

Fig. 222. The Bennett guide marked with carbon paper to indicate the area to be ground in order to duplicate the exact curvature of the Bennett movement traced by the patient.

(always being sure to ride against the Bennett guide for that side), it can be determined whether there is any curvature to the Bennett path and where it occurs. With some carbon paper or other suitable marking medium, one can locate on the Bennett guide just where the curvature is present (Fig. 222). Then, with mounted stones on a handpiece, the curvature for the particular movement is ground (Figs. 223 and 224). By repeated markings and adjustments on the Ben-

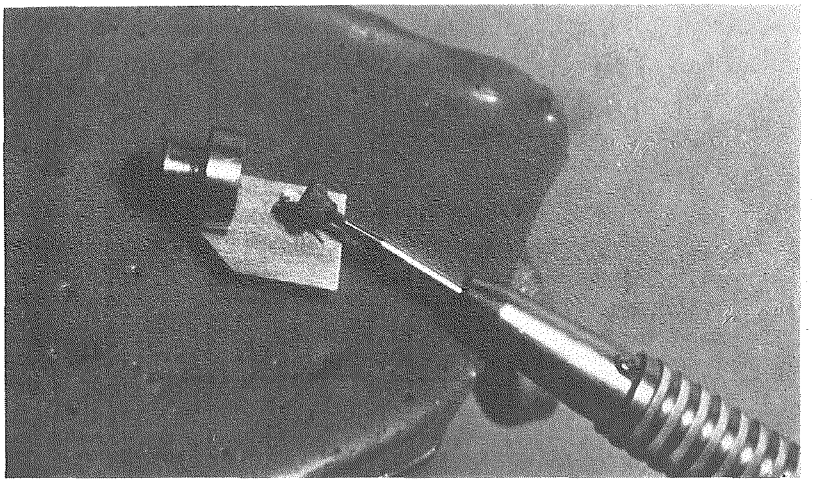

Fig. 223. Grinding the curvature of the Bennett movement on the Bennett guide.

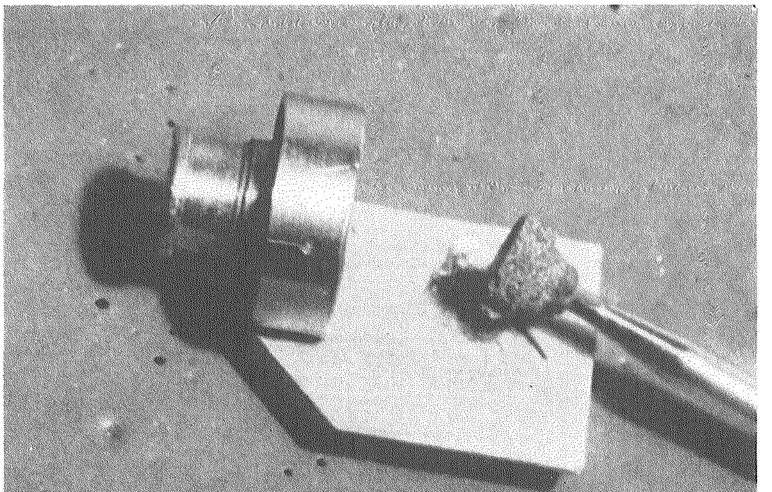

Fig. 224. Enlargement of grinding procedure shown in Fig. 223.

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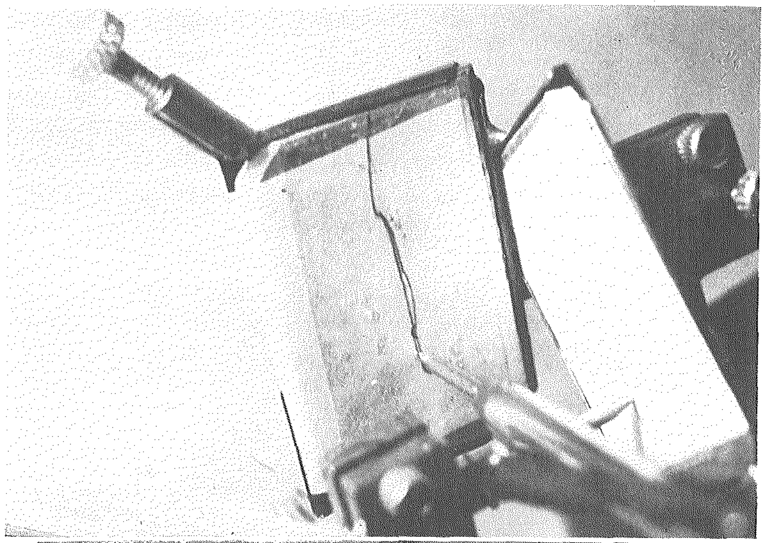

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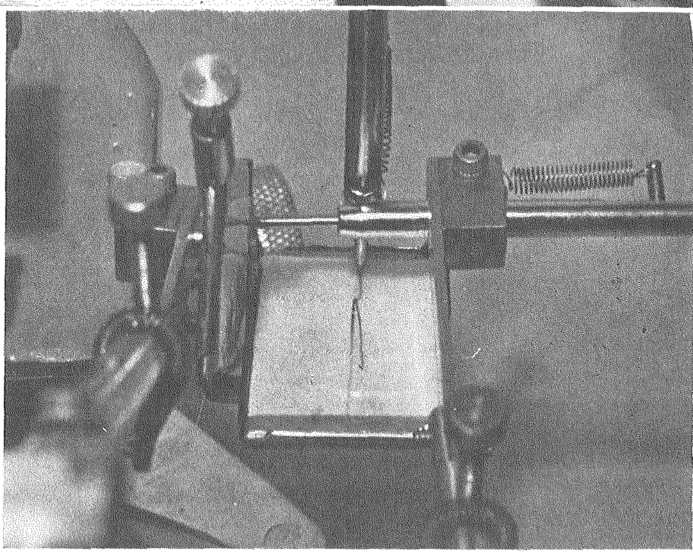
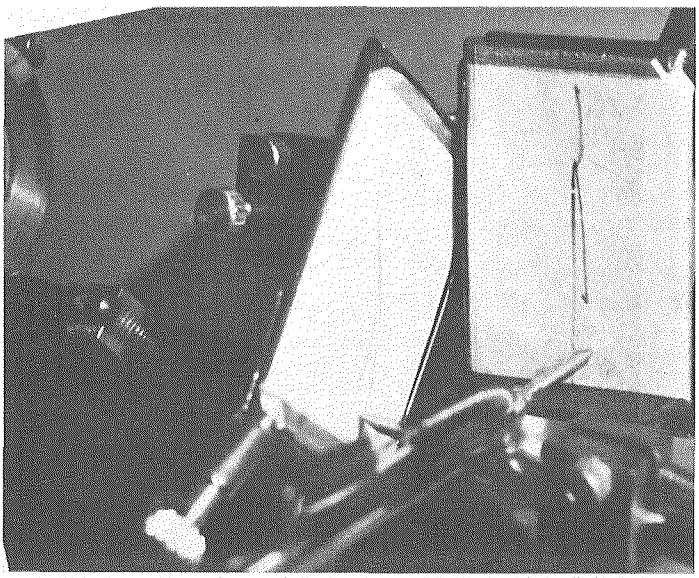


Fig. 225. The stylus of the pantograph on the articulator now follows the exact curvature and amount of Bennett movement traced by the patient.
Fig. 226. The backlash or reciprocal tracing on the opposite (working) side is used as a check on the Bennett guide adjustment.

nett guide, a curvature that will permit the stylus to follow the Bennett path exactly (Fig. 225) will soon be achieved.*

*A good procedure is to set the Bennett guide for the proper angulation and then select the nearest mark on the closed side. This facilitates the return of the guide as it is ground and also minimizes error when the instrument is reset. This means that the guide must be ground slightly at its extreme end of contact with the ball to offset any imbalance resulting from closing the guide.

Because the Bennett guides on McCollum's gnathoscope are located on the lower member, it is necessary to grind the guide in a wide path—not for depth, but for width. A moment's reflection will reveal why. The condyle path was not accurately selected or set in the first step. It was only approximated. Therefore, if a narrow Bennett path is ground in the guide, it may be necessary before the instrument is completely set to go back and regrind. Actually, the reason



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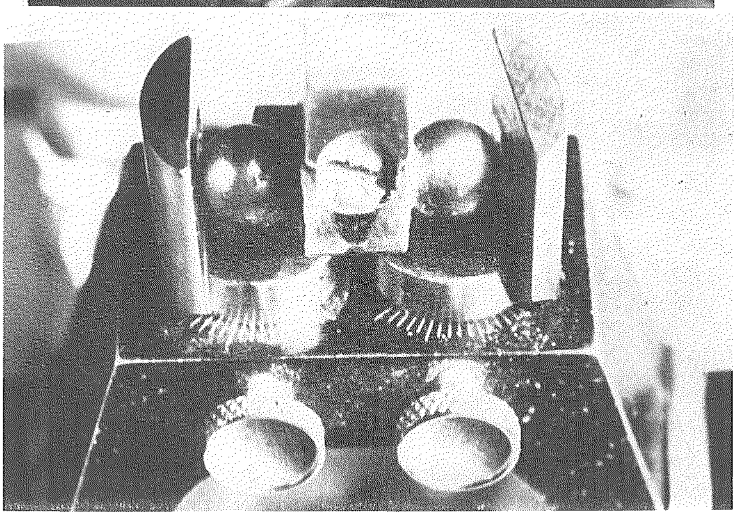

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Fig. 227. On the left side, the stylus of the pantograph on the articulator does not follow the Bennett tracing made by the patient.
Fig. 228. The Bennett guide of the left side must be set to the proper angle and ground if necessary to duplicate any curvature that may be present.

for approximately setting the condyle path was to minimize this very situation.

If the articulator is closed, which is the usual procedure, there will still be the correct Bennett limit because the registrations are taken in an open position.

In examining the stylus and tracing of the Bennett path, we will notice that

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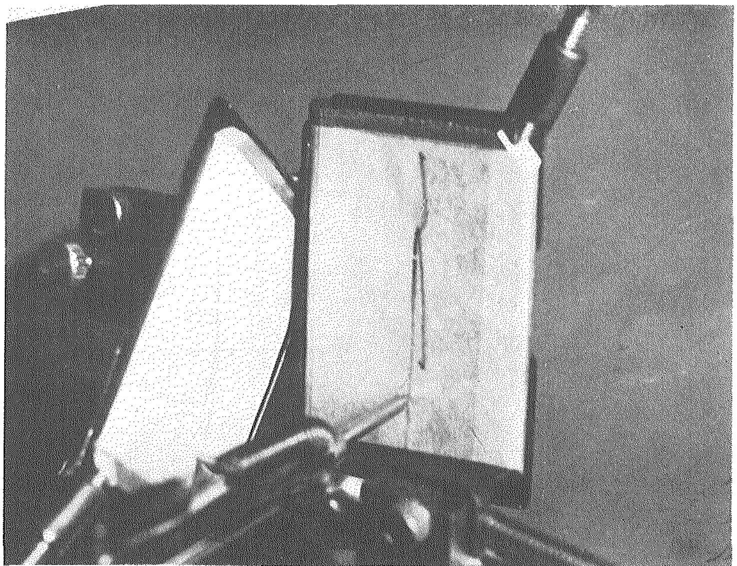

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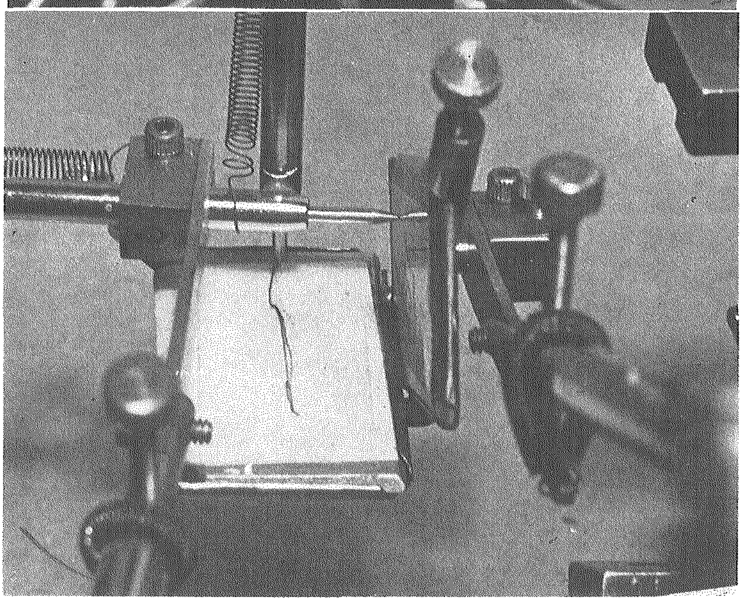

Fig. 229. The stylus of the pantograph on the articulator follows the Bennett tracing made by the patient after proper adjustment of the Bennett guide.
Fig. 230. The backlash or reciprocal tracing on the other side double checks the setting of the Bennett guide.

it follows in every detail. As a further check on our accuracy, examine the "tail" on the tracing of the opposite (working) side, at the same time examining the long Bennett tracing on the balancing side. Fig. 226 shows that the tail of the one side is accurately followed while the stylus on the larger tracing is being examined. The larger tracing is used for grinding in the path because its magnitude minimizes the possibility of error.

This procedure is repeated in every detail for the other side (Figs. 227 to 230).

Adjustment of vertical tilt of axis

The adjustment of the vertical tilt of the axis is the next step in the setting of the gnathoscope.

As we go into the lateral excursion, we examine the vertical slide on one side. On the balancing side, the stylus travels of course in the general direction of the condyle path, although not exactly since it has not yet been set. On the opposite (working) side, the stylus makes a short path (the tail), as in Fig. 231. In order to make the stylus follow this path accurately, it is necessary to tilt the axis (Fig. 232). Whether the axis is tilted upward or downward in relation to the outside end of the axis depends on whether the stylus is below or above the tracing when one is in the working occlusion. Remember that in the working occlusion the upper bow of the articulator moves inward (just the opposite of what the patient does at this moment). As the condyle pivots on the ball, it also slides the ball inward according to the amount determined by the Bennett

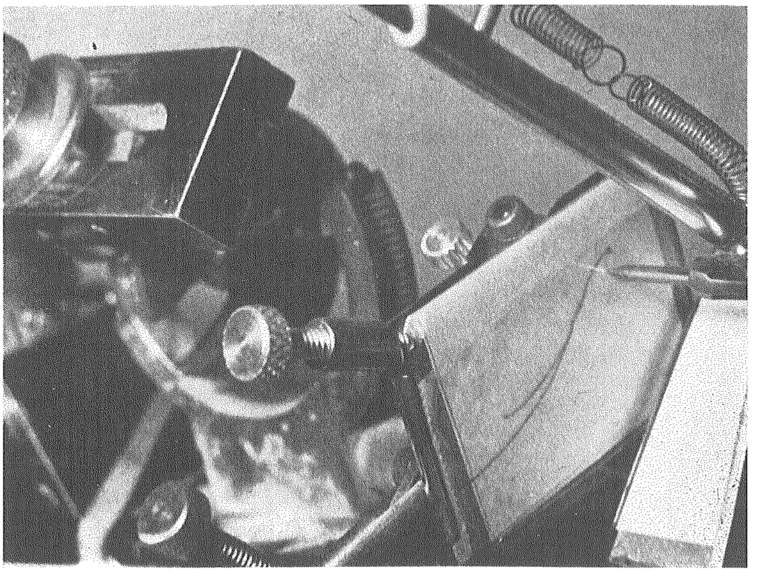

Fig. 231. The stylus of the pantograph on the articulator is below the backlash (the vertical component of the Bennett movement) made on the working side by the patient.

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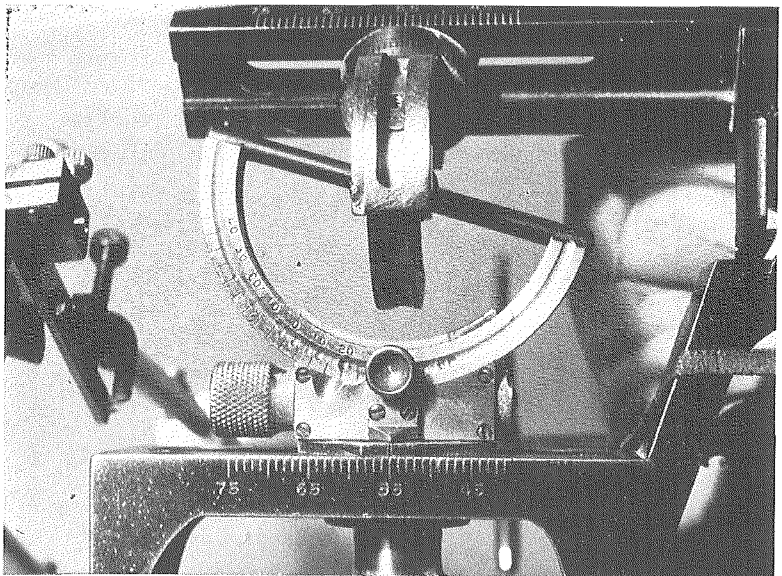

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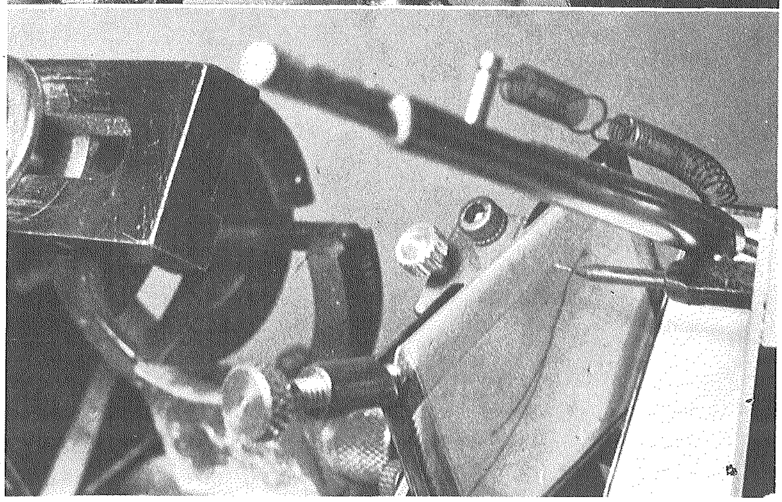


Fig. 232. The axis on the same side is tilted in order that the upper bow and slide will drop as the articulator is moved into the working occlusion. The dropping of the upper bow and slide will permit the stylus, which is attached to the lower member of the articulator, to follow the tracing.

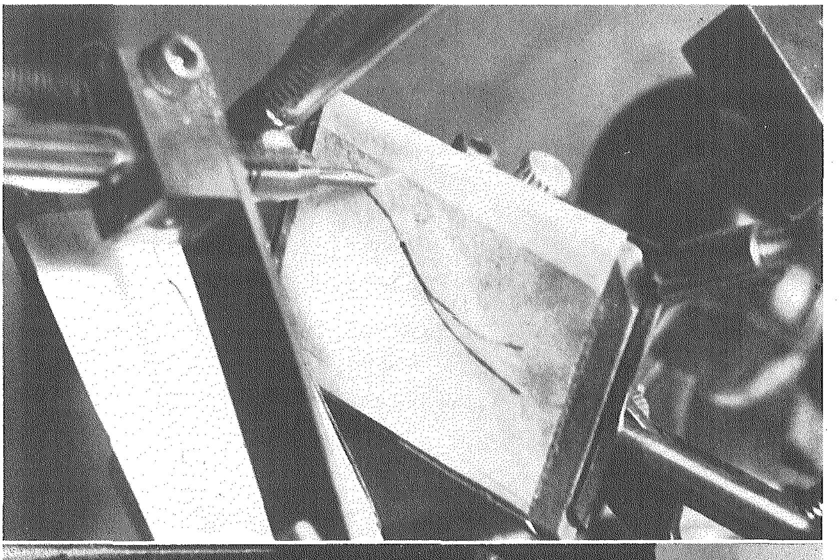
Fig. 233. After proper tilting of the axis, the stylus of the pantograph on the articulator will follow the backlash made by the patient.

guide (which was previously set). If the tracing attached to the upper bow has to be lowered in order that the stylus may follow the tracing, the axis will have to be tilted upward at its outside end. This will permit the upper bow, with the slide attached to it, to drop when the upper member moves inward (Fig. 233). A little experimentation with the apparatus should clarify what may appear to be a complicated procedure.

When the proper tilt has been arrived at by a process of trial and error, the stylus will accurately follow the tracing.

This procedure is repeated for the other side.

It will be noted in Fig. 234 that the stylus is above the tracing prior to adjustment. However, when the axis is tilted in the opposite manner (lower the outside end), as in Fig. 235, the stylus is adjusted to the tracing (Fig. 236).



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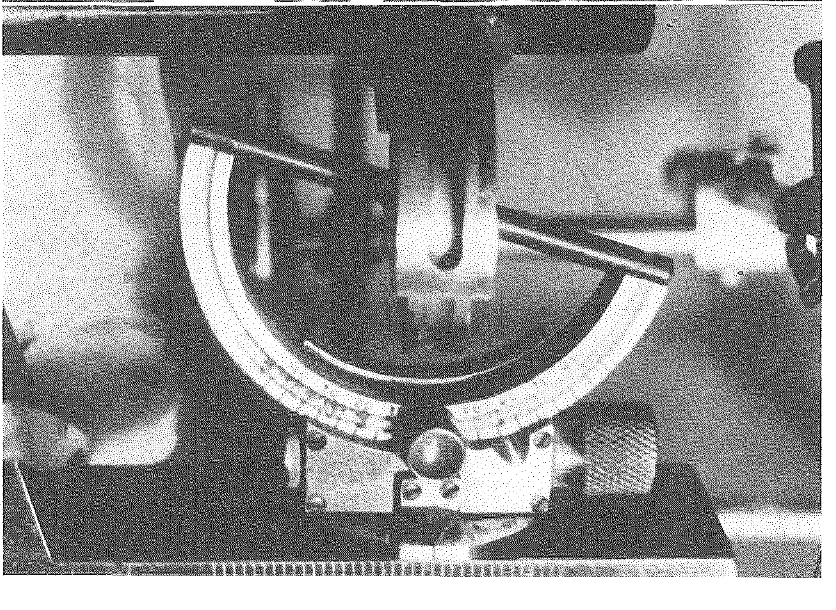

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Fig. 234. The stylus of the pantograph on the articulator is above the backlash on the right side.

Fig. 235. The axis has to be tilted so that, as the articulator is moved into the working occlusion, the upper bow (and slide) will be made to rise.

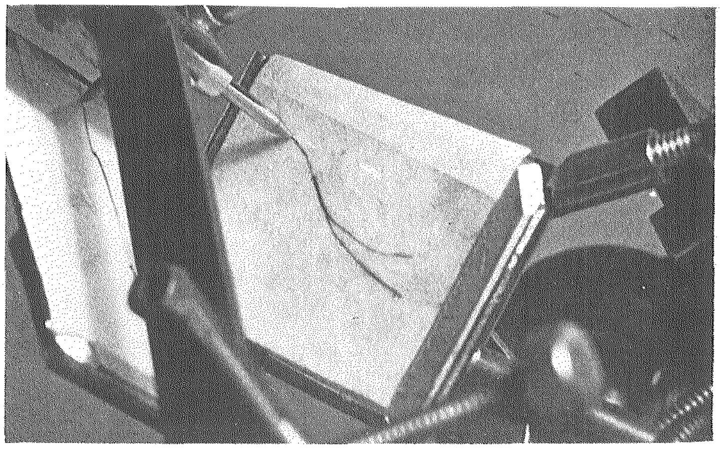


Fig. 236. After the correct tilt of the axis, the stylus of the pantograph on the articulator follows the tracing made by the patient.

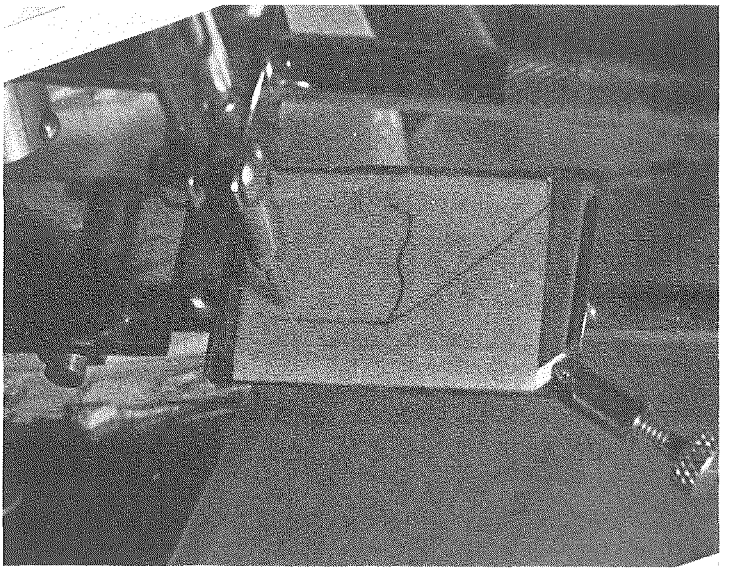


Fig. 237. The stylus of the pantograph on the articulator is behind the inner wing of the Gothic arch made by the patient on the left side.

Rotation of axis

In addition to being tilted, the axis may also have to be rotated. The inner wing of the Gothic arch on the *same* side being examined determines the axis rotation.

Fig. 237 shows the stylus inside the inner wing of the tracing. By rotating the axis forward at its inner end, we will permit the upper bow and the anterior stylus attached to it to move forward as the condyle ball assembly moves in-

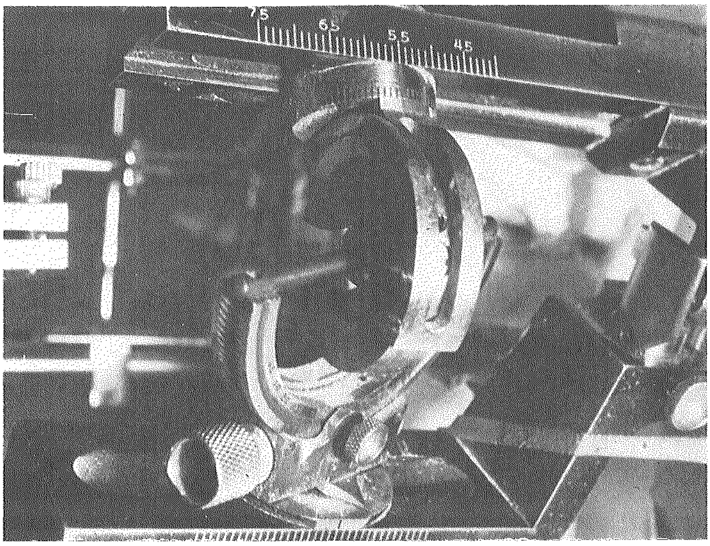


Fig. 238. The axis is rotated so that the condyle ball will travel inward and forward as it goes into the working occlusion. This permits the center of the imaginary compass to move inward and forward.

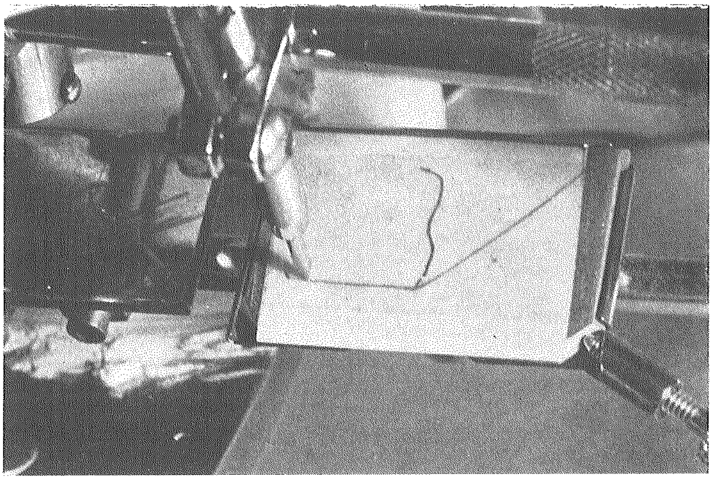


Fig. 239. After rotation of the axis, the stylus of the pantograph on the articulator follows the inner wing of the Gothic arch tracing made by the patient.

ward according to the degree determined by the Bennett guide (Fig. 238).

Fig. 239 shows the stylus on the inner wing after the axis has been rotated the proper amount.

Fig. 240 shows the inner wing of the opposite side with the stylus outside the tracing. The opposite turning, i.e., back at the inner aspect (Fig. 241), permits the stylus to duplicate the tracing accurately, as in Fig. 242.

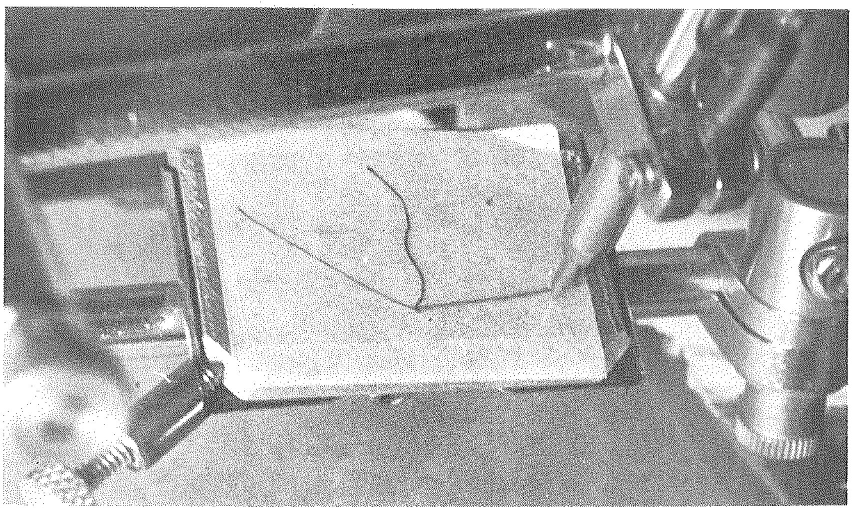


Fig. 240. On the right side, the stylus of the pantograph on the articulator is outside the inner wing of the Gothic arch tracing made by the patient.

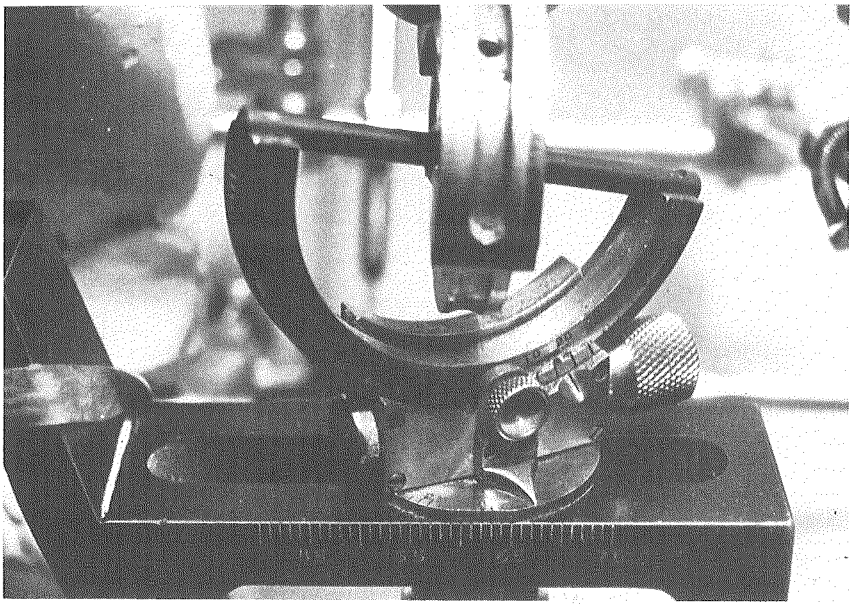


Fig. 241. The axis has to be rotated so that, as the condyle ball moves inward on a working occlusion, the center of the imaginary compass will move inward and backward.

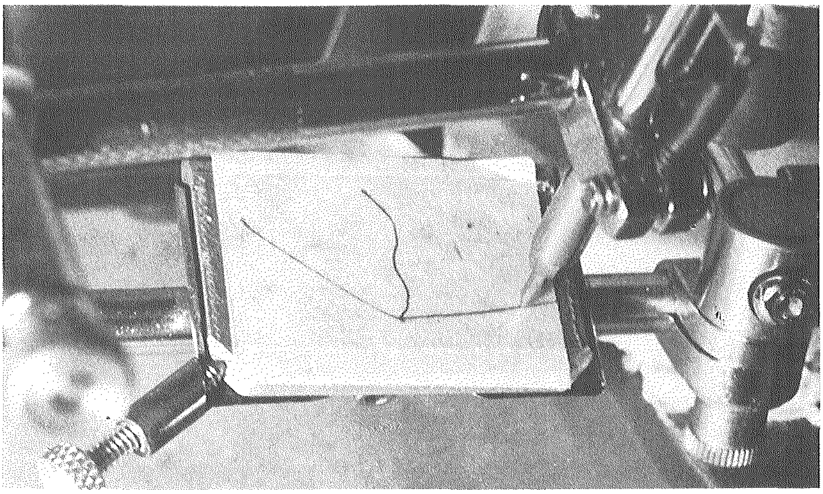


Fig. 242. The stylus of the pantograph on the articulator follows the inner wing of the Gothic arch tracing made by the patient after proper rotation of the axis on the same side.

Adjustment of condyle path by means of protrusive movement

This next step is rather complicated because it is necessary to make the equipment duplicate the particular protrusive path that the patient happened to take when the registrations were made.

In order to accomplish this successfully, it will be necessary to follow the protrusive path on the anterior slide and the protrusive path on the horizontal slide posteriorly. At the same time, we must also observe what is happening on

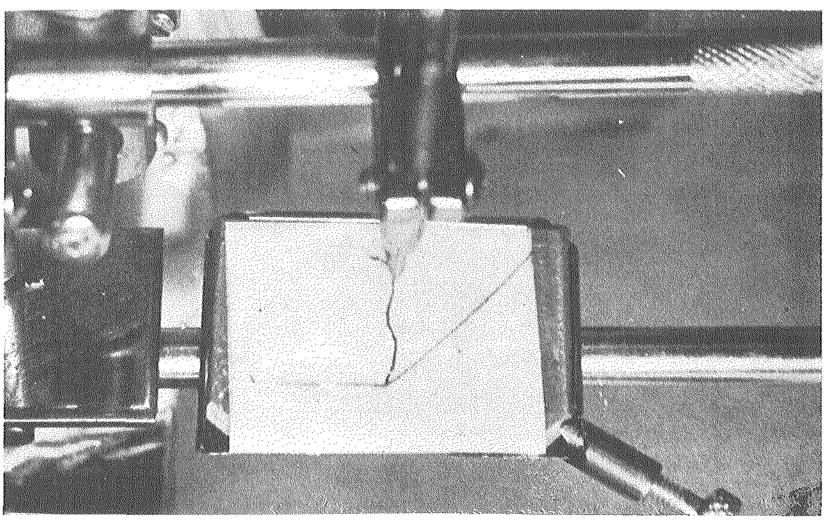


Fig. 243. The articulator and pantograph are moved so that the stylus follows the protrusive path on the anterior tracing made by the patient.

the vertical slide posteriorly to ascertain whether the stylus is following that path. In other words, three slides and three styli on one side must be watched simultaneously—a rather neat trick.

Study Figs. 243 and 244 simultaneously. The stylus can easily be adjusted to the end of the tracing (Fig. 245) by adjusting the angle of the condyle path, as in Fig. 246. However, the stylus must also follow the entire path. This will necessitate the selection of a path with the proper curvature.

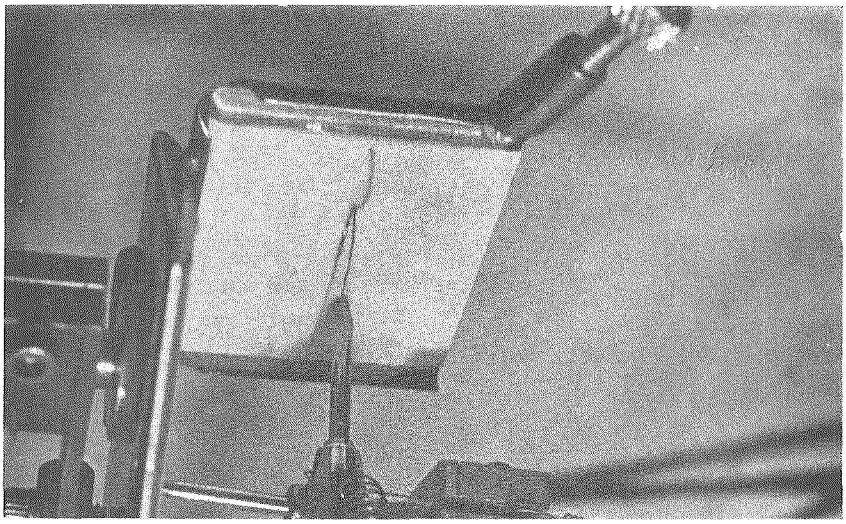


Fig. 244. The articulator and pantograph are moved so that the stylus follows the protrusive path on the posterior horizontal slide.

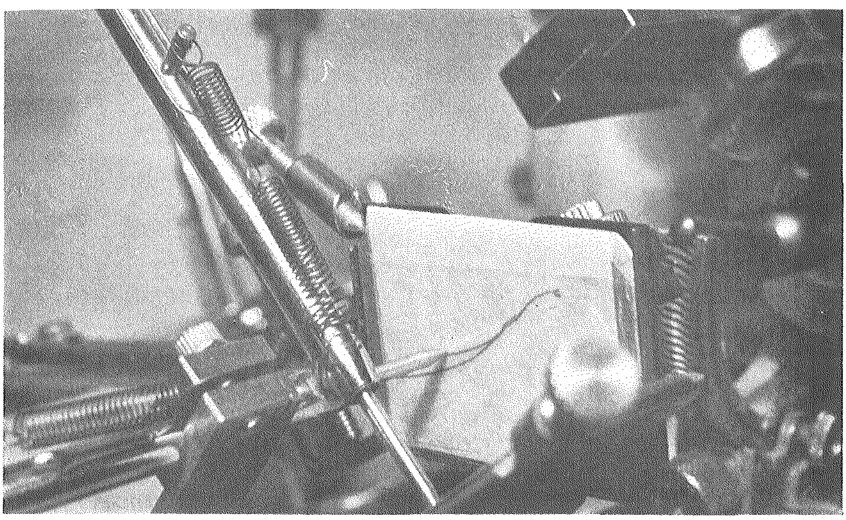


Fig. 245. The path of the stylus of the pantograph on the articulator is examined on the vertical slide while the articulator is guided into the protrusive path made by the patient.

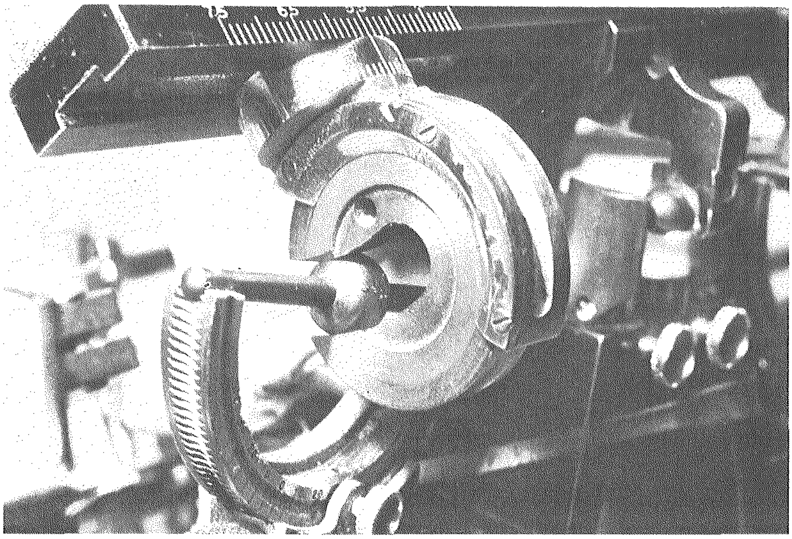


Fig. 246. The condyle disc with the proper curvature is selected by a process of trial and error.

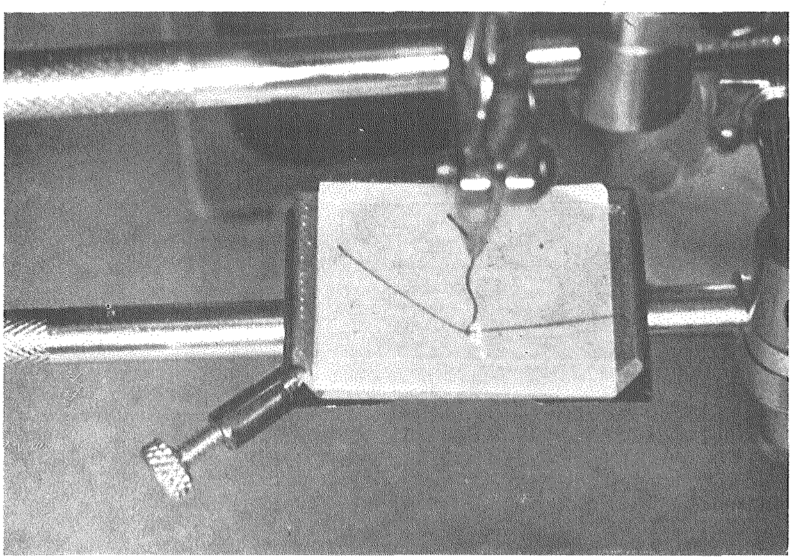


Fig. 247. The articulator and pantograph are moved so that the stylus follows the protrusive path on the anterior tracing made by the patient on the right side.

In Fig. 245, the stylus arcs below the path after it leaves the center and then gets back on the line at the end. Here we have in the instrument a path with too much curvature. By trial and error, one with less curvature is selected until the stylus follows the tracing completely.

These steps are repeated for the other side (Figs. 247 to 251).

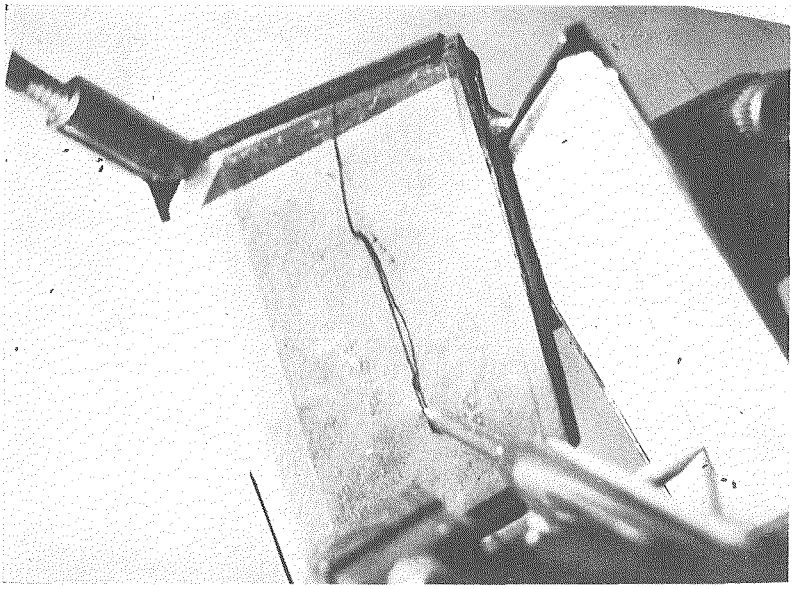


Fig. 248. The articulator and pantograph are moved so that the stylus follows the protrusive path on the posterior horizontal slide of the right side.

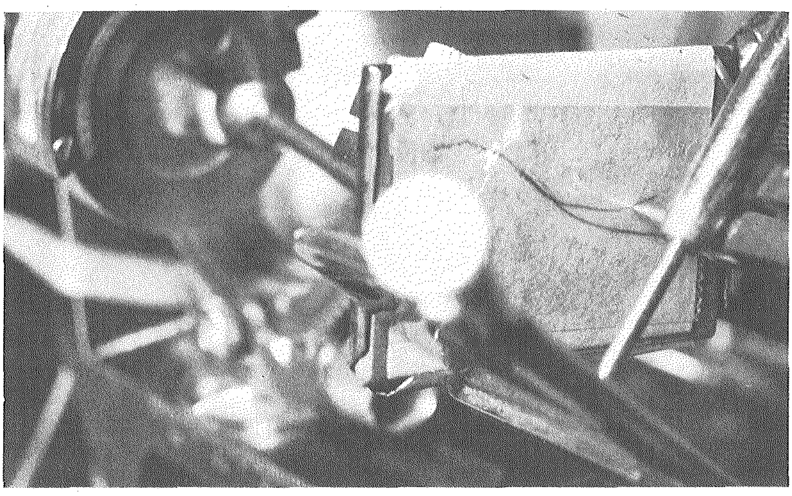


Fig. 249. The path of the stylus of the pantograph on the articulator is examined on the vertical slide of the right side while the articulator is guided into the protrusive path made by the patient.

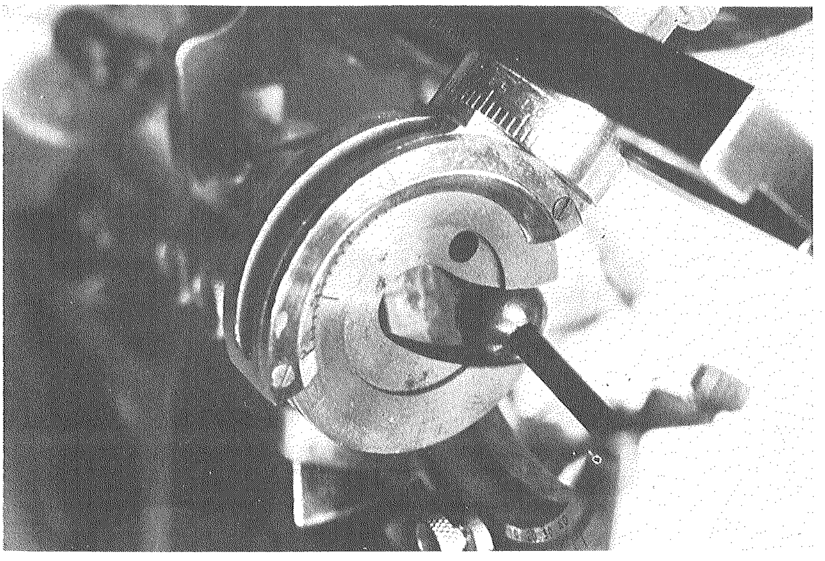


Fig. 250. The condyle disc with the correct curvature is selected by trial and error.

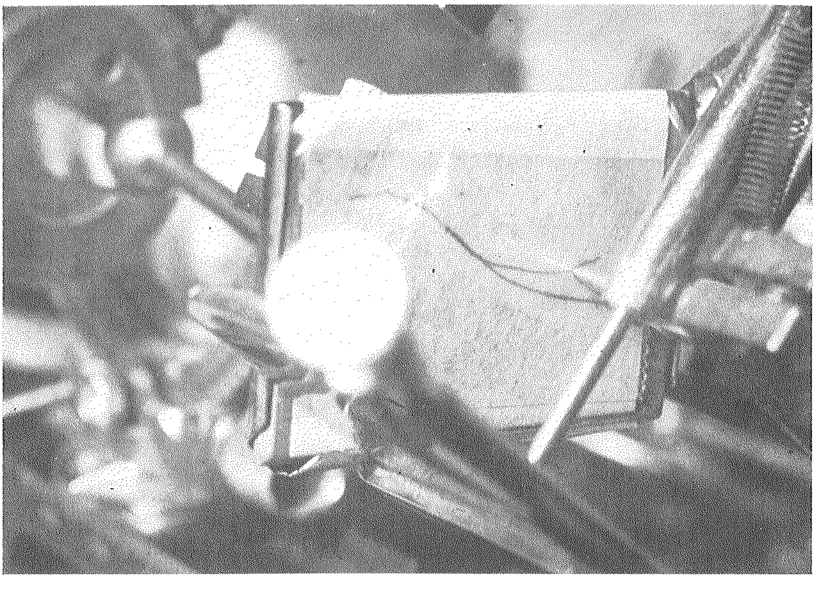


Fig. 251. The stylus of the pantograph on the articulator follows the protrusive path made by the patient.

If this constituted the only difficulty, the problem would not be too complicated. There is, however, another consideration. We have now to see whether the selected path will also produce an accurate tracing in the lateral excursion as well as in the protrusive for which it was selected.

Rotation of condyle path

There is one other adjustment that will accomplish this. We can, if necessary, *rotate* the path. The direction of rotation (in or out) depends on the inclination of the axis which was previously determined and set by the tail of the tracing on the working occlusion (the posterior vertical slide).

If the axis is tilted downward at its outer end, as in Fig. 252, then an inward rotation of the condyle path will effect a sharper rise in the condyle slide (and path) in the balancing position. This is so because, as the condyle path goes backward, it will (because of its rotation) cause the ball to go inward and, at the same time, upward on the tilted axis. If, in examining the travel of the pin, we find that it does not go down to the lower tracing, then the upper bow (carrying the slides) must be made to rise. This is accomplished by rotating the condyle inward at the anterior part if the axis is tilted downward at its outer end, as in Fig. 252. However, if in testing the lateral excursion it is found that the pin travels below the lateral tracing, it then becomes necessary to drop the upper bow as it moves into the lateral excursion. This can be accomplished by rotating the anterior part of the path inward if the axis is tilted down from the outside inward (Fig. 255).

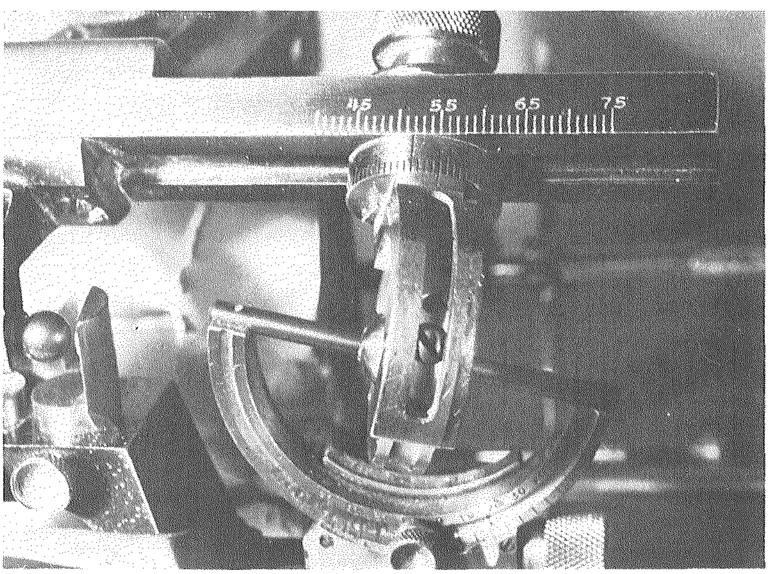
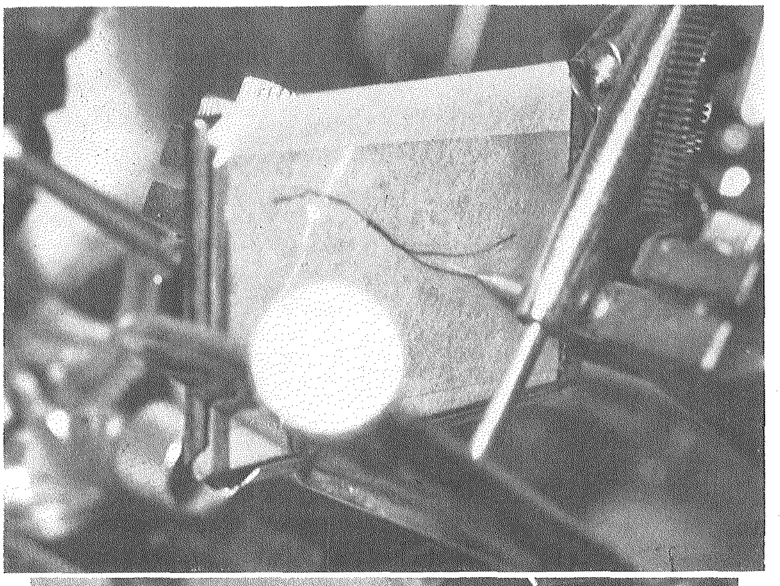


Fig. 252. Rotation of the condyle disc permits the stylus of the pantograph on the articulator to follow the lateral path as well as the protrusive path with one setting of the instrument.



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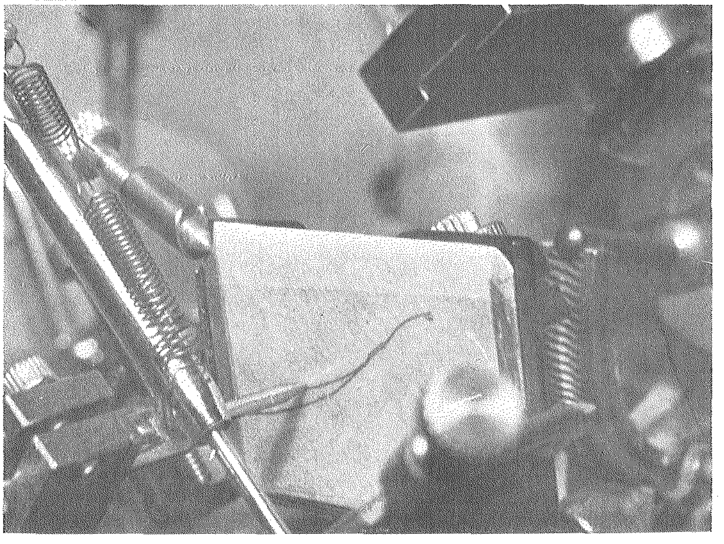

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Fig. 253. The stylus of the pantograph on the articulator follows the lateral path made by the patient after proper rotation of the condyle disc.
Fig. 254. The stylus of the pantograph on the articulator follows the protrusive path made by the patient on the left side.

Unfortunately, such maneuvering may have changed the protrusive adjustment, and thus it may be necessary to readjust the condyle inclination or even to select another path. It is possible, by trial and error, to arrive at the particular path curve and path rotation that will permit an accurate tracing in both the protrusive and lateral excursions. (Fig. 253).

This procedure is repeated for the opposite side (Figs. 254 to 256).

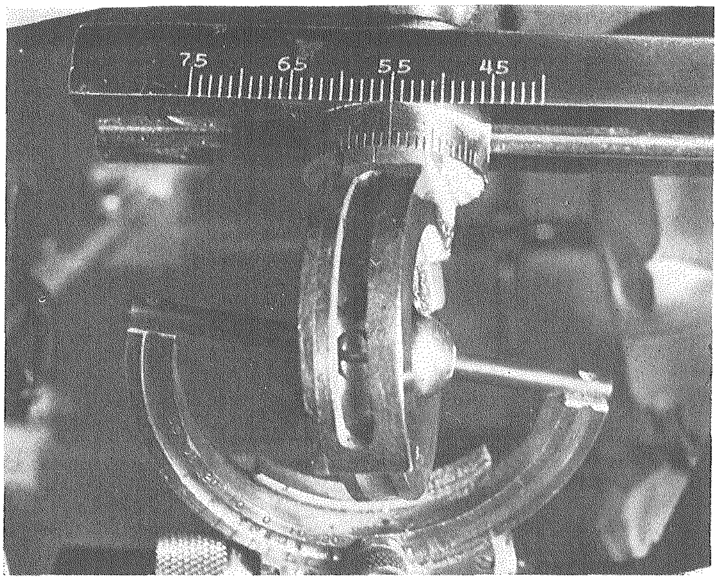


Fig. 255. Rotation of the condyle disc in the proper direction will permit the stylus of the pantograph on the articulator to follow the patient's lateral path with one setting of the instrument.

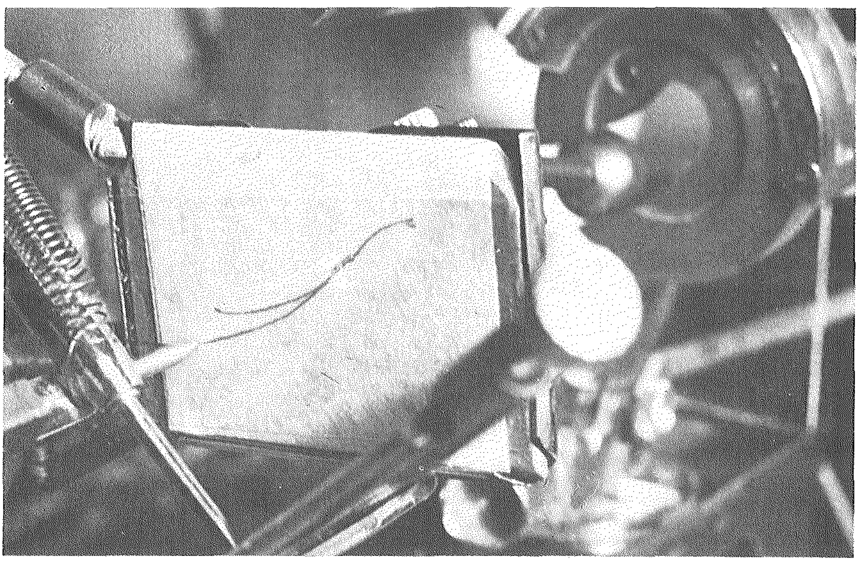


Fig. 256. The stylus of the pantograph on the articulator follows the lateral path made by the patient.

At this point, the gnathoscope is completely set (Fig. 257) and will follow all the tracings in every excursion.

The settings are recorded on the chart (Fig. 258), care being taken to read

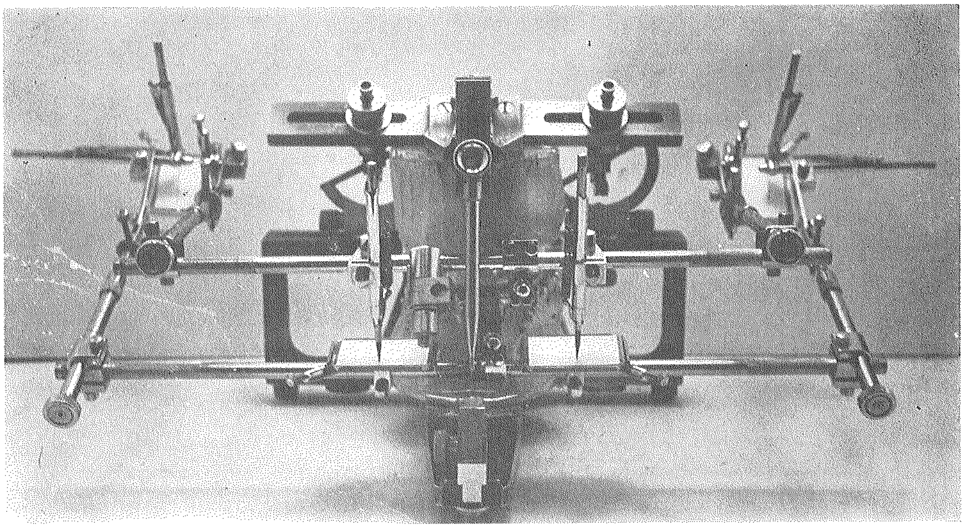


Fig. 257. The completely set articulator duplicates in every detail the pantographic tracings made by the patient.

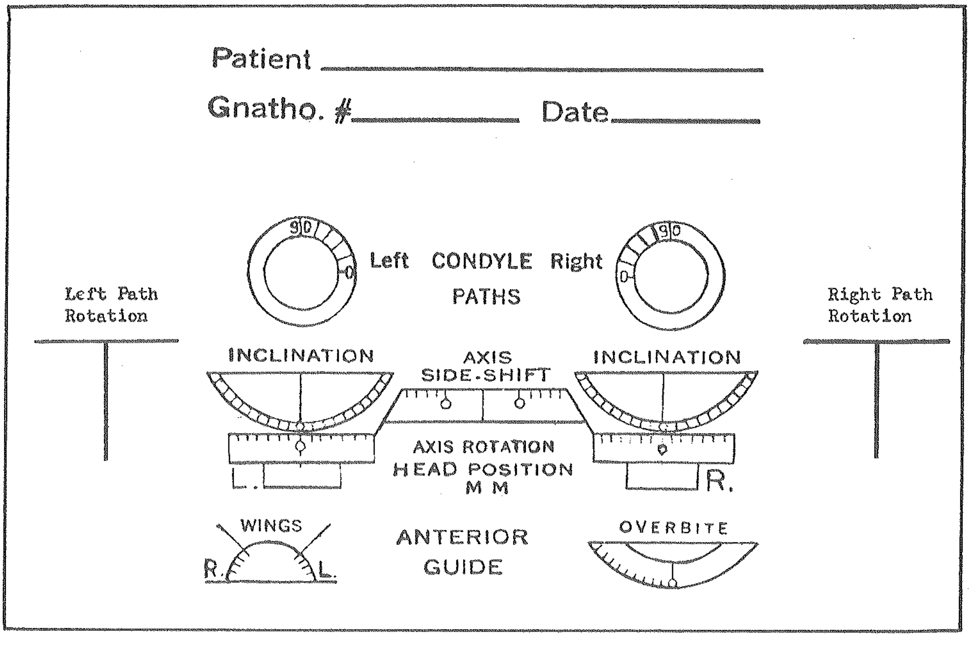


Fig. 258. Chart used to record the articulator settings. Reference to this chart will enable the articulator to be reset at any time to duplicate the patient's movements.

them accurately. The Bennett guides are inscribed with the patient's name for identification at a later date. The writing apparatus can now be removed from the articulator, and the casts can be mounted.

CHAPTER 9

Setting the Granger gnatholator

In Chapter 8 we examined in some detail the use of the gnathoscope in duplicating the patient's registrations. Another instrument which will reproduce the fundamental movements of the patient is the gnatholator,* designed by Dr. Ernest R. Granger of Mount Vernon, New York.

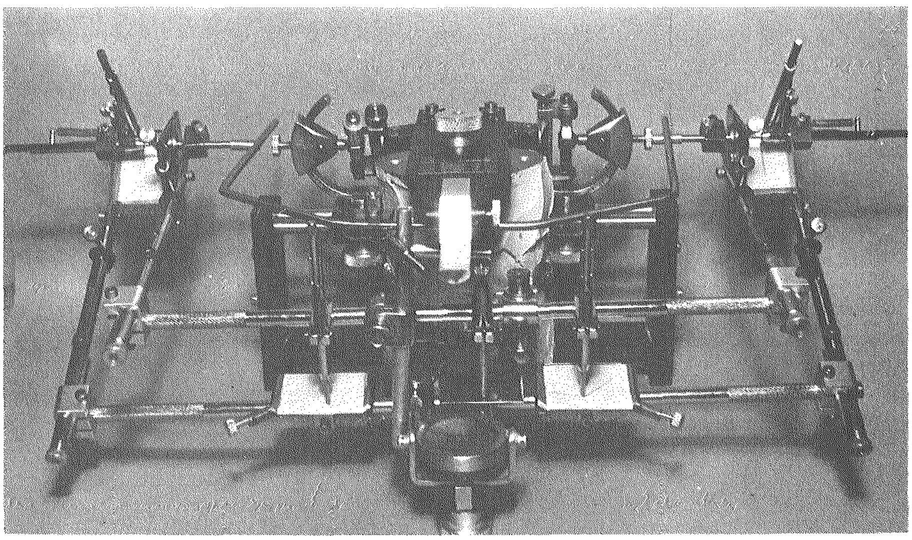
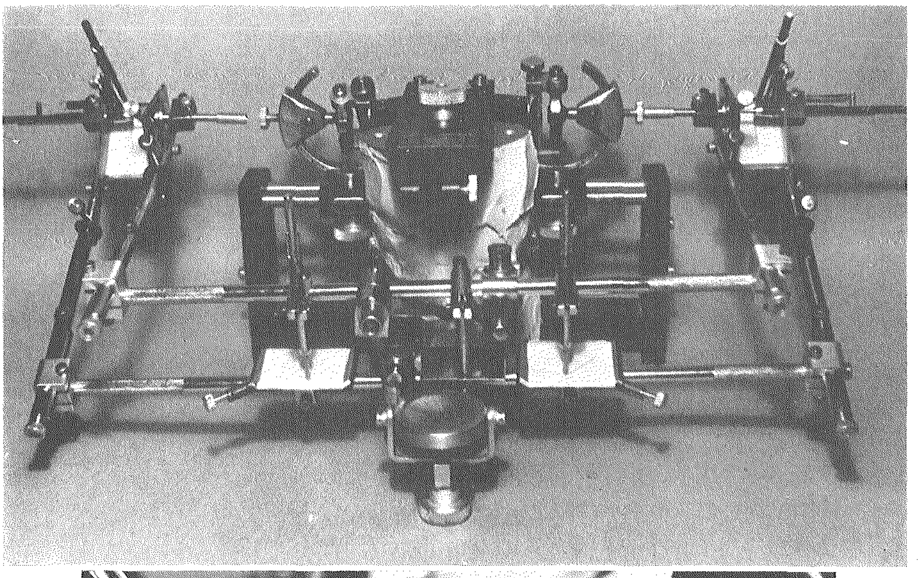


Fig. 259. The pantograph mounted on the gnatholator.

ASSEMBLY OF GNATHOLATOR AND GNATHOGRAPH AND APPROXIMATE SETTING OF INCLINATION OF CONDYLE PATHS

In the discussion here of the setting of the gnatholator by means of the gnathograph (see Chapter 5, discussion on registrations), each step follows a logical sequence. However, this sequence may be varied. Bear in mind always

*H. D. Justi & Son, Inc., Philadelphia, Pa.



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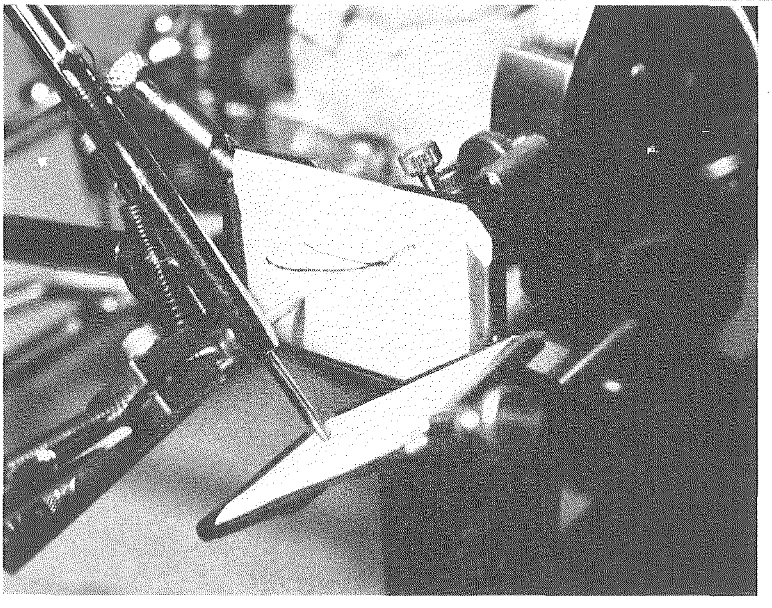

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Fig. 260. The axis-orbital indicator and support have been removed, permitting eccentric movements of the articulator and pantograph.
Fig. 261. Before adjustment of the condyle slot inclination, the stylus of the pantograph on the articulator is below the patient's tracing (left side).

that the adjustment of any articulator control will affect all other settings. Therefore, once a control is set, it must not be assumed that it will not have to be reset later in the adjustment procedure. The objective is to find the one setting of the controls which will produce an accurate reproduction of the writings, and the sequence about to be described is a logical way of arriving at an accurate and complete setting in a minimum of time.

When the gnathograph has been mounted on the gnatholator and the vise grips have been removed, as in Fig. 259, we can begin the adjustment of the instrument to follow the tracings obtained from the patient.

The axis-orbital indicator and support are removed, as in Fig. 260. The axis

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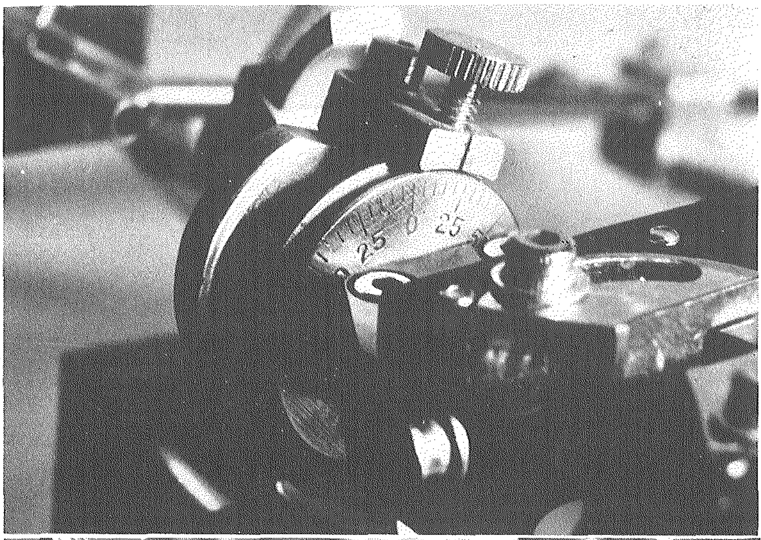

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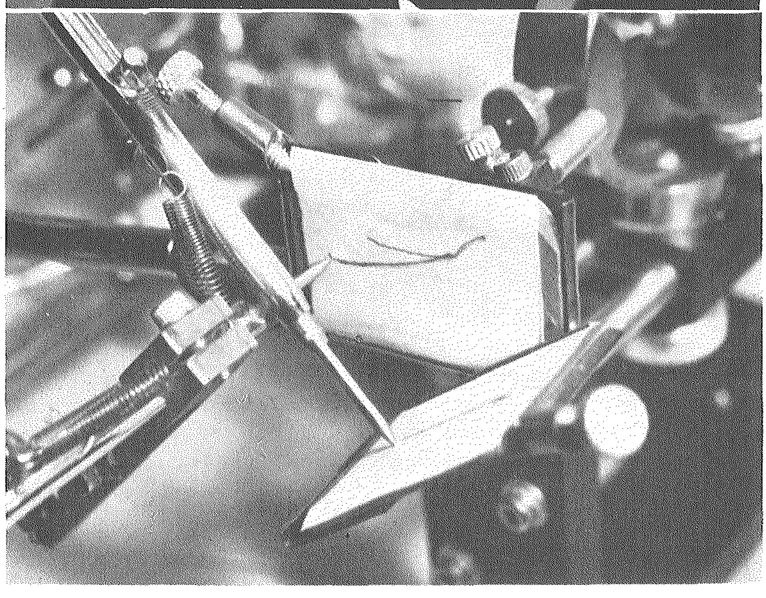
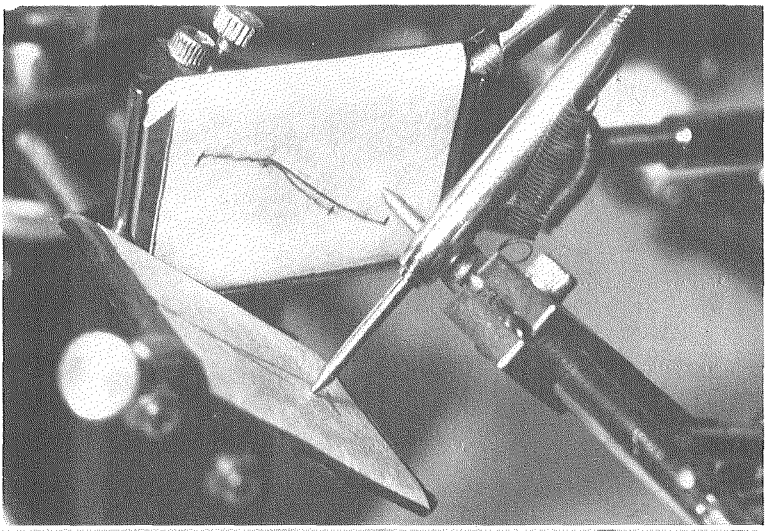


Fig. 262. Adjustment of the condyle slot inclination.
Fig. 263. The stylus of the pantograph on the articulator follows the patient's tracing after the condyle slot is properly adjusted.



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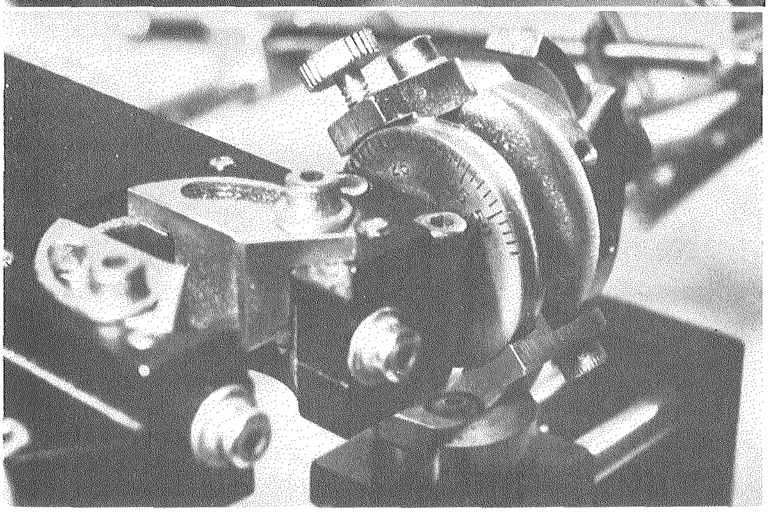

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Fig. 264. On the right side, the stylus of the pantograph on the articulator is above the patient's tracing.
Fig. 265. Adjustment of the condyle slot inclination (right side).

pins and collars should also be removed. (In Fig. 260, this has not yet been done.) The upper and lower members are now disengaged to permit the movement of the upper bow of the articulator and with it the upper part of the writing apparatus. Note that the latter carries four posterior slide holders (two on each side) and two anterior tracing pins.

The first step is to set the inclination of the condyle paths approximately on both sides. (Fig. 261, before approximate setting; Fig. 262, making the setting; Fig. 263, after setting; Figs. 264 to 266, repetition of the procedure on the

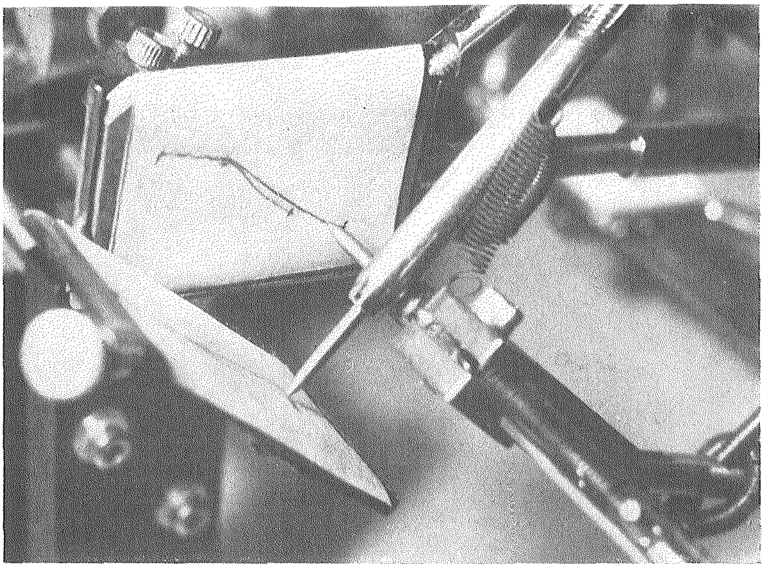
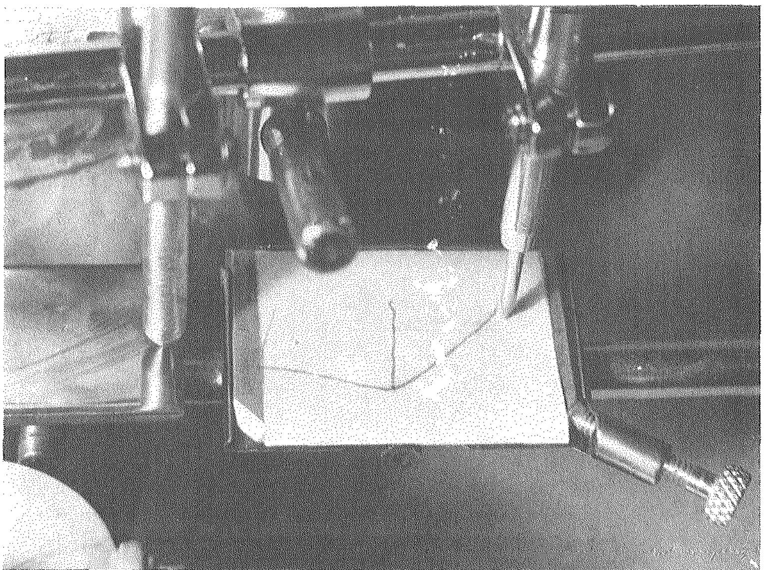


Fig. 266. After adjustment, the stylus of the pantograph on the articulator follows the patient's tracing.

other side.) This first step will facilitate the grinding of the Bennett paths, which will be done very soon.

ADJUSTMENT OF CENTERS OF ROTATION

The outside wing of each Gothic arch tracing is used to locate the lateral center of rotation on the opposite side of the instrument (Figs. 267 and 268). If one visualizes a compass with its pivoting point on the center of rotation and its tracing point making the outside wing of the Gothic arch on the opposite side from the center, he can readily see in which direction the center has to be moved in order to have the stylus retrace the outside wing. So, by changing the centers of rotation (the intercondylar distance), one can make the stylus retrace the outside wings at their ends. It will be noted that the stylus does not exactly follow a portion of the wing from the center (apex) to some point along the line. This is due to the Bennett movement or side shift which is also reflected in this tracing. The slight discrepancy, however, will be corrected during the grind-in of the Bennett guide. If, when the center of rotation adjustment is made, the stylus at the end of the stroke is outside the tracing (Fig. 267), then the radius of the imaginary compass is too short. Therefore, the radius is lengthened by moving the center of rotation (on the opposite side) outward (Fig. 268). With a longer radius, the stylus will settle on the end of the tracing (Fig. 269). Conversely, if the stylus is inside the tracing, the radius must then be shortened by moving the center of rotation (on the opposite side) inward.



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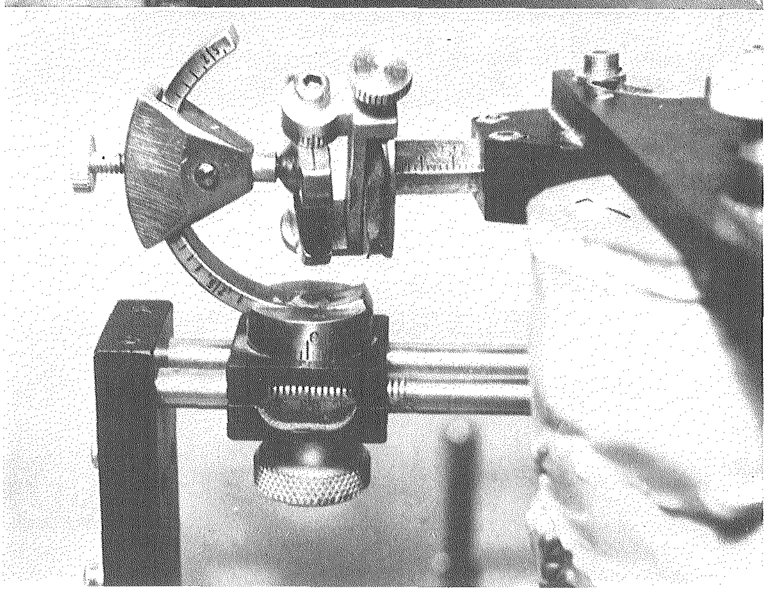

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Fig. 267. The stylus of the pantograph on the articulator is outside the outer wing of the Gothic arch tracing made by the patient (left side).
Fig. 268. The center of lateral rotation on the opposite side moved out to increase the length of the imaginary compass arm.

This procedure is repeated for the other side, using the outside wing of the other Gothic arch and moving the center of rotation on the opposite side (Figs. 270 to 272). When the adjustment of the Bennett guide is complete, the stylus will follow the outside wing of the Gothic arch in every detail.

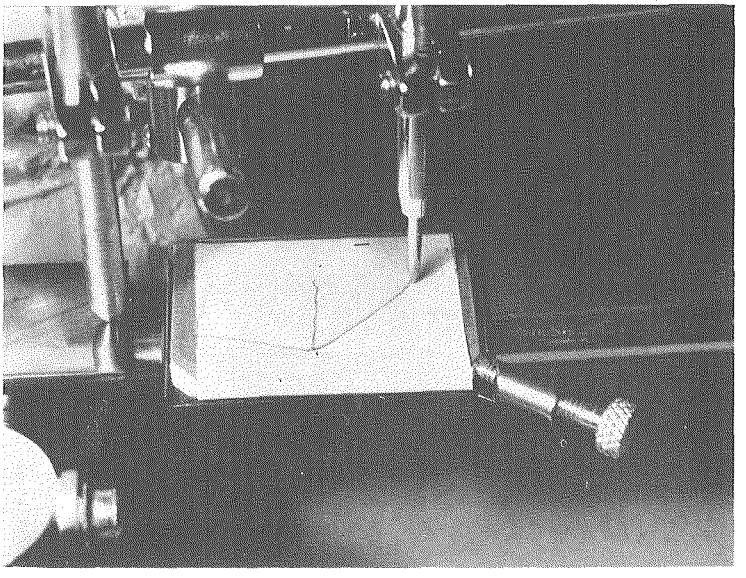

Fig. 269. After proper location of the center of lateral rotation, the stylus on the left side is on the outer wing of the Gothic arch and at its end.

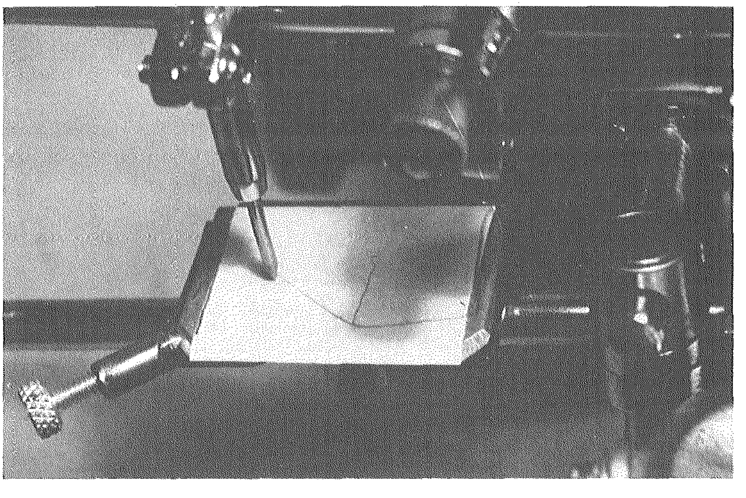

Fig. 270. The stylus of the pantograph on the articulator is outside the outer wing of the Gothic arch tracing made by the patient (right side).

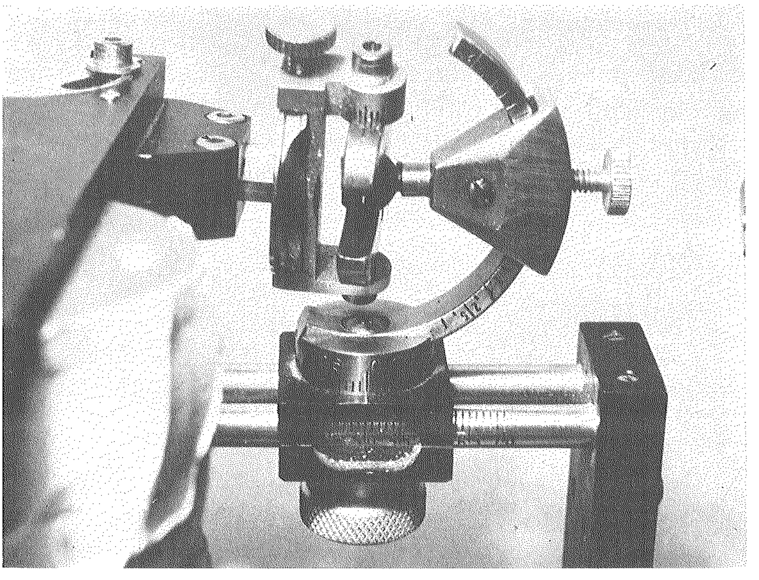

Fig. 271. The center of lateral rotation on the opposite side is moved outward to increase the length of the imaginary compass arm.

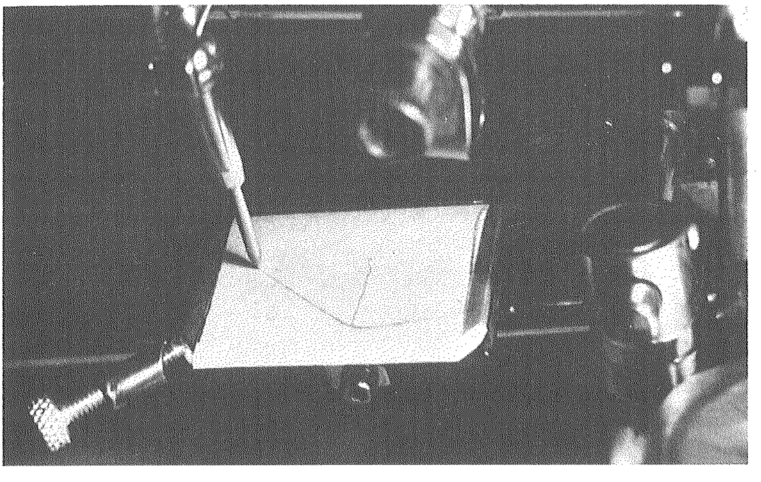

Fig. 272. After proper location of the center of lateral rotation, the stylus of the pantograph on the articulator is on and at the end of the outer wing of the Gothic arch tracing made by the patient (right side).

ADJUSTMENT OF BENNETT GUIDE

To adjust the Bennett guide, use the inner tracing on the horizontal slide in the posterior region (Fig. 273). The Bennett movement is more clearly visible on this slide because it is nearer the action. There are three tracings on this particular slide: the protrusive (with which we shall later be concerned), the

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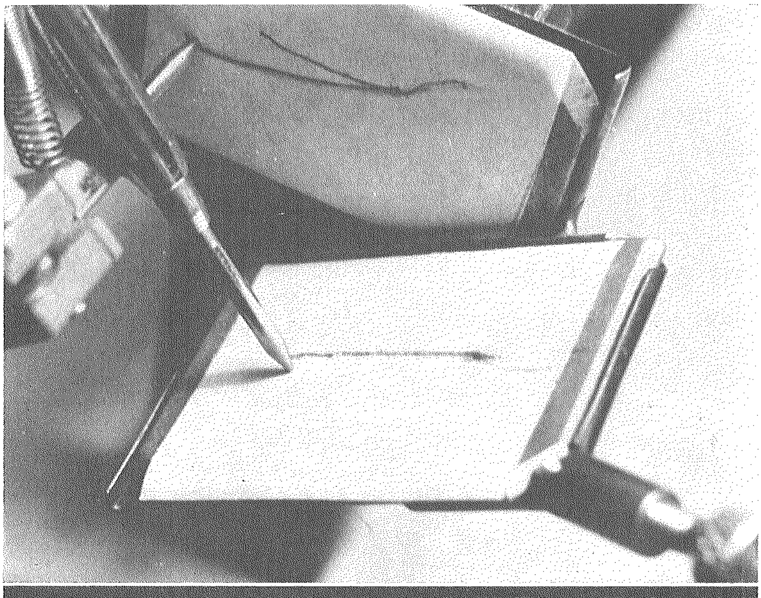

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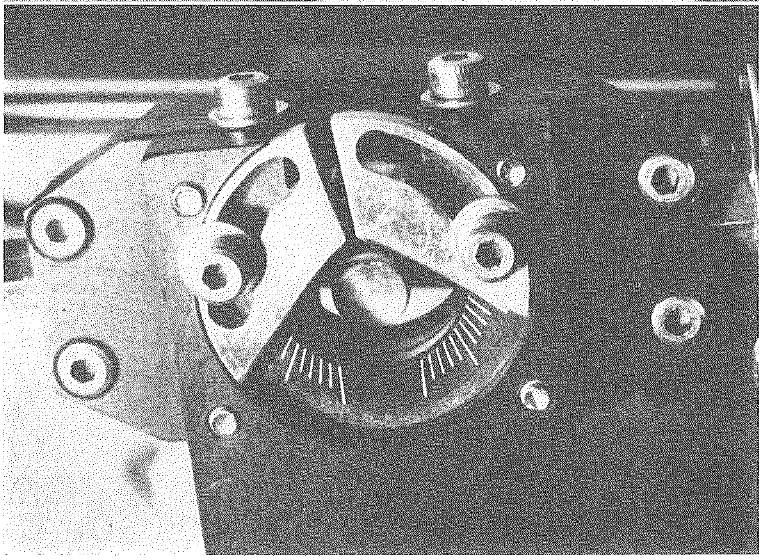

Fig. 273. The stylus of the pantograph on the articulator is not on the Bennett tracing made by the patient on the horizontal posterior slide of the left side.
Fig. 274. The Bennett guides, which limit the amount of side shift on the articulator, are opened to their widest position.

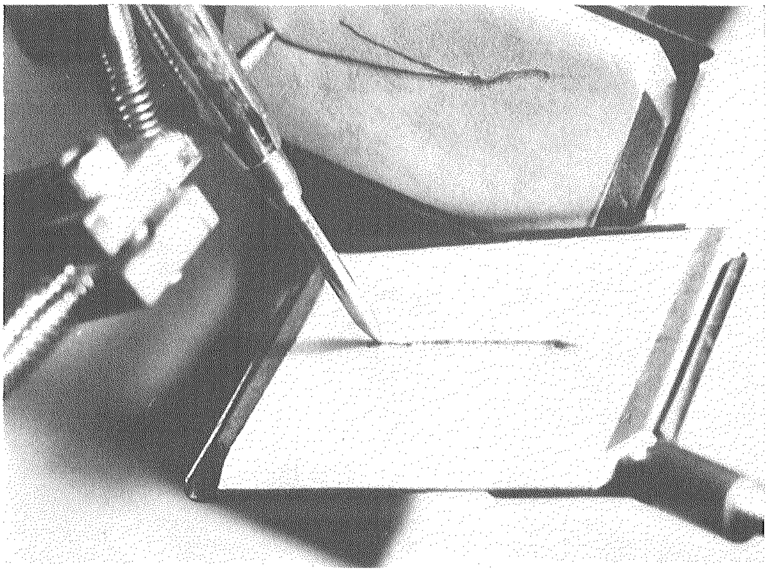

Fig. 275. The upper bow of the articulator and pantograph is moved into the lateral position until the stylus of the pantograph on the articulator is on the end of the Bennett tracing made by the patient.

Bennett movement for the one side, and the reciprocal Bennett movement for the other side. The Bennett movement represents the degree to which the balancing condyle travelled medially, and this tracing is used for the adjustment because it shows in a gross way what the Bennett movement is. The little tail ("reciprocal") on the other Bennett slide on the opposite side serves as a check on the adjustment. When the adjustment is made on one side, the tail in Fig. 273 is used to check the adjustment for the opposite side.

To make the Bennett adjustment, open the Bennett guides to their widest position (Fig. 274) and move the upper bow of the articulator until the stylus is at the end of the Bennett tracing (Fig. 275), usually the longest line and the farthest medially. Holding the upper bow in this position, close the Bennett guide until it rests against the guidepost which rises from the lower member of the articulator (Fig. 276) and lock the guide in this position.

If the articulator is now moved in this lateral position, care being taken to ride against the guidepost, the stylus may not follow the tracing as it begins from the centric position to the extreme. This is because the Bennett path may be curved. If such is the case, it will be necessary to grind the curvature into the Bennett guide until the stylus follows the path exactly. Mark the guide by interposing carbon paper between the guidepost and the Bennett guide and move the articulator several times in the area where the stylus misses the line. This is the area which has to be hollowed out until the exact curve is followed by the stylus. It may be advisable to set the Bennett guide to the first line nearest the setting on

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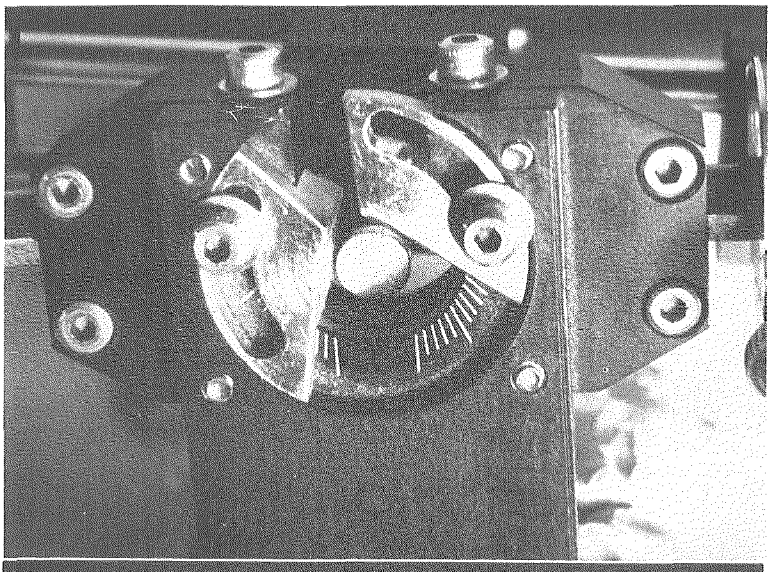

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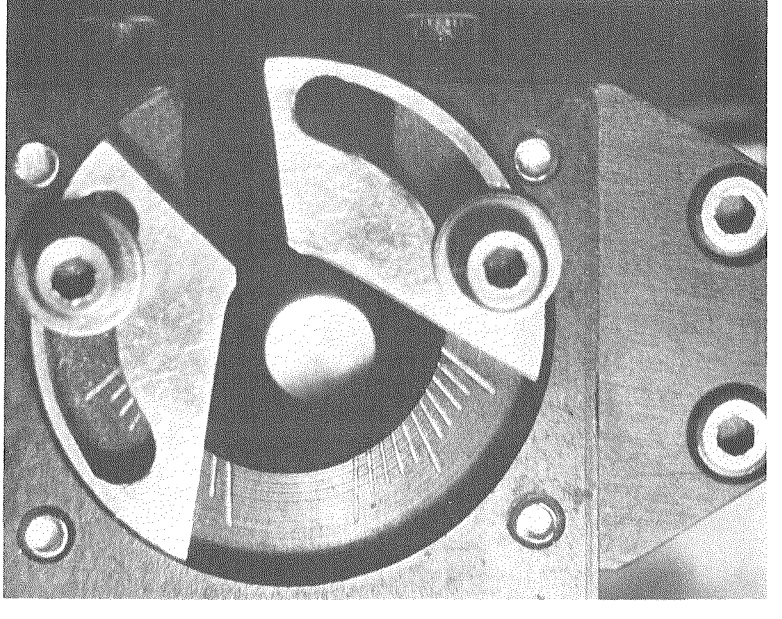
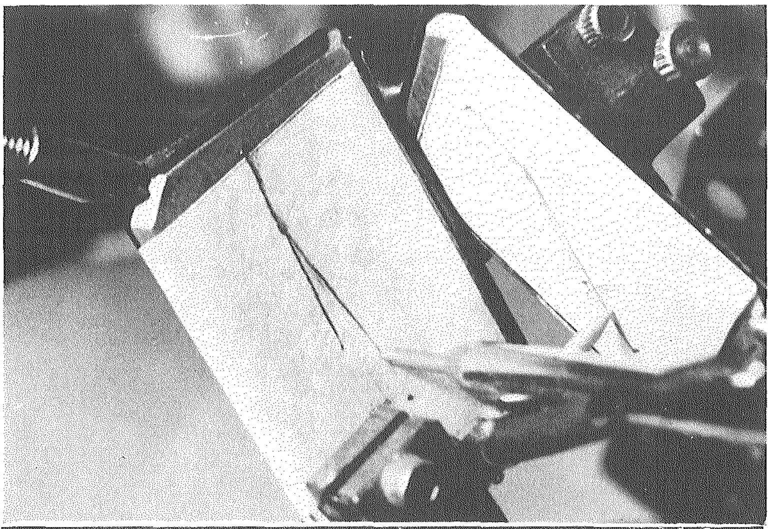


Fig. 276. The Bennett guide is closed until it just contacts the Bennett post. The Bennett guide now limits the amount of side shift in the articulator so that the stylus of the pantograph on the articulator will follow the Bennett tracing made by the patient.
Fig. 277. The Bennett guide for the left side has been set. The Bennett guide for the right side is opened to its maximum degree before adjustment.

the closed side (Fig. 277). This enables one to return the guide easily to its original position while grinding the curve. It will also make it easier subsequently to reset the machine because it will eliminate guesswork. Obviously, if one begins on a line instead of somewhere between two lines, there is no need for guesswork. It only means that a little of the Bennett guide may need to be ground to the extreme position, i.e., beyond the existing curve, including a portion of the flat surface.

To set the Bennett guide for the opposite side, this entire procedure is repeated (Figs. 278 and 279).

When both Bennett guides have been adjusted and ground (if necessary), the styli on both Bennett tracings will follow the long Bennett line on one side and



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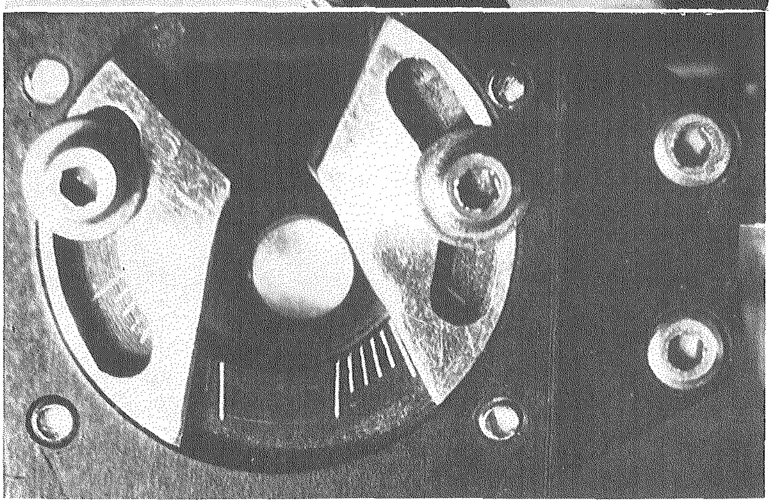

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Fig. 278. The upper bow of the articulator and pantograph is moved into the lateral position until the stylus of the pantograph on the articulator is on the end of the Bennett tracing made by the patient (right side).
Fig. 279. The Bennett guide is closed until it just contacts the Bennett guidepost.

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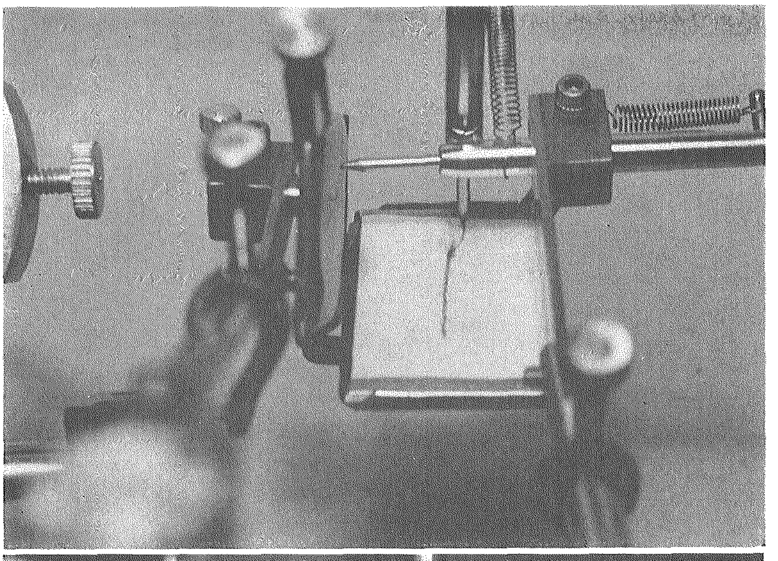

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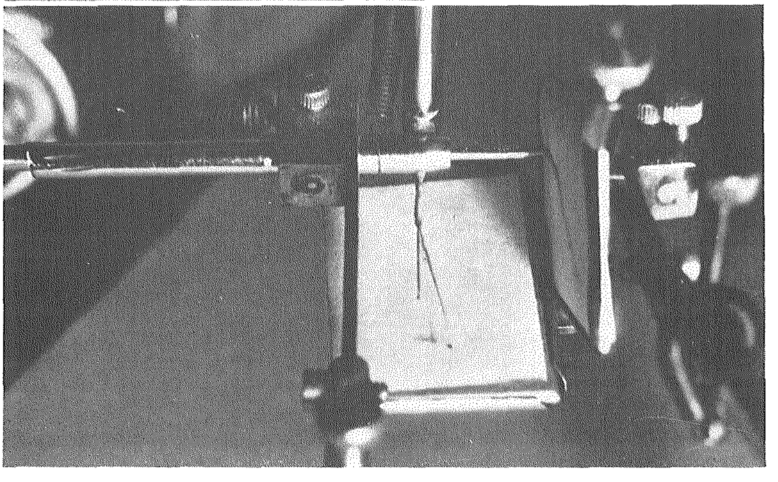


Fig. 280. The reciprocal tracing on the working side (left side) checks the Bennett movement of the opposite side (right side).
Fig. 281. The reciprocal tracing on the working side (right) checks the Bennett movement of the opposite side (left).

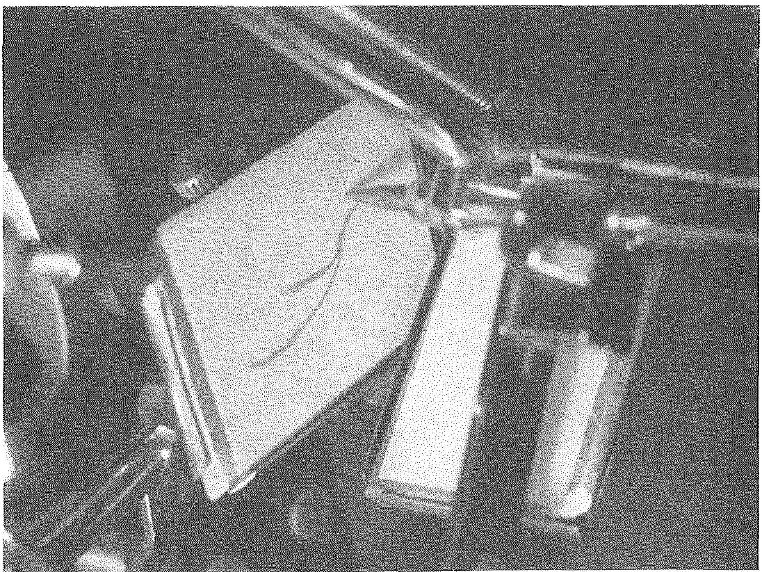
the tail on the opposite side (Fig. 280). The same is true when the opposite lateral movement is examined. Both the long line on the one side and the tail on the opposite side will be followed simultaneously (Fig. 281).

TILT OF AXIS

The next adjustment is the tilt of the axis.

The little tail on the posterior vertical slide represents the vertical component of the Bennett movement on the working side (Fig. 282).

As the upper bow of the articulator is moved into the working occlusion on the side being examined, check the path of the stylus. If the path is accurately followed, no adjustment is necessary. If the stylus cuts above the tracing (Fig. 282), then the axis must be tilted so that the upper bow of the articulator (carrying the slide), will be made to rise as we go into the working occlusion. In other



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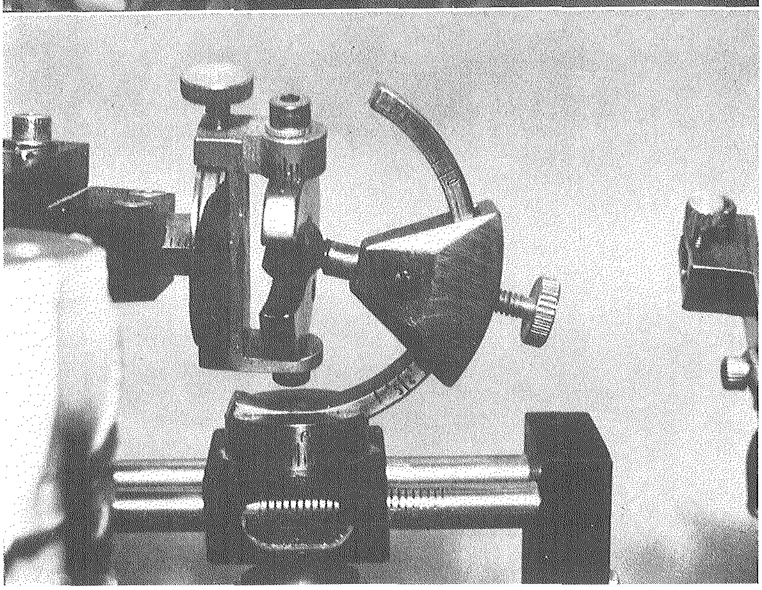

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Fig. 282. The stylus of the pantograph on the articulator is above the vertical tracing of the Bennett movement made by the patient.
Fig. 283. The axis is tilted so that the upper bow of the articulator and the slide on the pantograph are raised as they are moved into the working occlusion.

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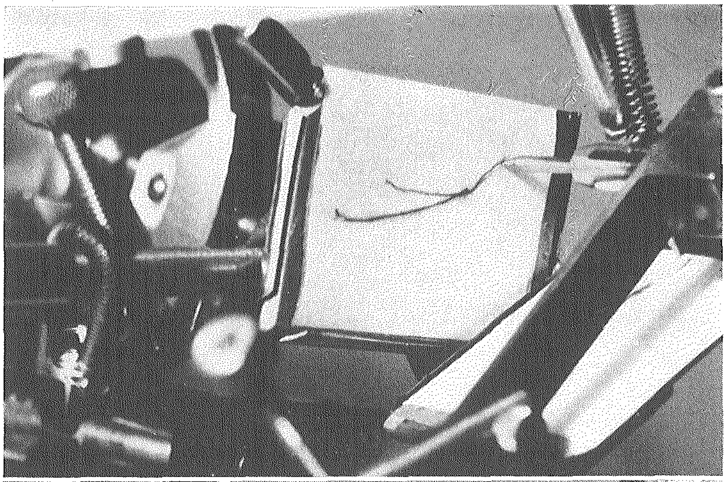

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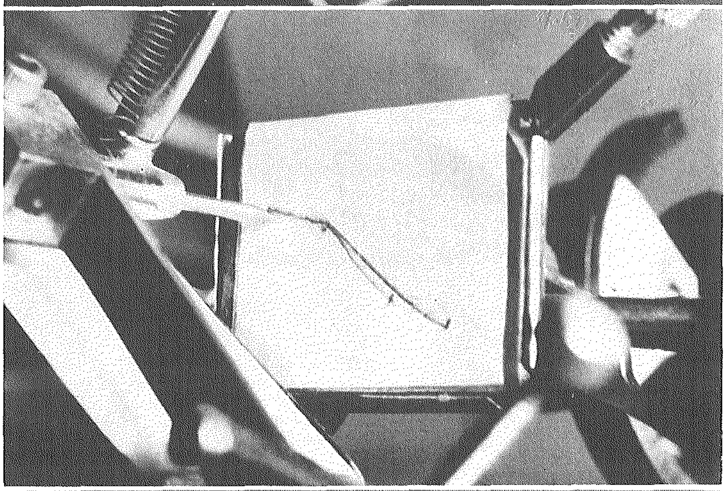

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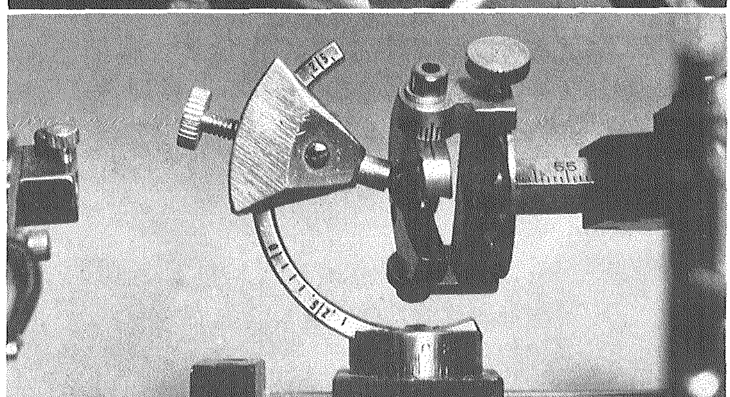

Fig. 284. The stylus of the pantograph on the articulator follows the vertical tracing of the Bennett movement made by the patient after the axis is properly tilted.
Fig. 285. On the right side, the stylus of the pantograph on the articulator is below the vertical tracing of the Bennett movement made by the patient.
Fig. 286. The axis is tilted so that the upper bow of the articulator and the slide on the pantograph are lowered as they are moved into the working occlusion.

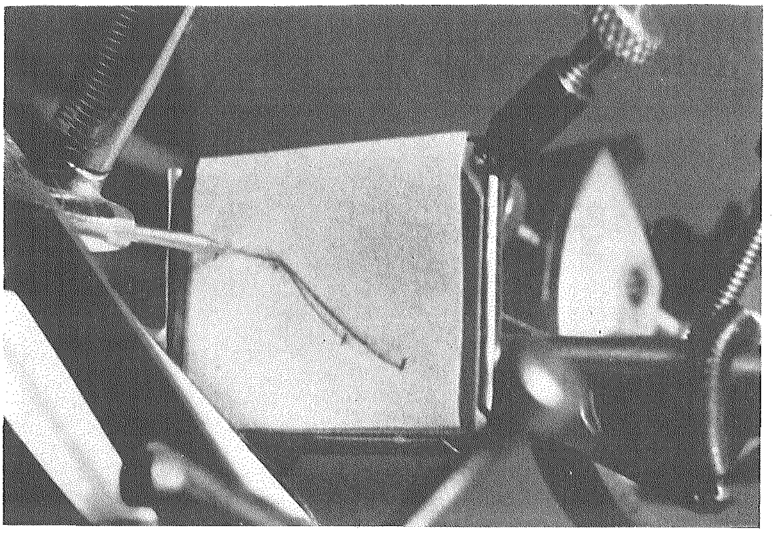

Fig. 287. The stylus of the pantograph on the articulator follows the vertical tracing of the Bennett movement made by the patient after the axis is properly tilted.

words, the axis is tilted so that the medial part is higher than the lateral portion (Fig. 283). Fig. 284 shows the stylus after the axis has been properly tilted.

These steps are repeated for the opposite side (Figs. 285 to 287).

It may be found that tilting the axis on one side will affect the adjustment on the other. If such is the case, the first setting will have to be readjusted.

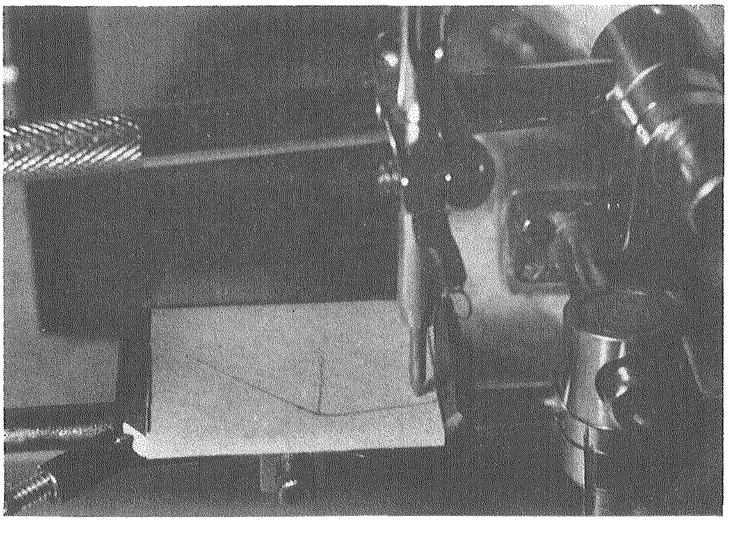

Fig. 288. The stylus of the pantograph on the articulator is inside the inner wing of the Gothic arch tracing made by the patient.

ROTATION OF AXIS

The next tracing to which the gnatholator has to be adjusted is the inside wing of the Gothic arch (Fig. 288). This is accomplished by rotation of the axis (Figs. 289 and 290).

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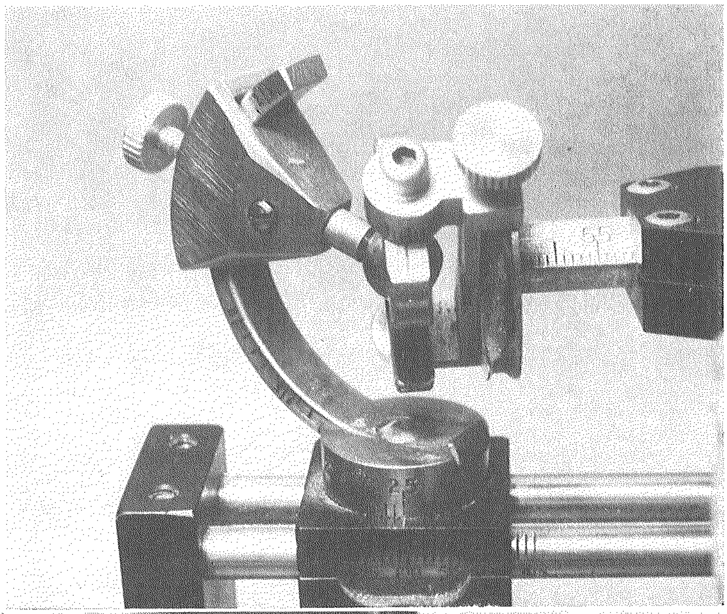

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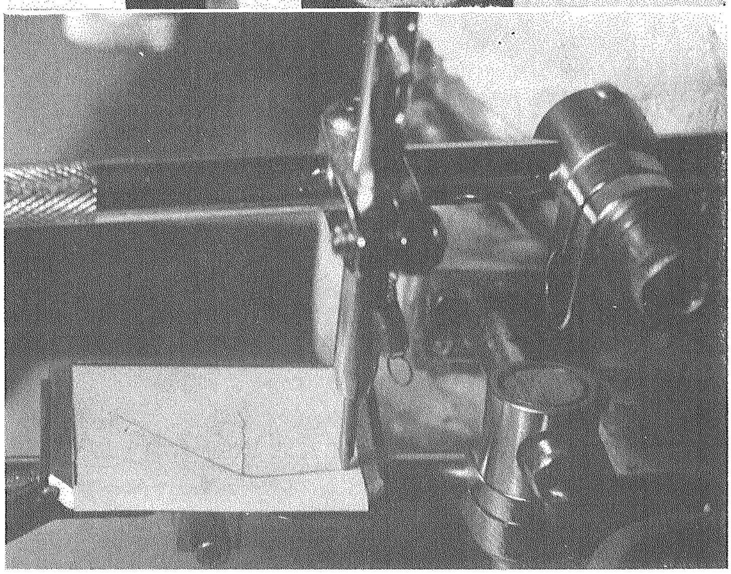
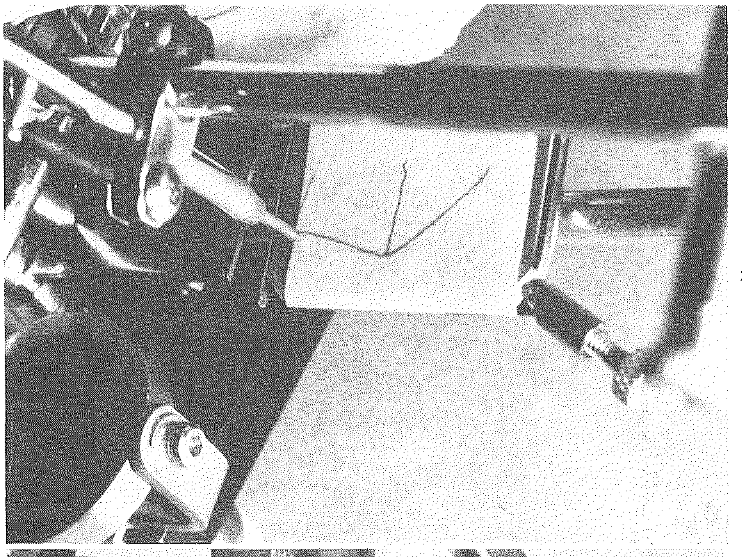


Fig. 289. The axis is rotated to permit the center of the imaginary compass to move forward as it moves inward.
Fig. 290. The stylus of the pantograph on the articulator follows the inner wing of the Gothic arch tracing made by the patient after proper axis rotation.



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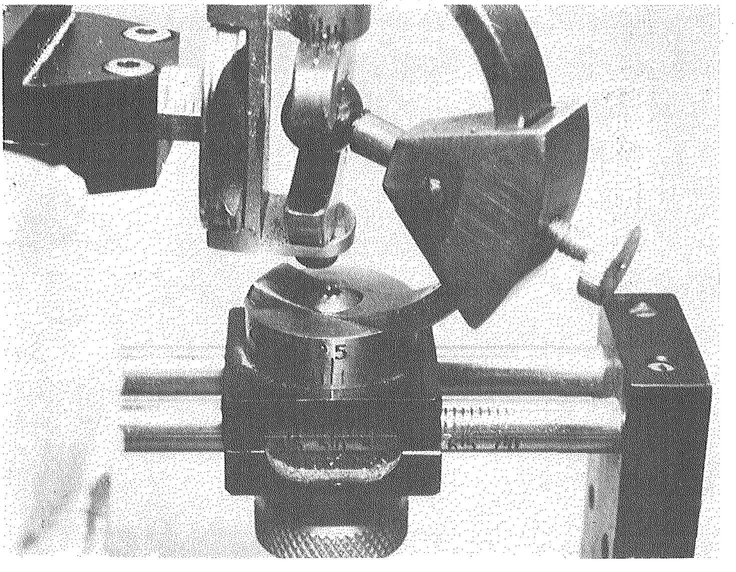

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Fig. 291. On the left side, the stylus of the pantograph on the articulator is outside the inner wing of the Gothic arch tracing made by the patient.
Fig. 292. The axis is rotated to permit the center of the imaginary compass to move backward as it moves inward.

Again visualize a compass with the pivoting center travelling along the axis on the same side that is being examined. If the stylus travels beyond (outside) the inner wing of the tracing (Fig. 291), the axis must be rotated so that the medial portion is farther back than the lateral part (Fig. 292). In other words, the pivoting center of the compass will move backward as it moves inward on the axis. This will cause the tracing part of the compass to cut more sharply in

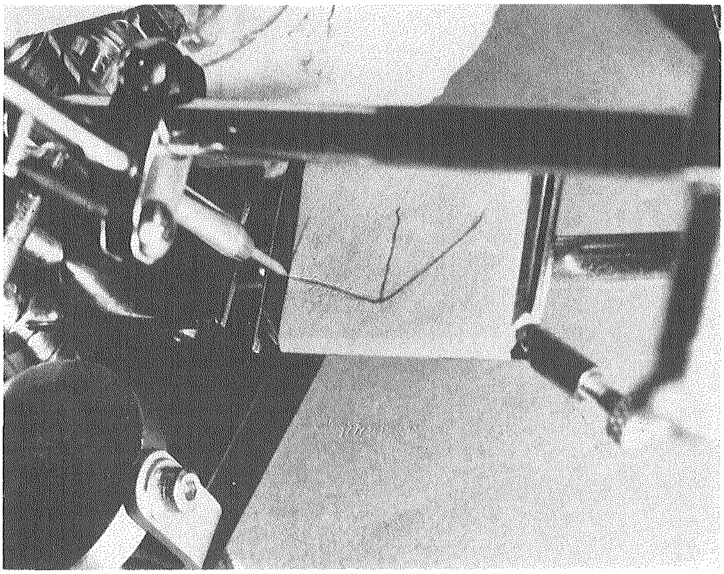


Fig. 293. On the left side, the stylus of the pantograph on the articulator follows the inner wing of the Gothic arch tracing made by the patient after proper axis rotation.

a posterior direction as it travels medially. After the axis is properly rotated, the stylus will accurately follow the inner wing of the tracing (Fig. 293).

Conversely, when the stylus travels inside the inner wing (Fig. 288), it becomes necessary to allow the pivoting part of the compass to travel forward as it goes medially along the axis. The rotation of the axis, then, is such that the medial side (inner portion) of the axis is more forward than the lateral or outer side (Fig. 289).

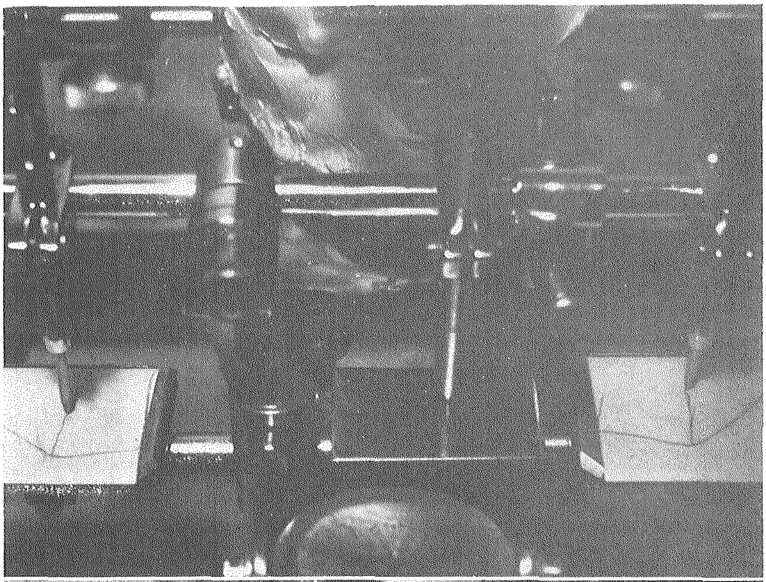
This is repeated on the other side until the inner wing of the tracing on that side is accurately followed.

At this point, all the tracings should be followed by the styli, with the exception of the protrusive and lateral paths on the posterior vertical (condyle) slides.

SELECTION OF CONDYLE DISC

In order to get the stylus to follow the protrusive tracing, one must select a condyle disc which has the proper curvature for the particular patient.

It is now necessary to execute a rather complicated maneuver. The upper bow of the articulator must be made to follow the same protrusive tracing made by the patient when the registrations were taken. To do this, one must follow the protrusive tracing on one Gothic arch (Fig. 294) and the protrusive path on the horizontal (Bennett) slide (Fig. 295). At the same time, the path travelled by the horizontal pin on the vertical (condyle) slide (Fig. 296) must



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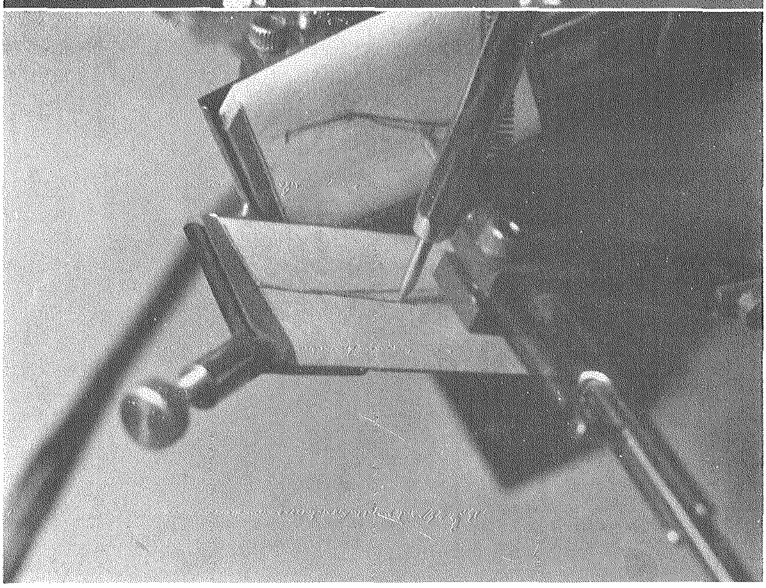

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Fig. 294. The protrusive path of the Gothic arch tracing guides the upper bow of the articulator and pantograph into the recorded protrusive path of the patient.
Fig. 295. The protrusive path recorded on the horizontal slide helps to move the upper bow of the articulator and pantograph into the recorded protrusive path of the patient.

be observed. By adjusting the inclination of the condyle slot, one can easily make the pin terminate on the end of the protrusive path of the vertical slide, but must now check to see whether it follows the path in its entirety, i.e., whether the curvature is correct for the patient. If the pin travels across (above) the tracing from the beginning to the end, there is not enough curvature. If the

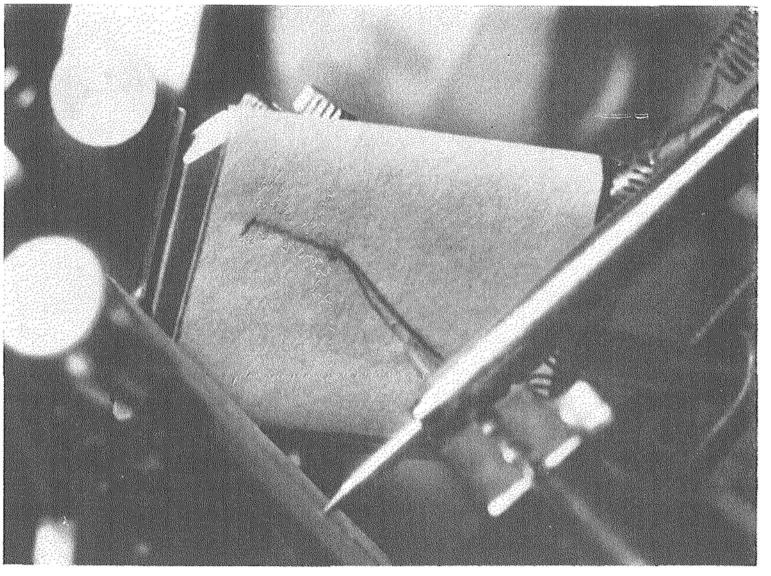

Fig. 296. The fidelity with which the stylus of the pantograph on the articulator follows the protrusive path made by the patient is examined on the posterior vertical tracing.

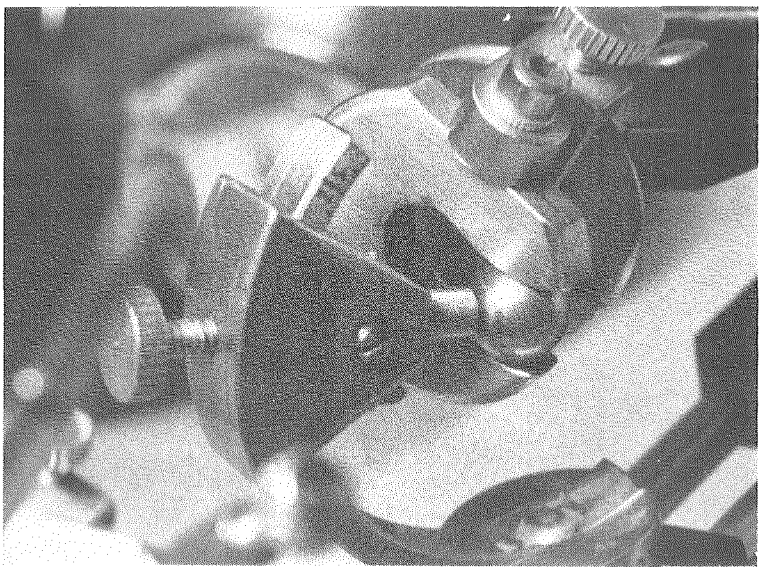

Fig. 297. Selection of the correct condylar curvature is made by a process of trial and error.

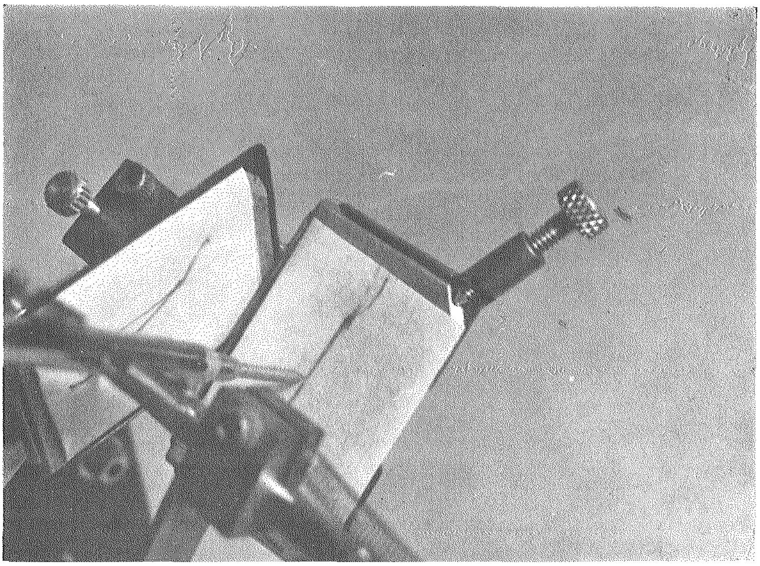

Fig. 298. The protrusive position is duplicated by the tracing on the horizontal slide (with the aid of the protrusive path on the anterior slides).

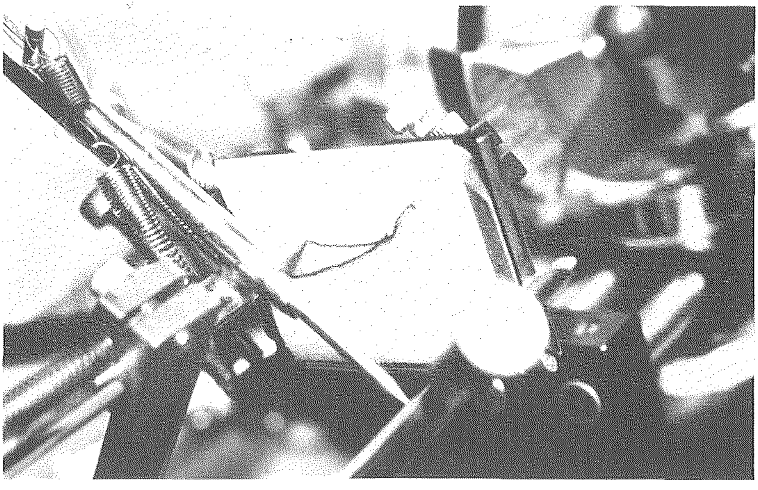

Fig. 299. The fidelity with which the stylus of the pantograph on the articulator follows the protrusive path made by the patient is examined on the posterior vertical tracing.

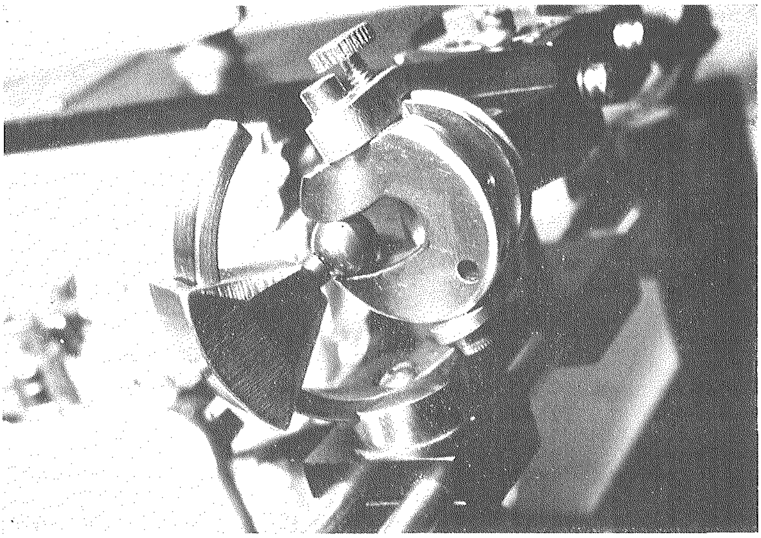

Fig. 300. Selection of the correct condylar curvature is made by trial and error for the left side.

pin cuts below the tracing and then coincides at the end, the curvature of the condyle slot is too great, and one with less curvature must be substituted. By a process of trial and error, the proper condyle slot is selected for each side (Figs. 297 to 300).

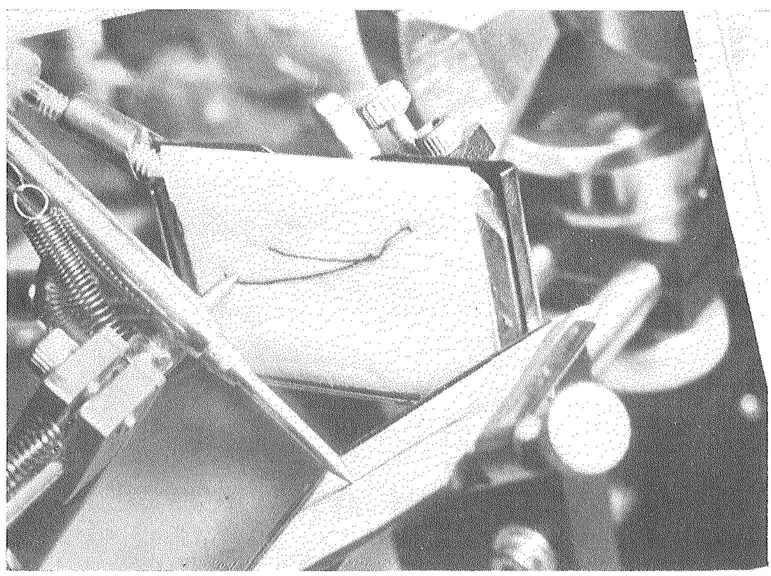

Fig. 301. The selected path is checked to determine whether it permits the stylus of the pantograph on the articulator to follow the lateral path made by the patient.

ROTATION OF CONDYLE PATH

Now the most tedious part of the adjustment has to be made. Occasionally the selected path will follow the lateral tracing (the lower, longer one), as well as the protrusive tracing. However, if it does not, as in Fig. 301, one other adjustment is necessary—the rotation of the condyle path (Fig. 302). To which di-

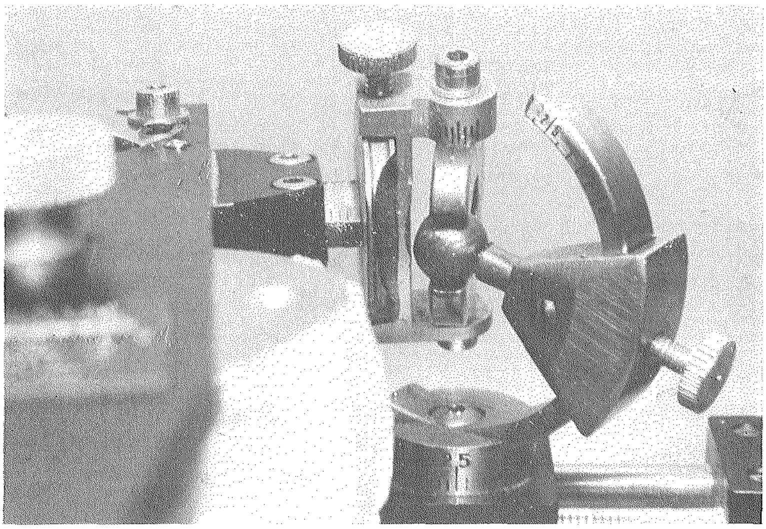

Fig. 302. The selected path is rotated.

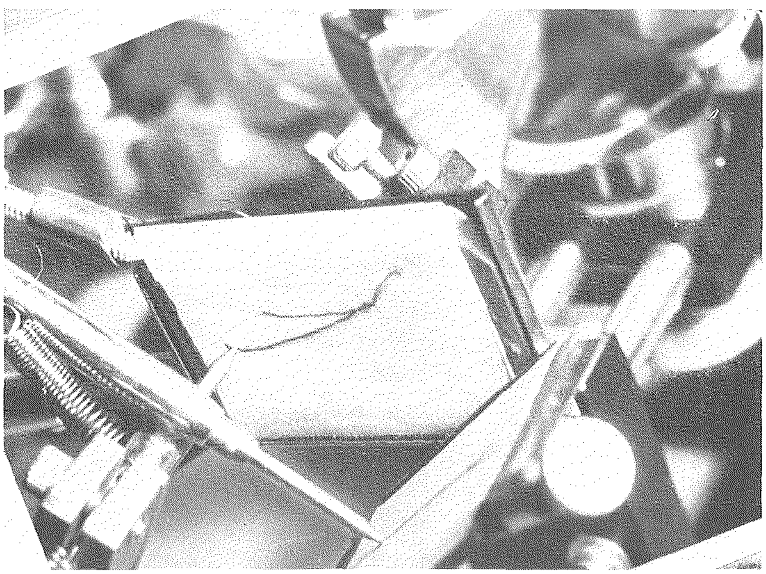

Fig. 303. The stylus of the pantograph on the articulator follows both the protrusive and lateral paths made by the patient.

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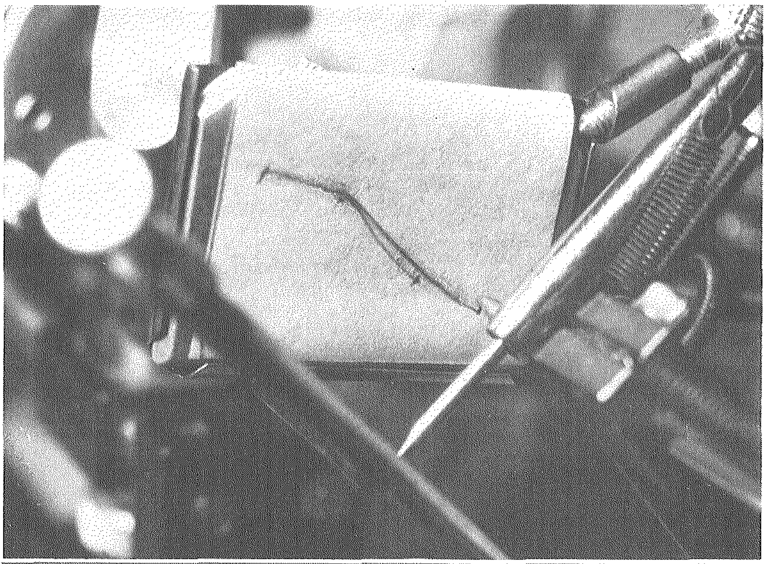

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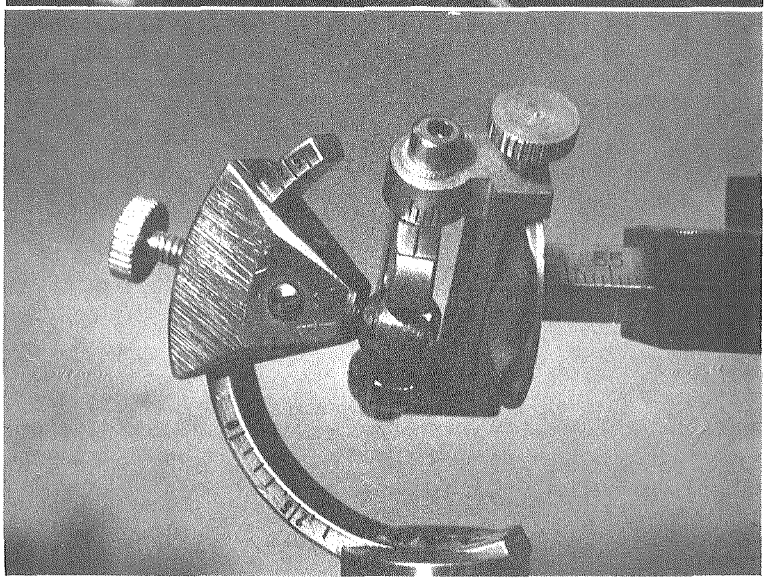

Fig. 304. On the right side, the selected path is checked to determine whether it will permit the stylus of the pantograph on the articulator to follow the lateral path.
Fig. 305. The selected path is rotated on the right side.

rection (in or out) it must be rotated depends upon the inclination of the axis, which was previously determined and set by the tail of the tracing.

If, when the lateral excursion is tested, the pin travels below the tracing, it is necessary to make the upper bow drop as it comes into the lateral movement. This is done by rotating the anterior part of the path outward if the axis is tilted upward from the outside inward. However, if the pin does not go down to the

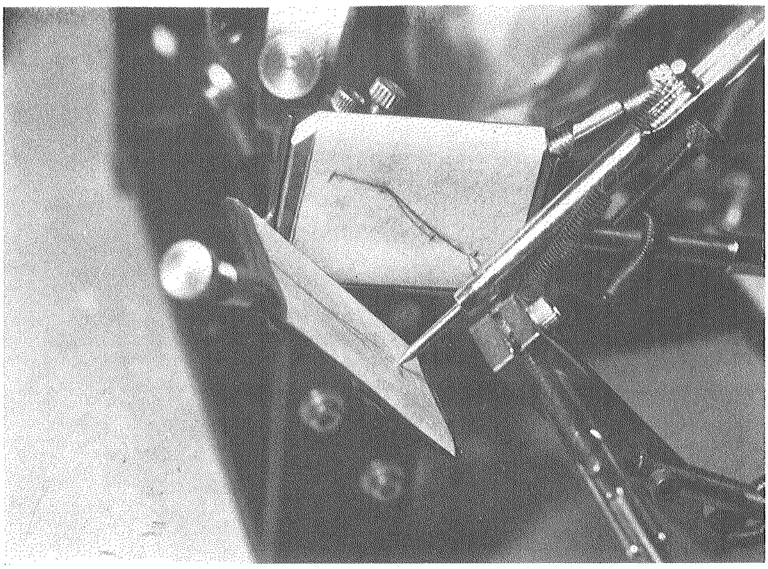

Fig. 306. The stylus of the pantograph on the articulator follows both the protrusive and lateral paths made by the patient on the right side.

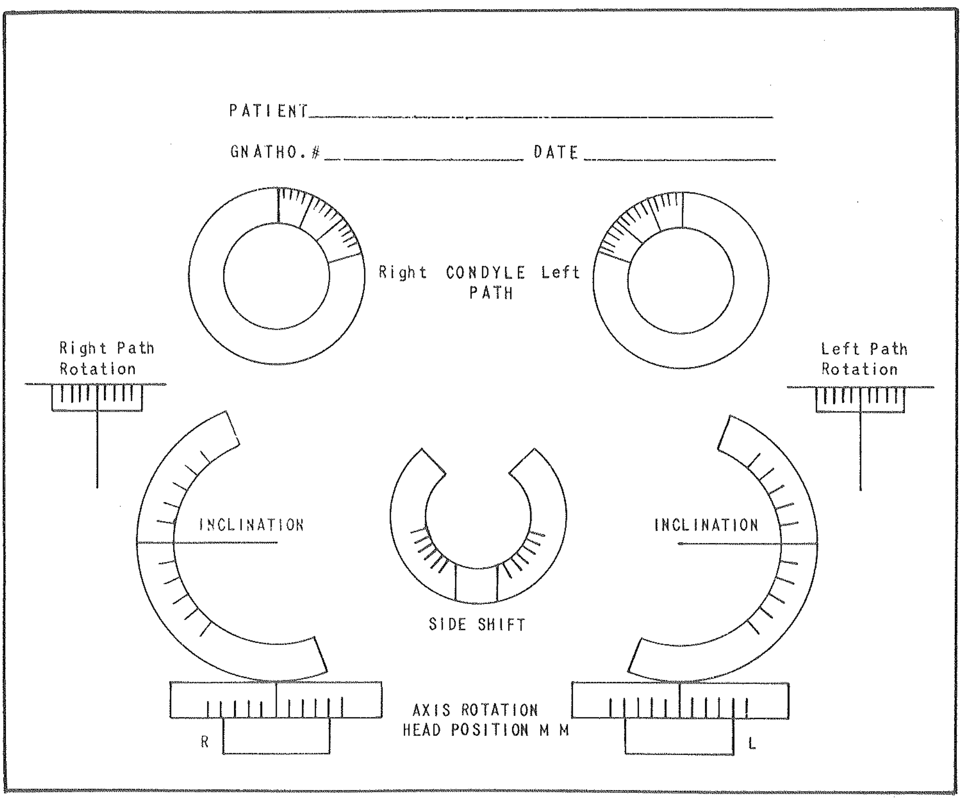

Fig. 307. Card on which articulator settings are recorded.

lower tracing (Fig. 301), then the upper bow (carrying the slide) must be made to rise. This can be accomplished by rotating the condyle inward at the anterior part if the axis is tilted upward from the outside inward, as in Fig. 302. Usually this has some effect on the protrusive travel of the pin, necessitating certain adjustment and possibly a change of the condyle slot for one of another curvature. Not until there is a proper combination of condyle curvature and instrument setting will both paths be followed exactly (Fig. 303). The finding of this combination may be extremely trying, but it can be done.

When the other condyle slot has been selected and made to follow both paths (Figs. 304 to 306), the instrument is fully set and should faithfully follow all the paths of the tracings.

The settings are carefully recorded (Fig. 307), and the Bennett plates inscribed with the patient's name.

The writing apparatus and clutches may now be removed, and the study casts, working models, or restorations are mounted.

CHAPTER 10

Setting the Stuart articulator

The articulator of Dr. Charles E. Stuart of Ventura, California, is another instrument which can faithfully duplicate the registrations made by the patient. As in the case of the gnathoscope and the gnatholator, it warrants our attention here.

ASSEMBLY OF THE ARTICULATOR AND PANTOGRAPH

The upper and lower members of Stuart's pantograph (see Chapter 5, discussion on registrations), locked together, are removed from the patient by loosening the separable studs. The locked apparatus (Fig. 308) is then taken to the laboratory and prepared for mounting on the articulator. The clutches are reassembled and replaced on the writing apparatus, and the upper clutch is attached with stone to the upper bow of the articulator. While the stone sets, the apparatus is held in proper relation to the articulator by the mounting frame (Fig. 309). The articulator, with the writing apparatus attached to the upper bow, is then removed from the mounting frame, and the lower clutch is attached with stone to the lower bow.

When the mounting is completed, the adjustment of the articulator can be made. The vise grips that have locked the upper and lower members of the writing apparatus together are removed. Now, with the upper and lower bows of the pantograph fixed to the upper and lower bows respectively of the articulator, the articulator can be moved.

The practical accomplishment of setting an articulator is finding the combination of settings that will permit a faithful reproduction of the writings made by the patient. Because of the interaction of the adjustments, it is necessary to re-examine each previous setting after a subsequent adjustment has been made. Usually a slight change has to be made in the previous adjustment.

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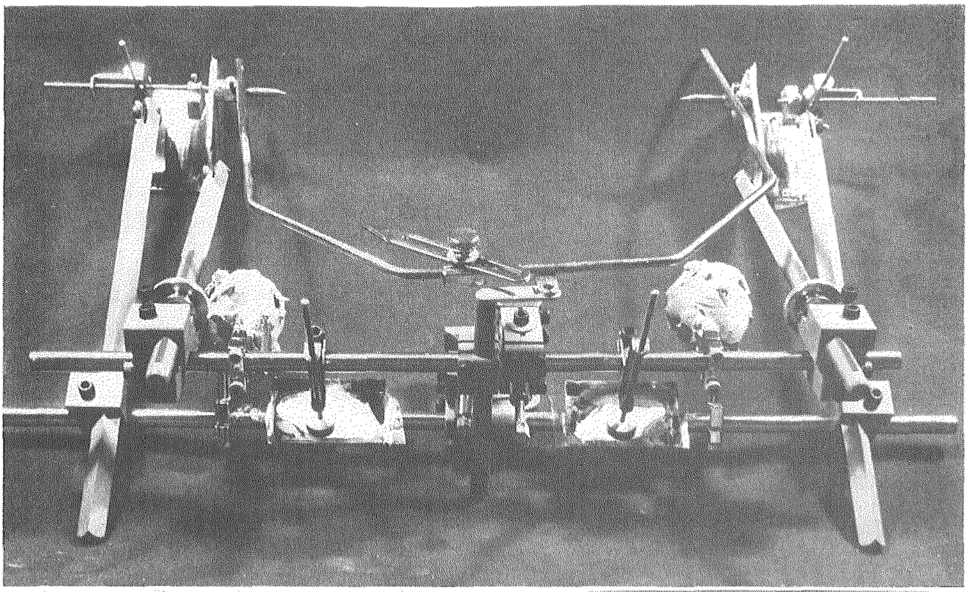

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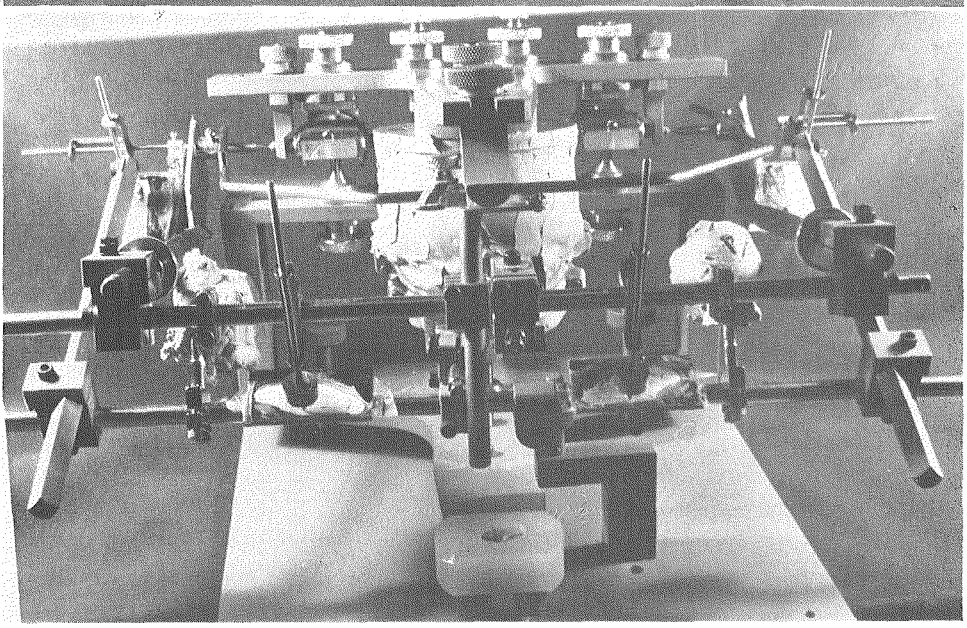
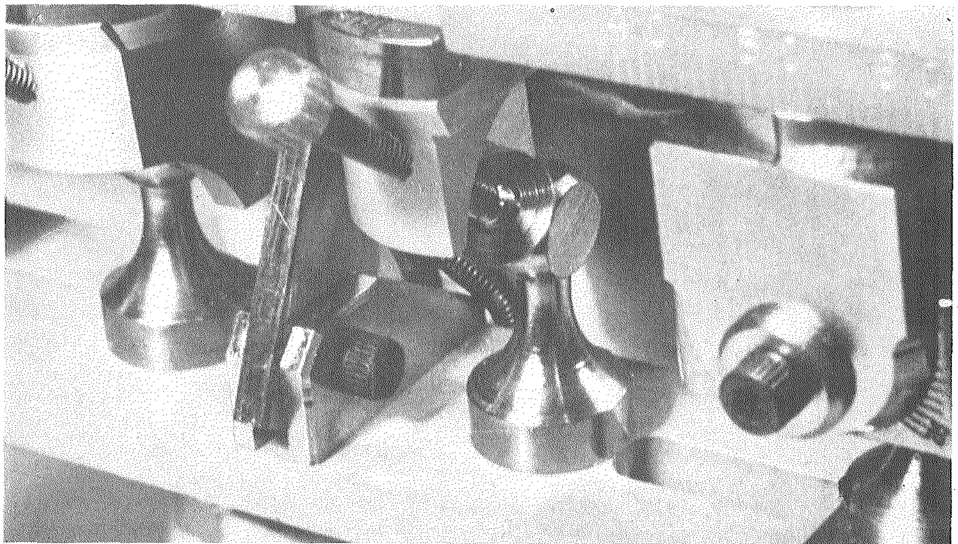


Fig. 308. Stuart's pantograph as removed from the patient.
Fig. 309. Stuart's pantograph held in position by the mounting frame and attached to the upper bow of his articulator.

SETTING INCLINATION OF FOSSA

The first step is to turn in the jackscrew on the side about to be adjusted (Fig. 310). The jackscrew is located on the back of the side shift guide wing and is turned in until the recorder stylus approximates the end of the recorded line on



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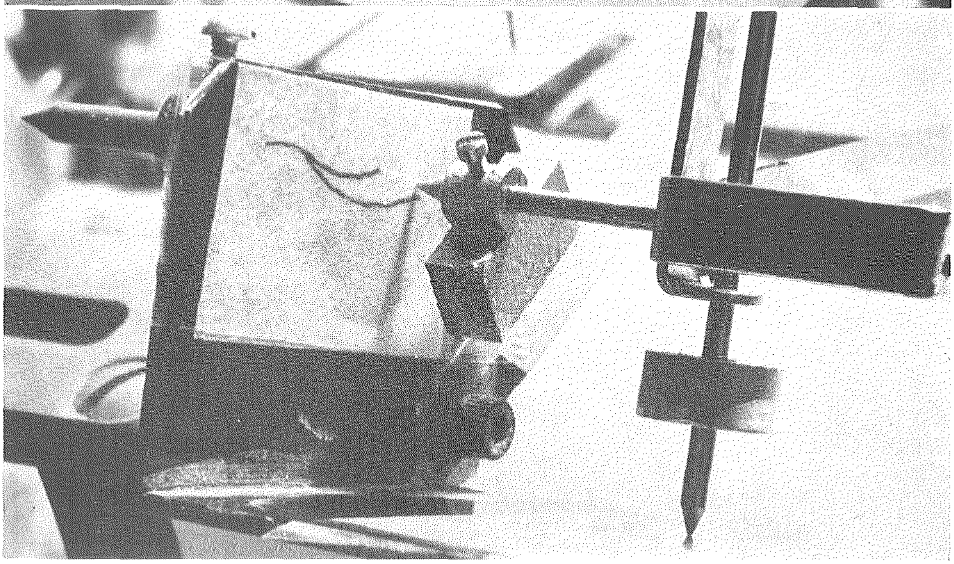

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Fig. 310. The jackscrew on the right side turned in until the stylus of the pantograph on the articulator approximates the end of the lateral tracing made by the patient.
Fig. 311. The stylus near the end of the lateral tracing after the jackscrew on that side has been turned in.

the vertical (condyle) slide (Fig. 311). With the aid of the right-angle Allen wrench, the screw holding the fossa (Fig. 312) is loosened, and the inclination of the fossa (Figs. 313 and 314) is adjusted so that the stylus point coincides with the end of the condyle tracing on the recorder (Fig. 315). If the stylus point is above the tracing, the inclination of the fossa is increased. If it is below the tracing, the inclination is decreased.

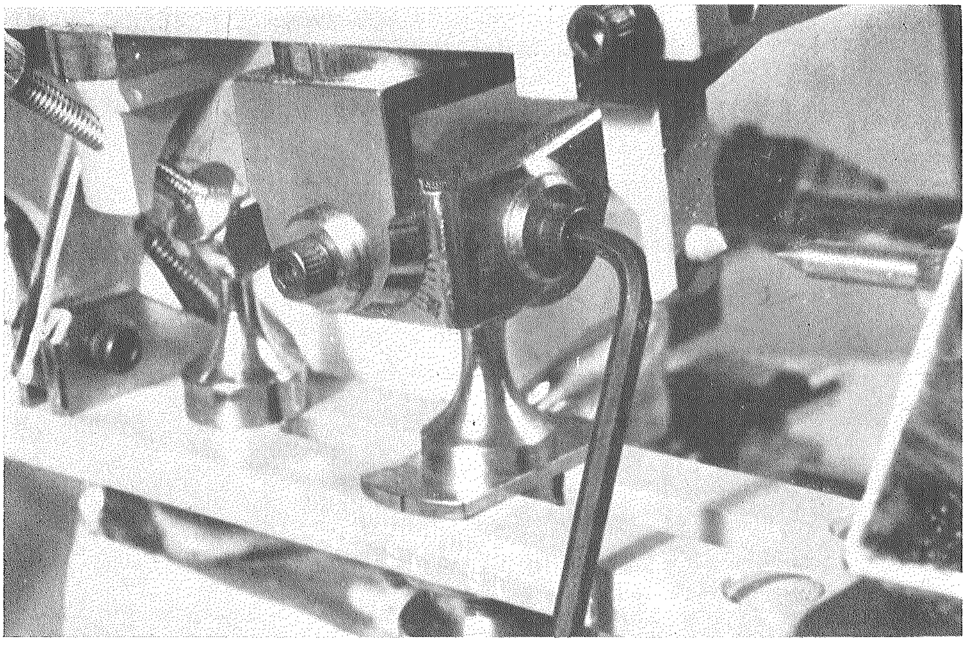

Fig. 312. The right-angle Allen wrench unlocks the screw holding the fossa.

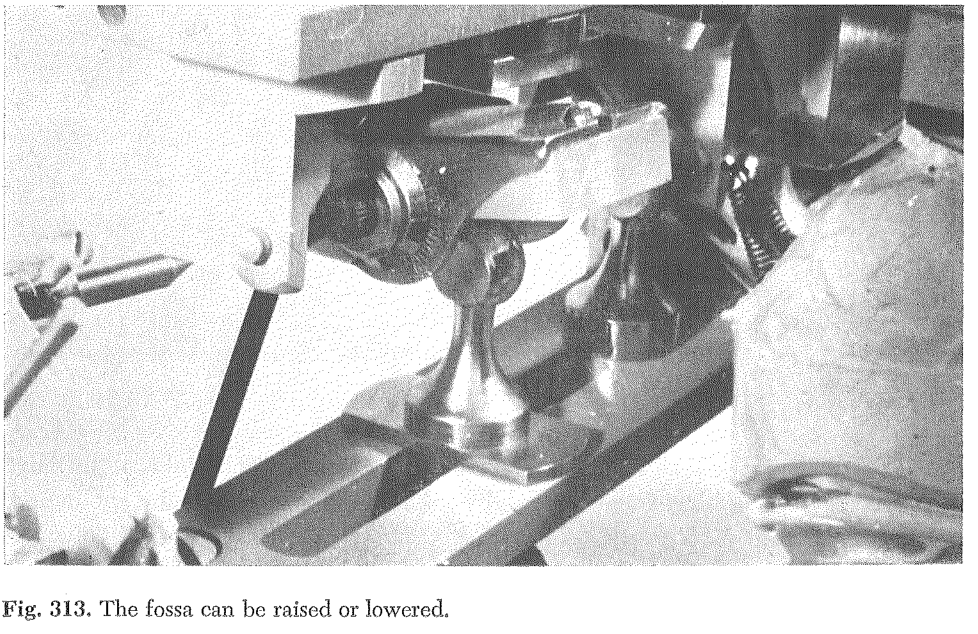

Fig. 313. The fossa can be raised or lowered.

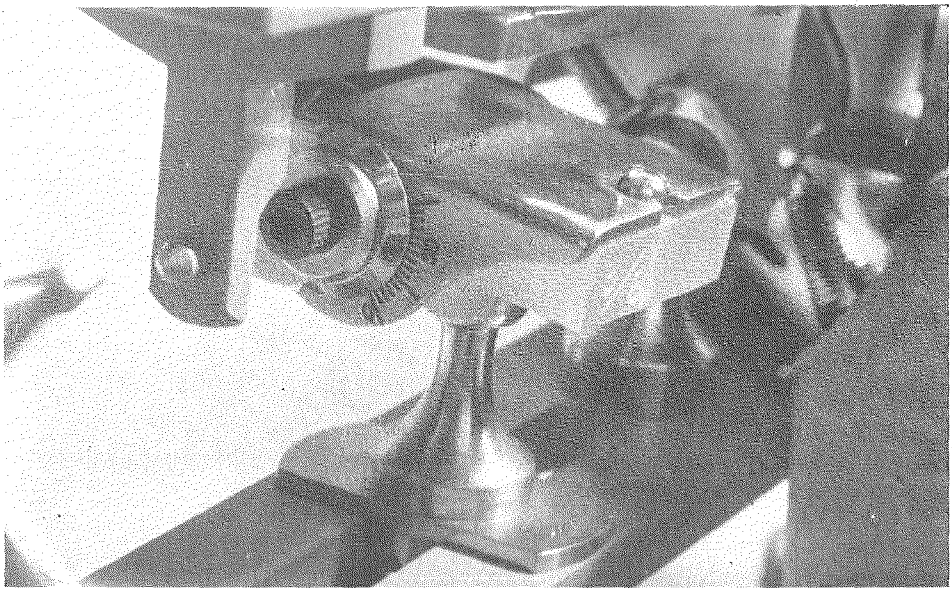

Fig. 314. The fossa inclination adjusted so that the stylus of the pantograph on the articulator coincides with the end of the recorded path.

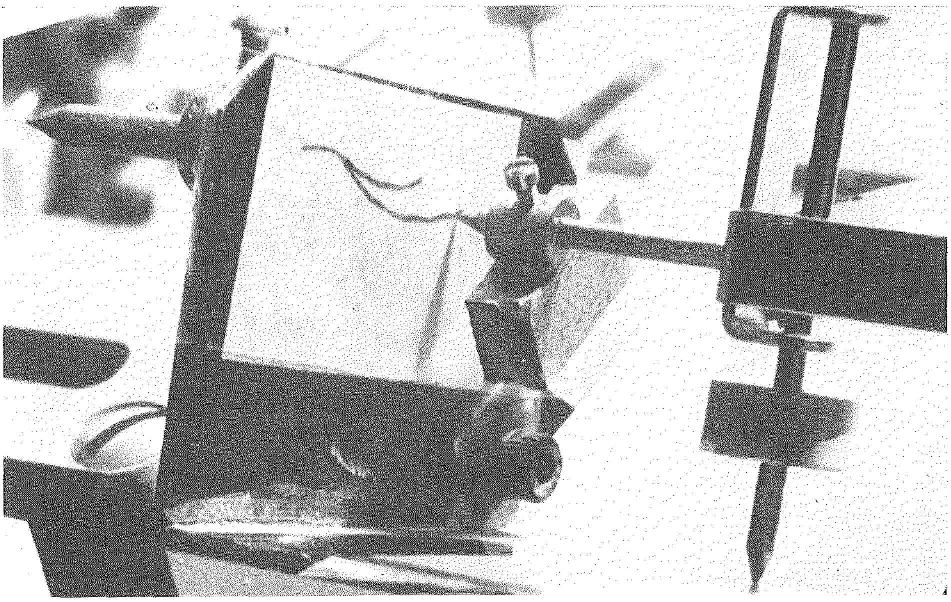

Fig. 315. The stylus at the end of the tracing after the fossa is properly inclined.

SETTING ANGLE OF BENNETT SHIFT

The angle of the side shift is next adjusted. With the jackscrew turned in as for the previous adjustment, the lock nut holding the side shift wing is loosened (Fig. 316). At this point, let us examine the relation of the vertical

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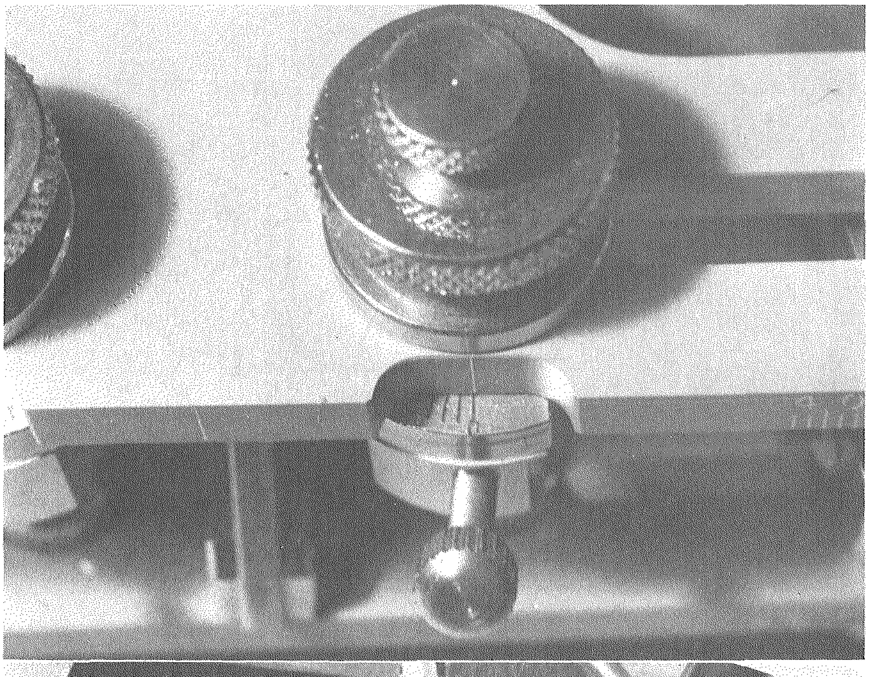

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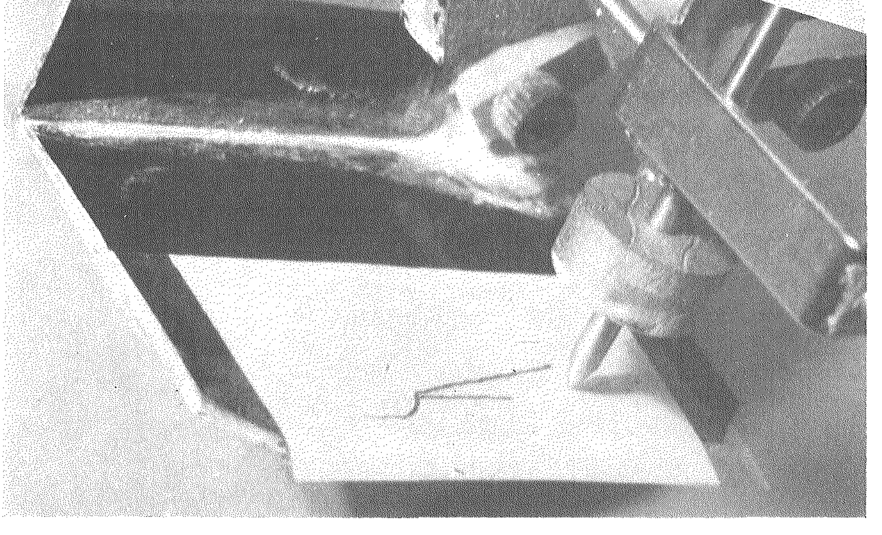
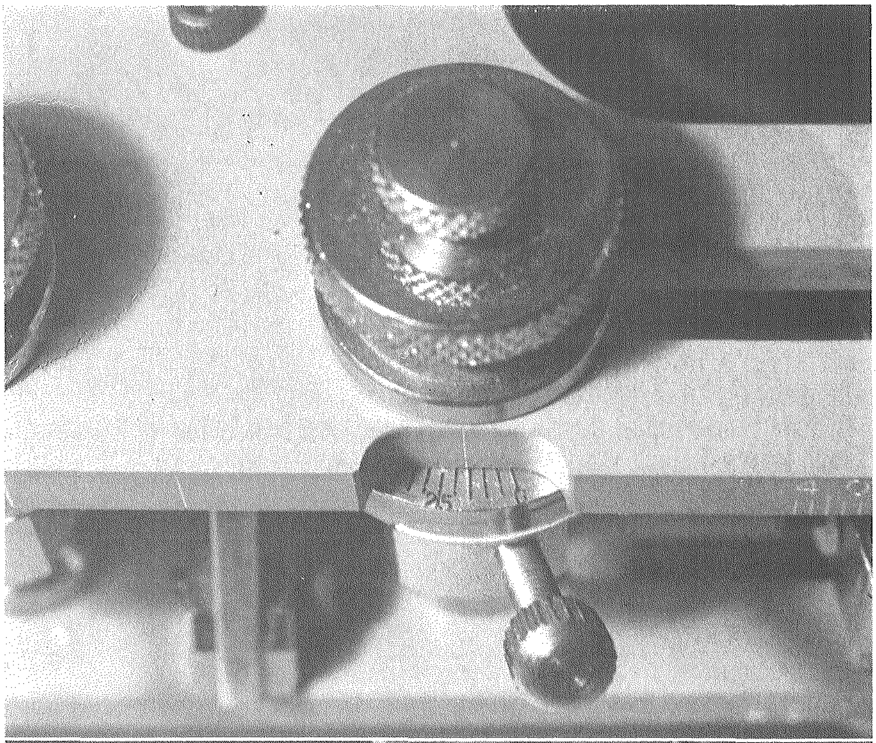


Fig. 316. Loosening the lock nut that holds the side shift wing.
Fig. 317. The stylus of the recorder on the articulator is lateral to the tracing made by the patient.

stylus to the tracing on the horizontal recording plate on the same (balancing) side. The side shift control ball must be against the side shift guide wing. If the stylus is lateral to the recorded line, as in Fig. 317, it is necessary to increase the angle of the side shift guide wing (Fig. 318). By doing this, we will



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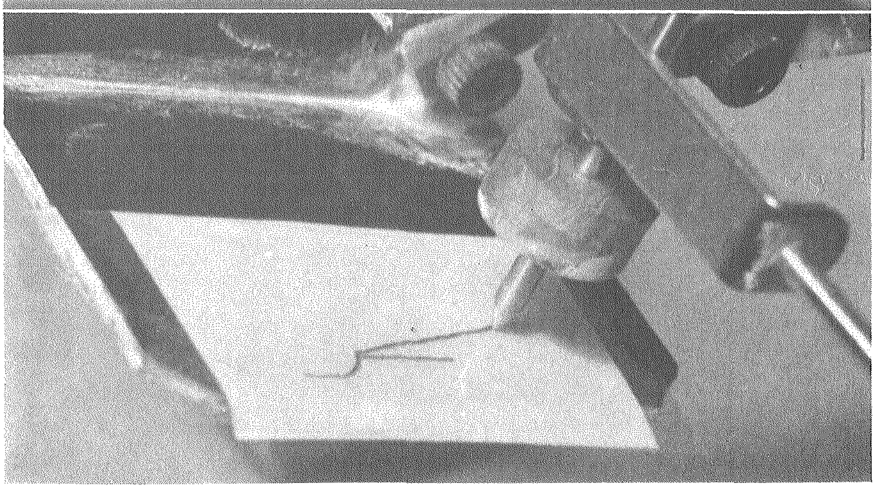

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Fig. 318. The angle of the side shift guide is increased.
Fig. 319. The stylus of the recorder on the articulator is at the end of the lateral tracing made by the patient.

make the stylus point coincide with the end of the recorded tracing (Fig. 319). To maintain the side shift wing in this position, the holding screw is tightened. If the stylus were medial to the recorded path, the angle of the side shift wing would have to be decreased.

At this stage, recheck the condyle tracing on the same side to determine whether there has been any interaction as a result of the subsequent setting.

SETTING CENTER OF LATERAL ROTATION

Keep the jackscrew turned in as before, maintaining the same lateral position with the styli on the ends of the lines of the condyle and lateral shift tracings. With the articulator in this position, it is now possible to set the rotation center of the opposite side (Fig. 320). Let us examine the relation of the vertical stylus on the front horizontal plate on the rotating side. In Fig. 321, we note that the stylus is anterior to the medial wing of the Gothic arch tracing. Loosen the holding nut of the main fossa bracket, as well as the holding nut of the condyle ball on the lower frame of the articulator. Then slide the main fossa bracket and the condyle ball laterally a few millimeters at a time (always an equal number on the upper and lower bow) until the vertical stylus is at the end of the medial wing of the Gothic arch tracing (Figs. 322 and 323). It is important always to have the exact number of calibrations on the upper bow as on the lower bow; otherwise the articulator members will not be centered.

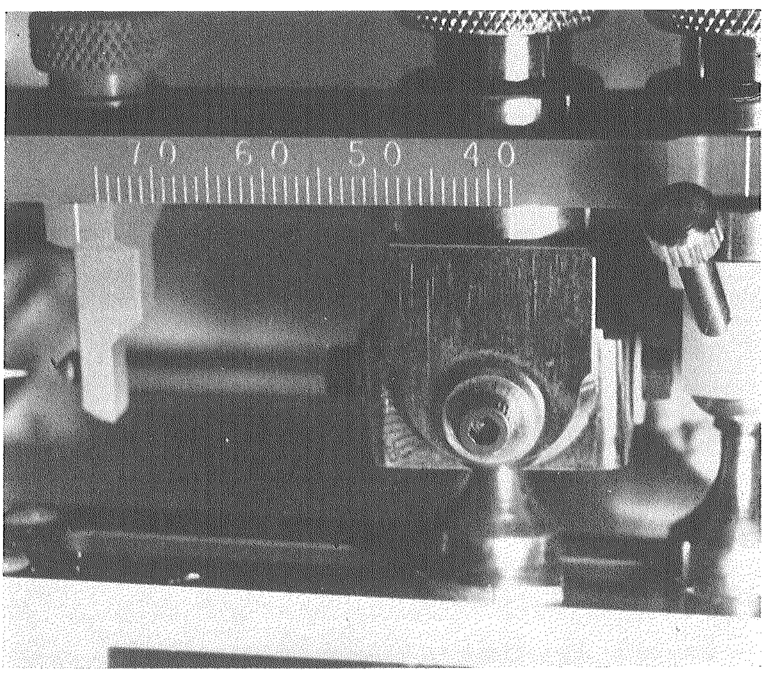

Fig. 320. The center of lateral rotation of the opposite side.

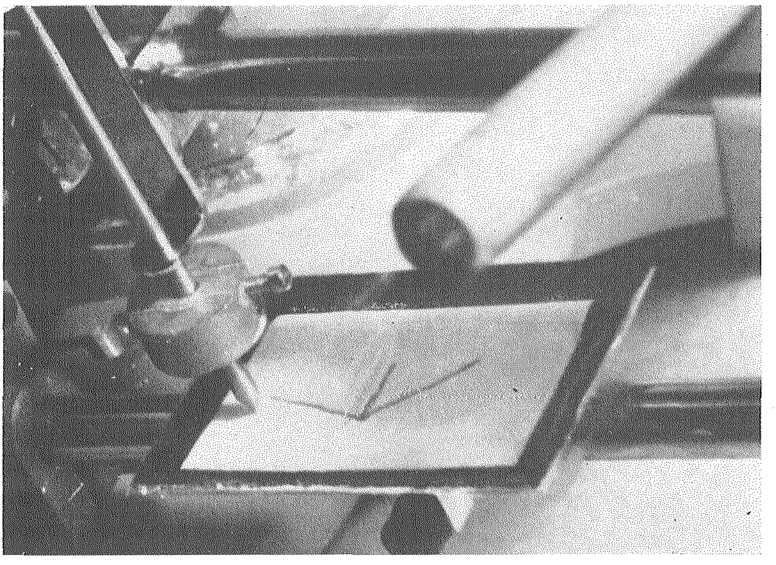

Fig. 321. The stylus of the recorder on the articulator is in front of the inner wing of the Gothic arch tracing made by the patient.

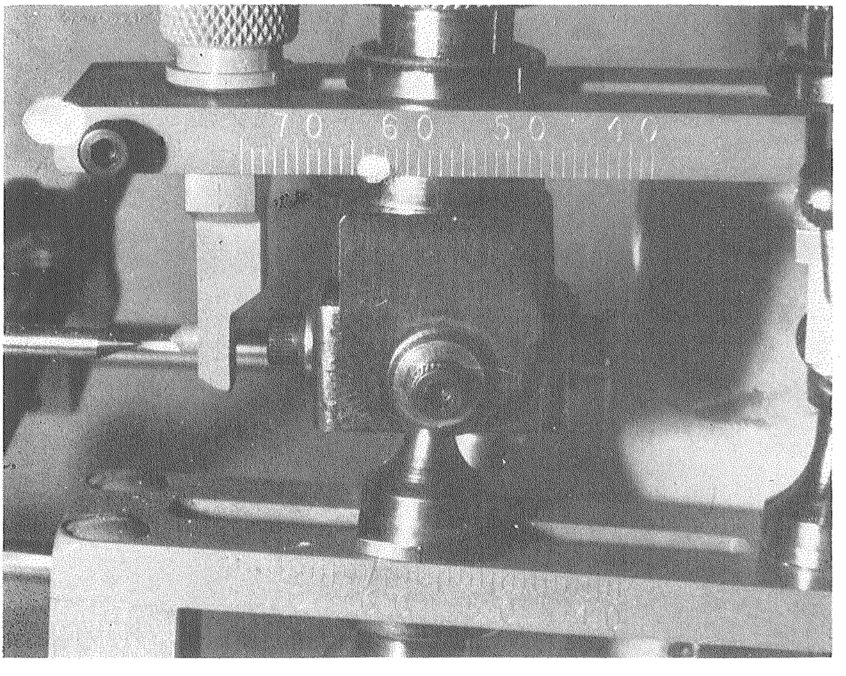

Fig. 322. The center of lateral rotation moved outward. The upper and lower members of the articulator must be moved exactly the same number of calibrations.

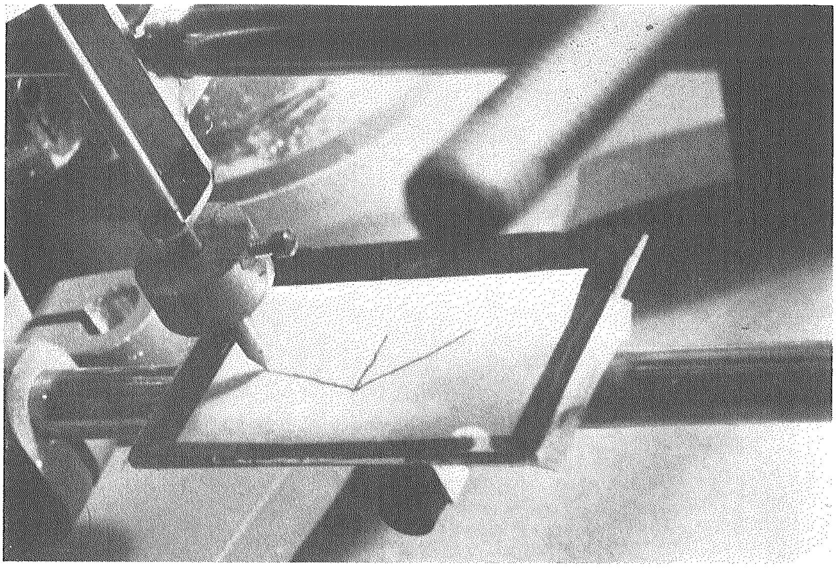

Fig. 323. The stylus of the recorder on the articulator is at the end of the inner wing of the Gothic arch tracing made by the patient.

ADJUSTING TILT AND ROTATION OF AXIS

With the jackscrew in the same position, examine the tracing on the vertical condylar recording plate on the rotating (working) side. It will be noticed that a "back line" or reciprocal tracing, which is there because the tracings are

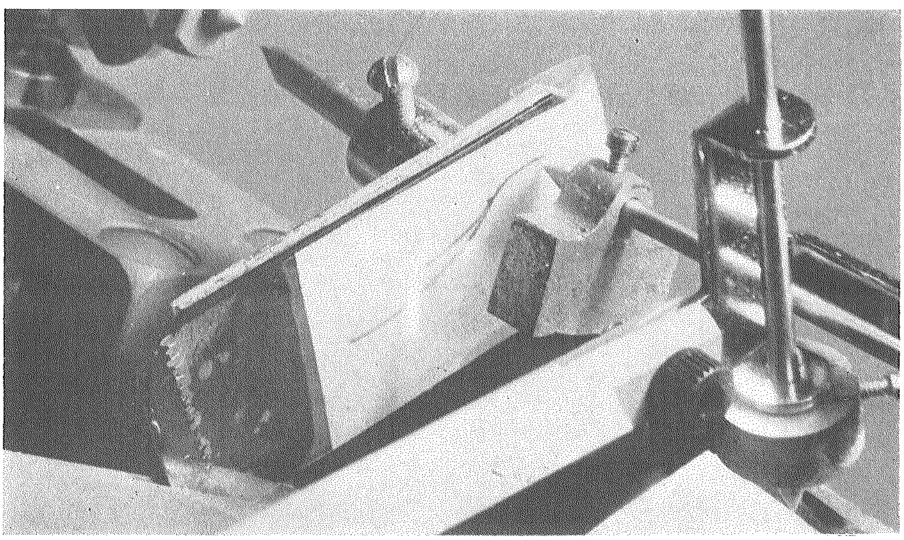

Fig. 324. The stylus of the recorder on the articulator is below the reciprocal tracing made by the patient.

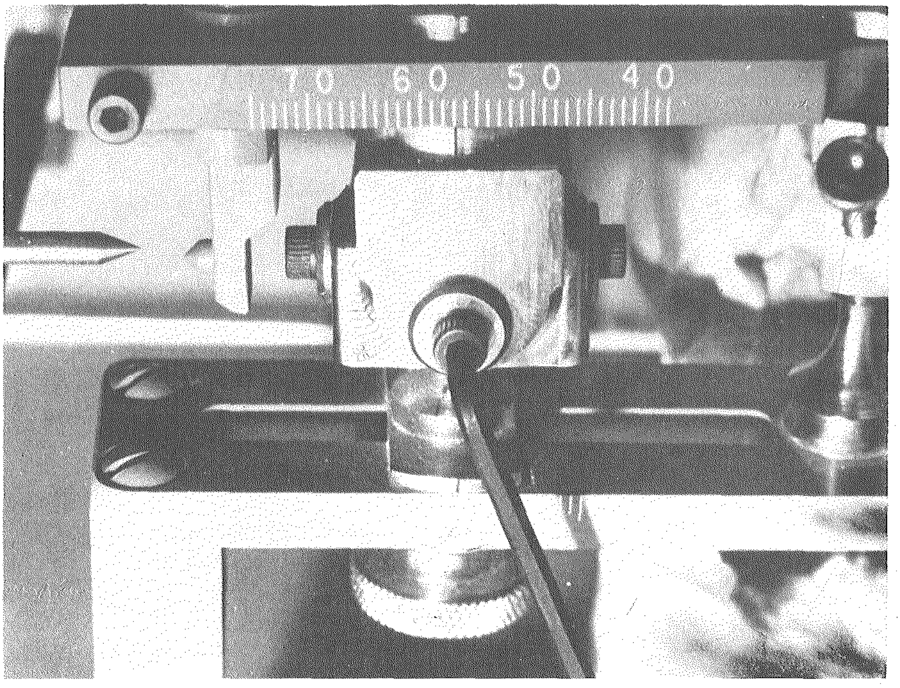

Fig. 325. The right-angle Allen wrench is used to loosen the screw holding the fossa trunnion bracket.

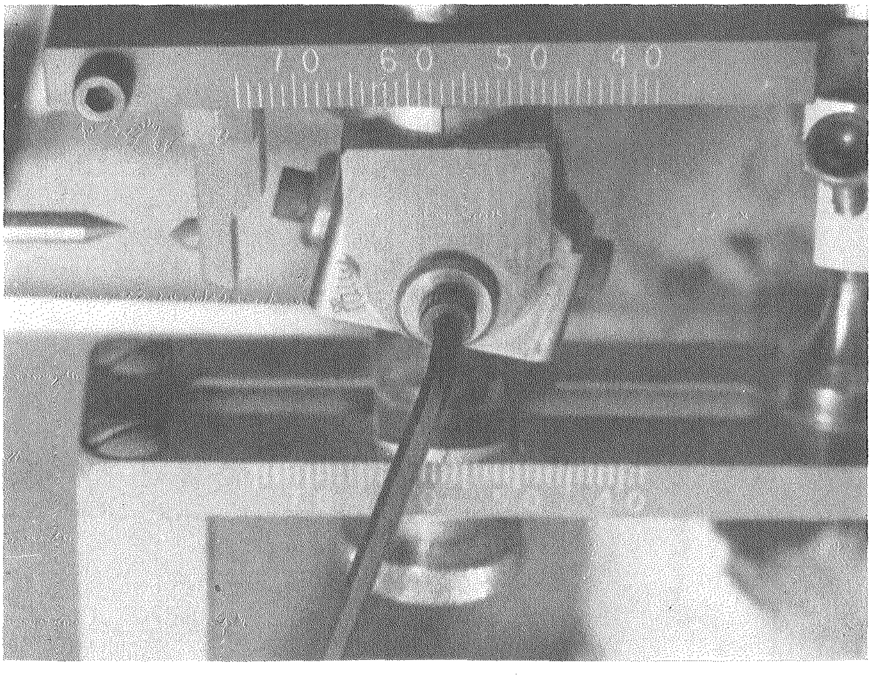

Fig. 326. The medial side of the trunnion is depressed.

projected from the actual centers of rotation. This back line enables us to determine the direction and extent of the axis shift. The styli points in the three adjustments just made are on the ends of their respective tracings. If the stylus point is below the end of the back line, as in Fig. 324, the screw holding the fossa trunnion bracket (Fig. 325) must be loosened, and the medial side of the trunnion holding the fossa must be depressed (Fig. 326) until there is coinci-

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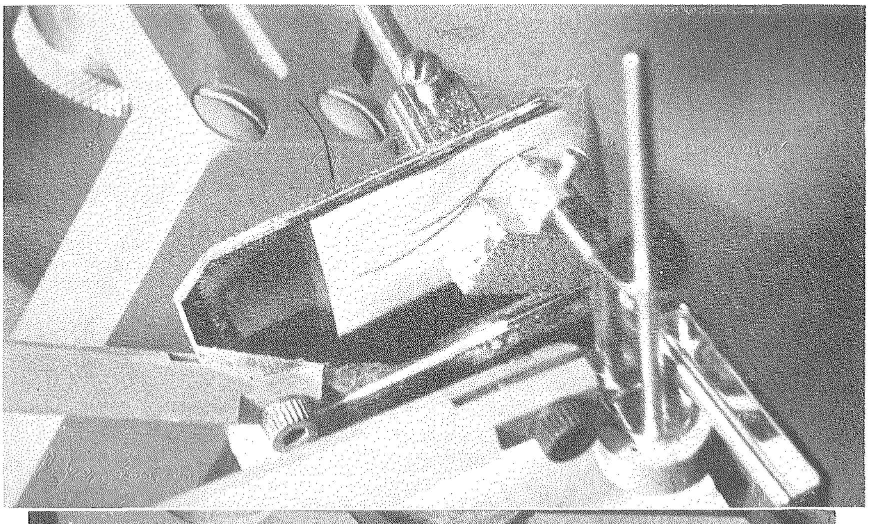

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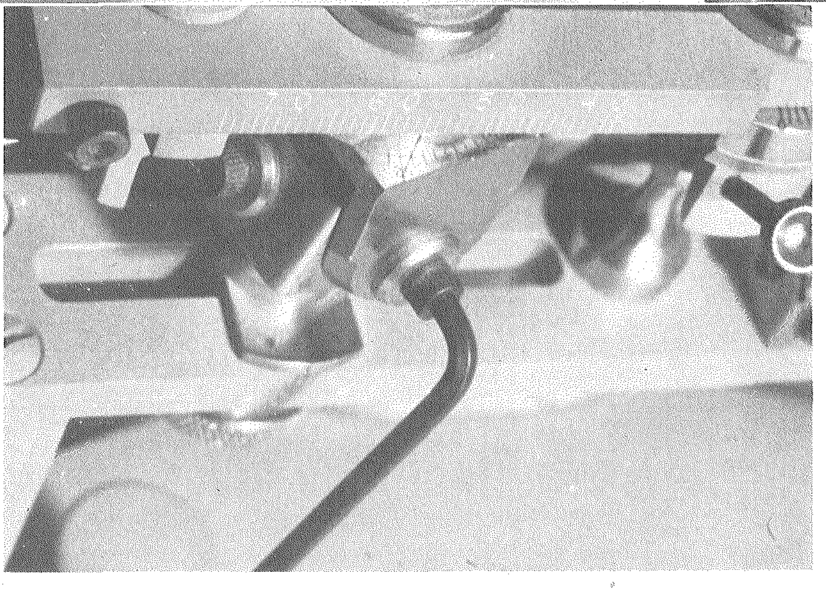
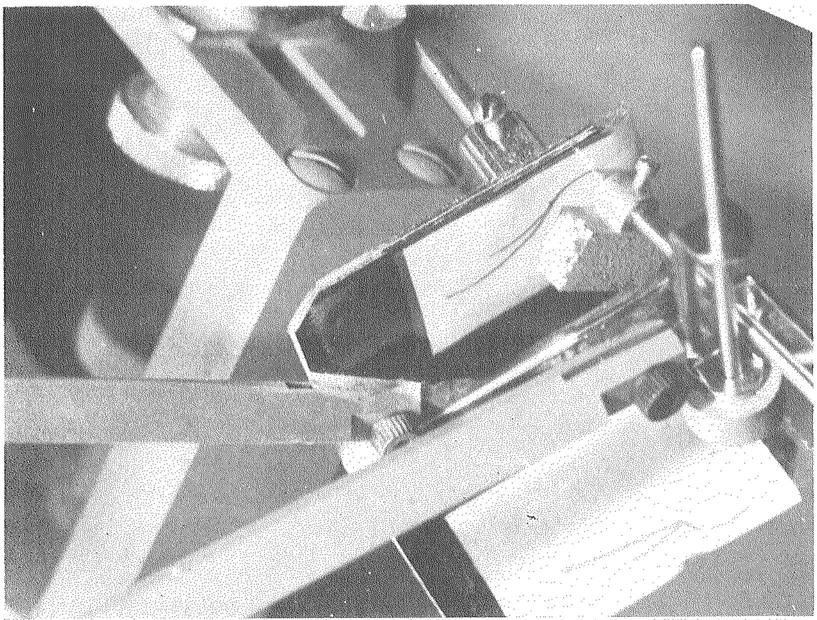


Fig. 327. The recorder stylus on the articulator is *on* but not at the *end* of the reciprocal tracing made by the patient.
Fig. 328. The holding nut of the main fossa bracket is loosened, and the outer end of the bracket is rotated posteriorly.



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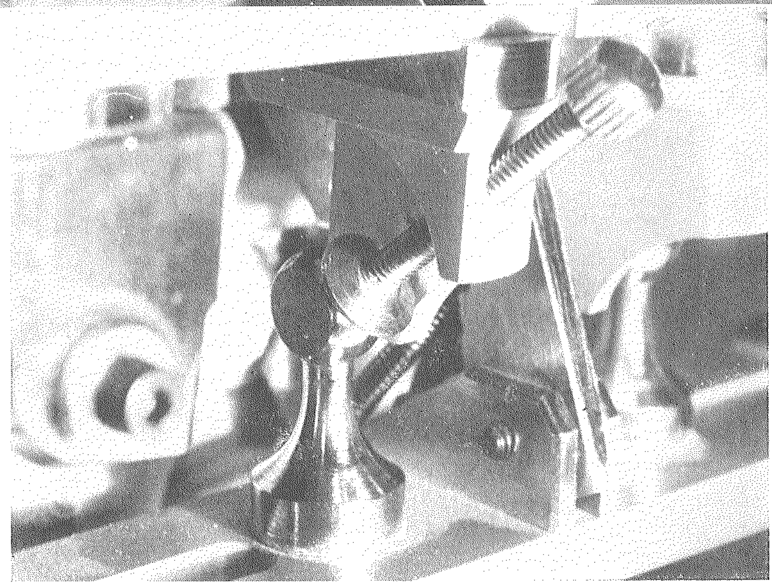

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Fig. 329. The recorder stylus on the articulator is *on* and at the *end* of the reciprocal tracing made by the patient after proper rotation of the bracket and tilt of the trunnion.
Fig. 330. The adjustment of the left side is begun by turning out the jackscrew of the right side and turning in the jackscrew of the left side.

dence at the end of the line. If, however, as in Fig. 327, the stylus is still in front of the end of the line, loosen the holding nut of the main fossa bracket and rotate the outer end of the fossa bracket posteriorly, as in Fig. 328, until there is coincidence at the end of the line (Fig. 329). When the main fossa bracket is being rotated, care must be taken not to move the position of the fossa in relation to the condyle ball of the lower frame. It will be noticed that it is sometimes necessary to tip the trunnion bracket, as well as to turn the main fossa bracket, in order to have the stylus coincide at the end of the back line.

Before proceeding with the corresponding settings on the oppposite side, recheck the styli points for coincidence at the ends of the lines on the condyle path, side shift, rotation center, and back line tracings. Because of the interaction between the controls, it will probably be necessary to make slight readjustments in some of the settings.

Now "back out" the jackscrew that has been holding the articulator in a lateral position during the settings, return the articulator to centric position, and turn in the other jackscrew, as in Fig. 330.

SETTING INCLINATION OF FOSSA ON OPPOSITE SIDE

The adjustments are repeated for this, the opposite side. Fig. 331 shows the horizontal stylus below the lateral condyle path. To correct this, loosen the fossa cup-holding screw (Fig. 332) and decrease the angulation of the fossa cup (this causes the tracing to be lowered) until the stylus is on the lateral condyle path tracing (Fig. 333). Then lock the fossa cup in this position and remove the right-angle Allen wrench (Fig. 334).

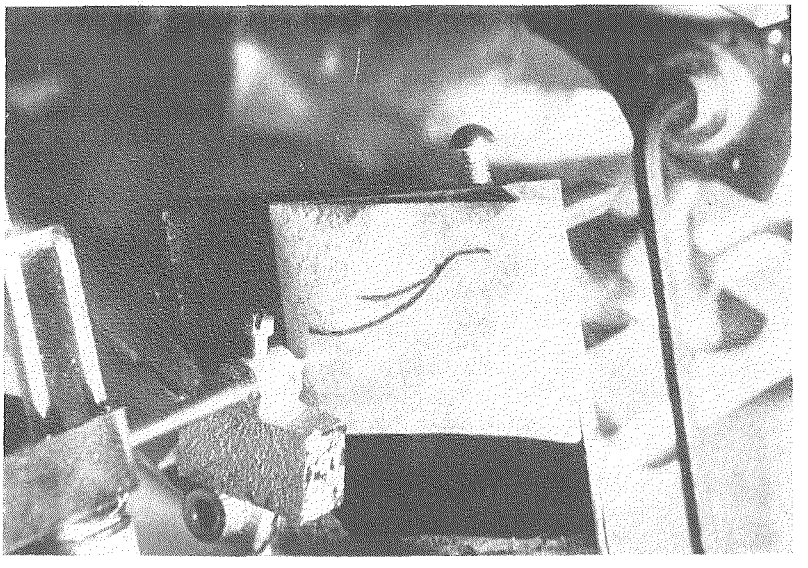

Fig. 331. The recorder stylus on the articulator is below the lateral tracing made by the patient.

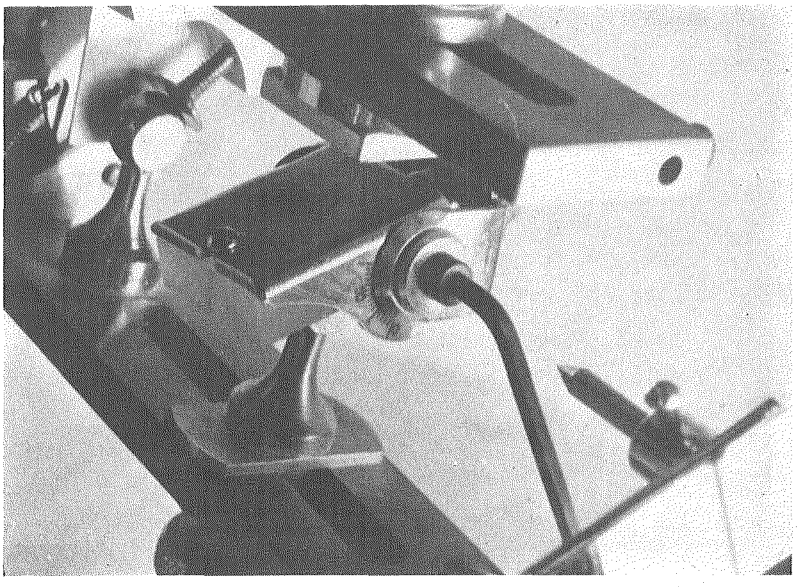

Fig. 332. The right-angle Allen wrench is used to loosen the fossa cup-holding screw. The fossa cup is elevated (the angulation is decreased).

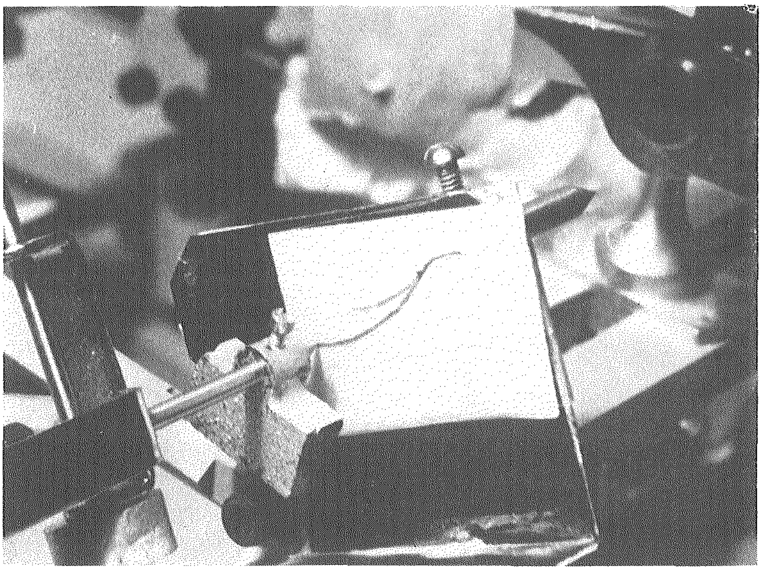

Fig. 333. The recorder stylus on the articulator is *on* and at the *end* of the lateral tracing made by the patient.

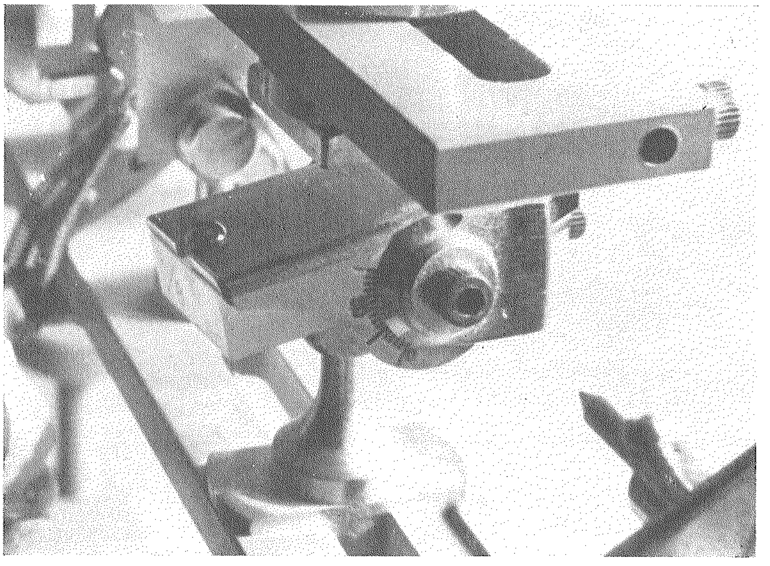

Fig. 334. The fossa cup inclination is adjusted and locked in position.

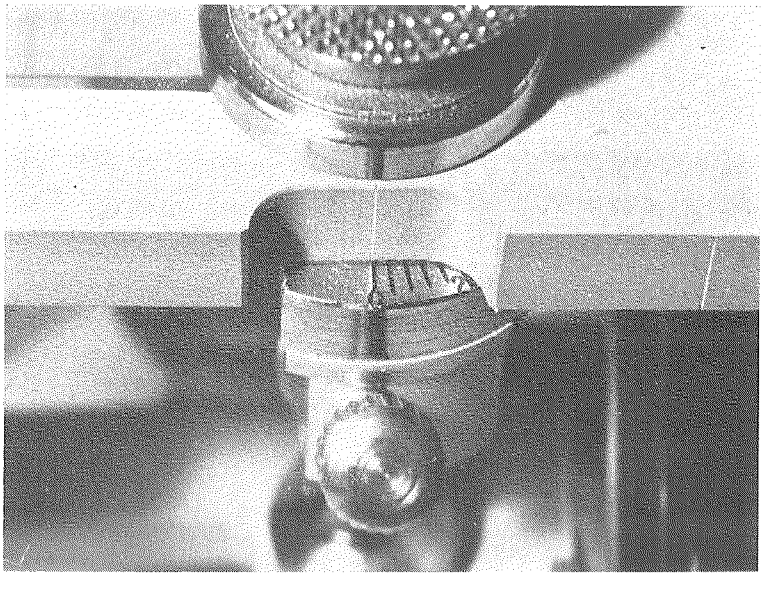

Fig. 335. Loosening the holding nut of the side shift wing.

SETTING ANGLE OF BENNETT SHIFT ON OPPOSITE SIDE

Next proceed with the angle of the side shift wing. Loosening the holding nut (Fig. 335), examine the side shift tracing to see whether the stylus is

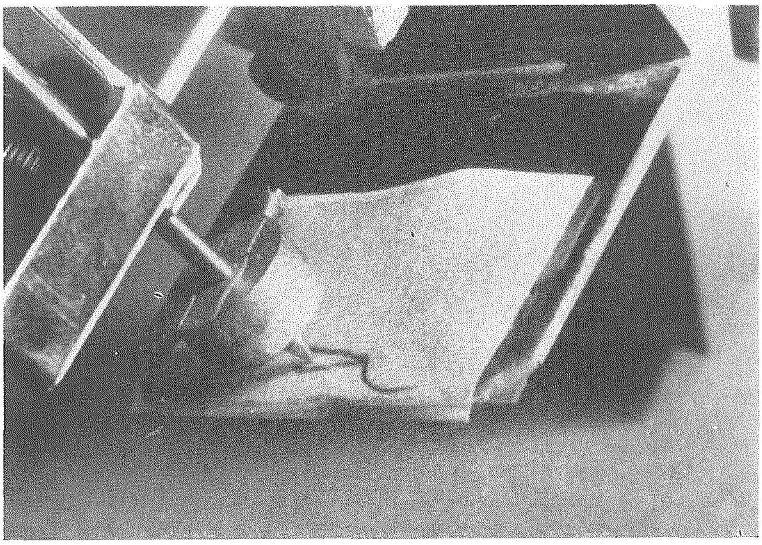

Fig. 336. The recorder stylus on the articulator is outside the Bennett path tracing made by the patient.

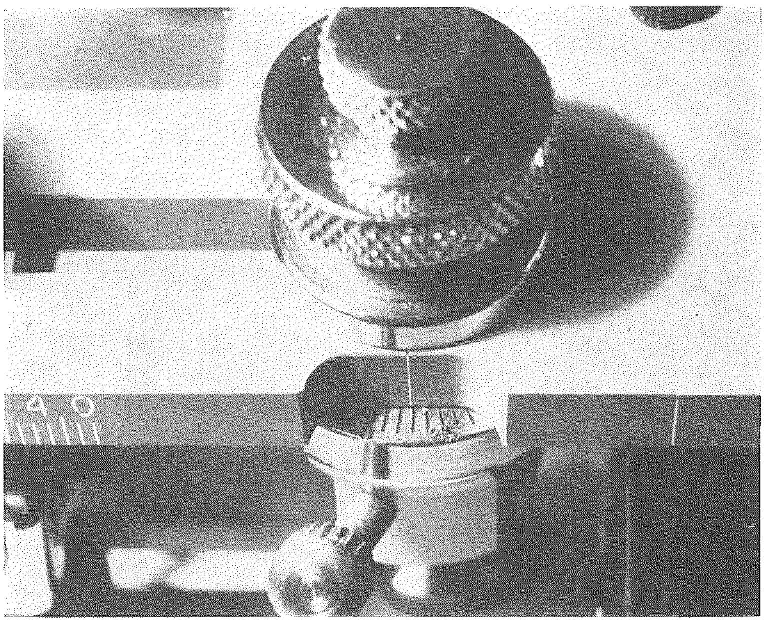

Fig. 337. The side shift wing is opened to permit the tracing on the articulator (and the upper bow) to move further to the side.

near it (Fig. 336). With the side shift ball against the wing, move the side shift wing (Fig. 337) until the vertical stylus point is on the side shift tracing (Fig. 338).

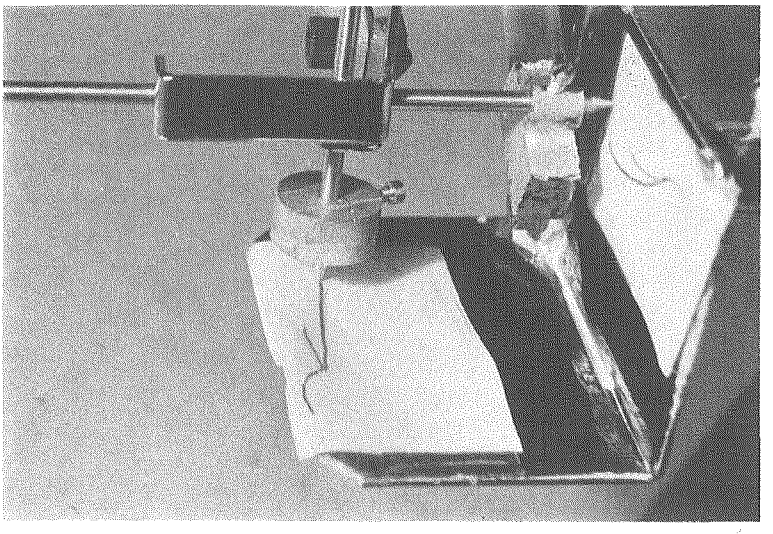

Fig. 338. The recorder stylus on the articulator is on the end of the Bennett path tracing made by the patient after proper setting of the side shift wing.

SETTING CENTER OF LATERAL ROTATION ON OPPOSITE SIDE

With the styli points on the ends of the tracings in the two previously adjusted positions, examine the inner wing of the Gothic arch tracing on the ro-

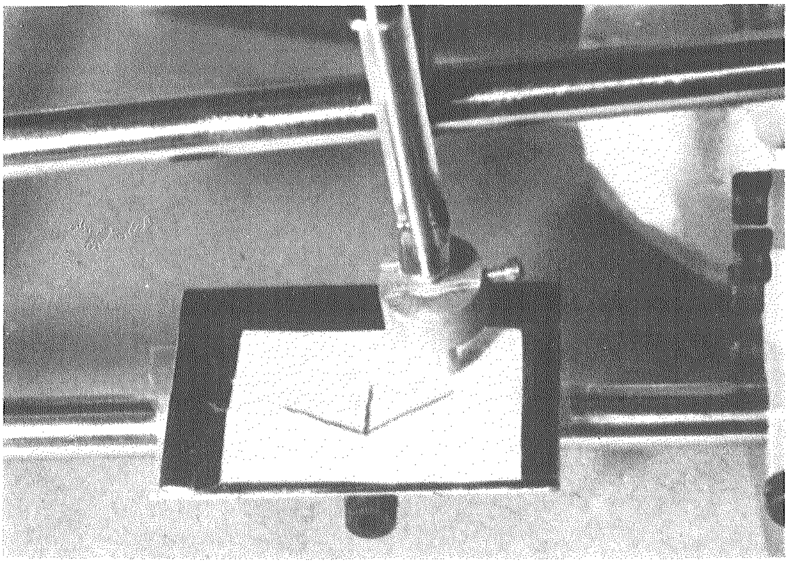

Fig. 339. The recorder stylus on the articulator is behind the inner wing of the Gothic arch tracing made by the patient.

tating side (Fig. 339) and note that the stylus point is behind the tracing. Fig. 340 shows the position of the center of rotation. In order to bring the stylus forward in relation to the inner wing of the Gothic arch tracing (Fig. 341), it will be necessary to move the center of rotation inward, as in Fig. 342. One must remember to maintain the centric relation of the upper and lower members of the articulator by keeping the millimeter readings exactly the same on both the upper and lower bows.

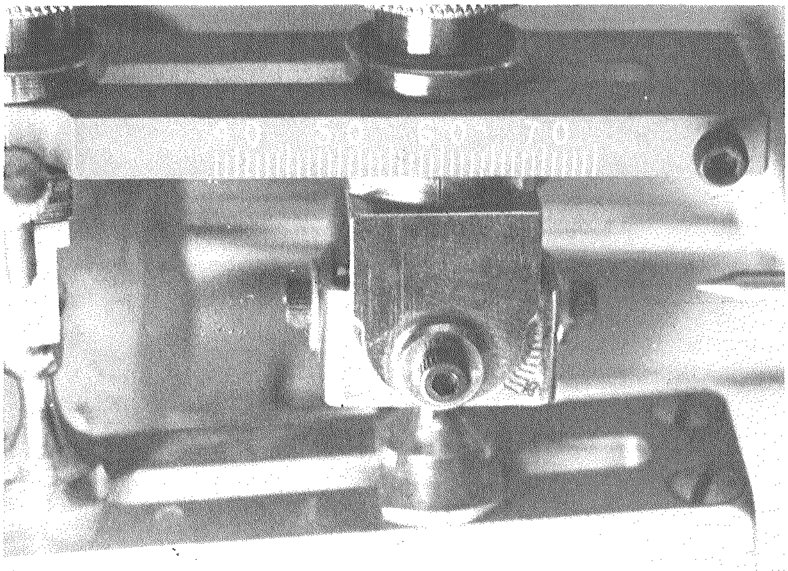

Fig. 340. The position of the center of lateral rotation before adjustment.

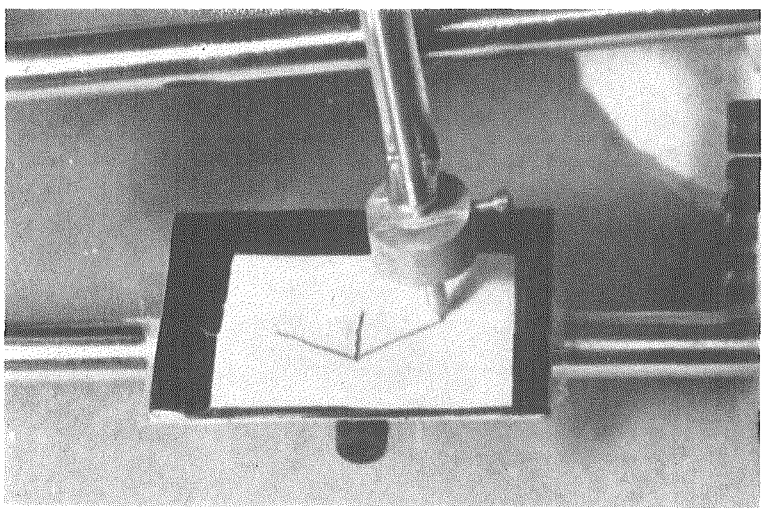

Fig. 341. The recorder stylus on the articulator is on the end of the inner wing of the Gothic arch tracing made by the patient.

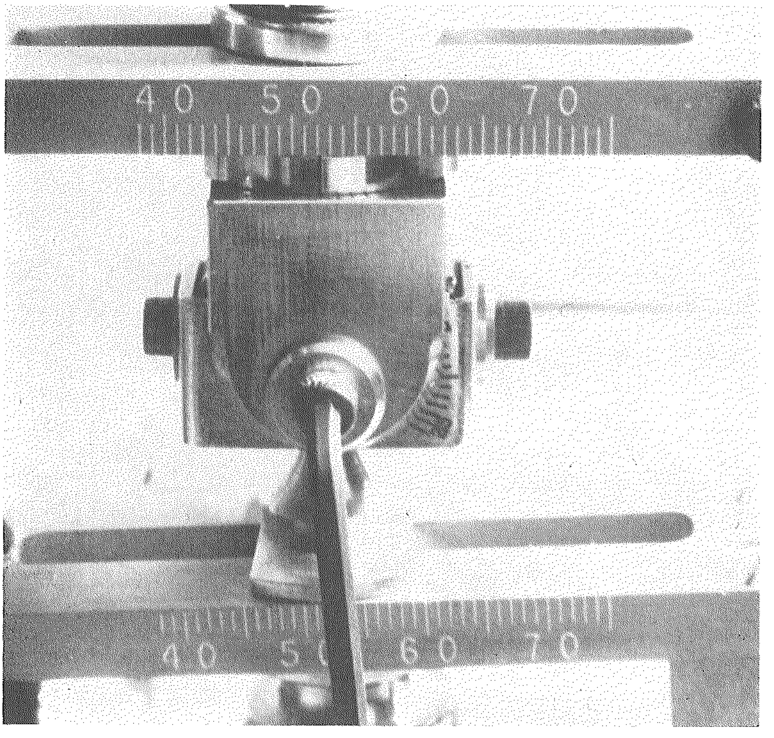

Fig. 342. The position of the center of lateral rotation after adjustment.

ADJUSTING TILT AND ROTATION OF AXIS ON OPPOSITE SIDE

The back line on the rotating side is now examined, and we find that the point of the horizontal stylus is above this line (Fig. 343). Loosening the screw which holds the fossa trunnion bracket and raising the medial end a few degrees (Fig. 344) until the stylus is on the line (Fig. 345) will cause the point to be in front of the end of the back line. The next step is to loosen the nut holding the main fossa bracket and rotate the outer end of the main fossa posteriorly, as in Fig. 346, until coincidence is obtained at the end of the line, as in Fig. 347.

Having obtained coincidence at the end of the back line, one should check to see whether there is still coincidence at the ends of the other lines. If there is not, then it is necessary to make minor readjustments to overcome the effect of the interaction of the various adjustments.

In adjusting to the back line, occasionally one may have to tip the outer portion of the fossa downward on its outer extremity to provide for a downward shift of the outward-moving rotating condyle.

If the setting is extreme, it is possible to avoid subsequent extensive grinding

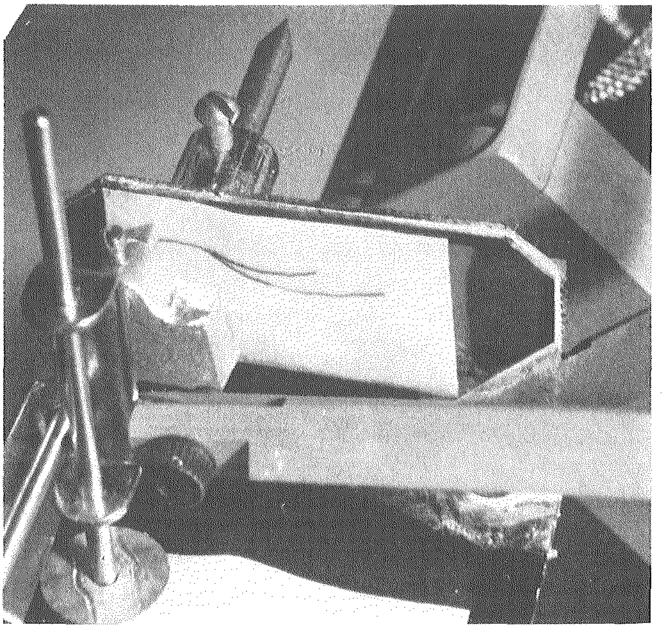

Fig. 343. The recorder stylus on the articulator is above the reciprocal tracing made by the patient.

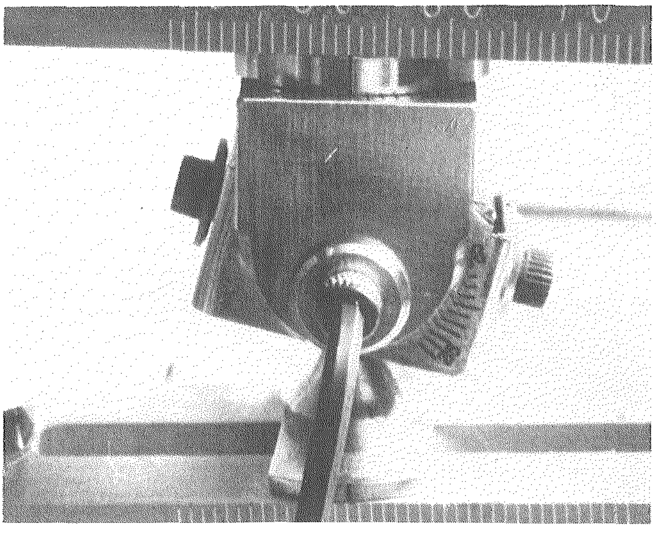

Fig. 344. The screw holding the fossa trunnion is loosened, and the medial end of the trunnion is raised.

of the eminentia for protrusive and lateral adjustment by adding a little quick-curing plastic to the eminentia. Set the fossa at zero, remove the eminentia, and attach a small rounded cone of the plastic, about a quarter inch in diameter, just

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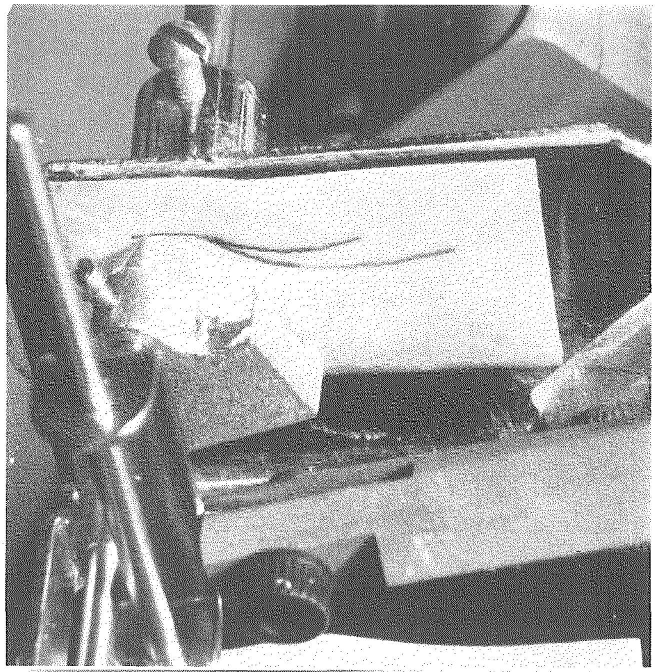

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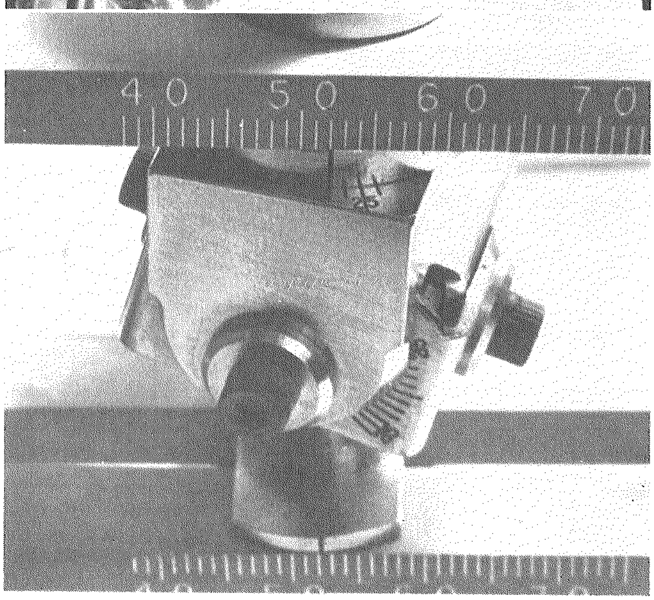

Fig. 345. The recorder stylus on the articulator is *on* but not at the *end* of the reciprocal tracing made by the patient.
Fig. 346. The outer end of the main fossa bracket is rotated posteriorly.

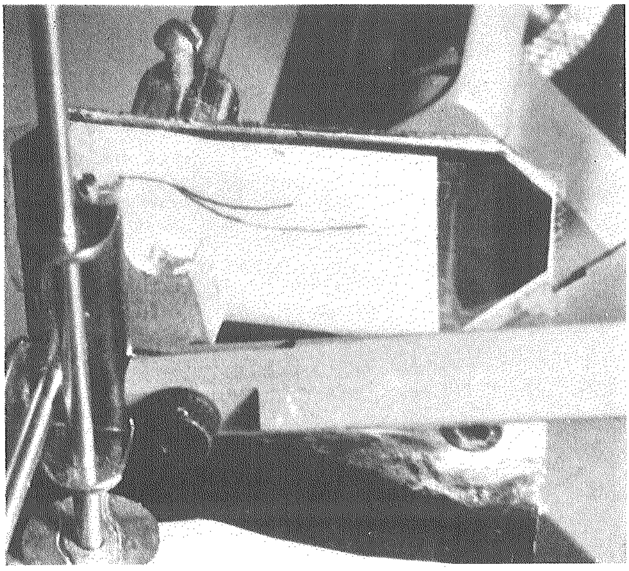

Fig. 347. The recorder stylus on the articulator is *on* and at the *end* of the reciprocal tracing made by the patient.

lateral to the centric contact point of the condyle ball with the eminentia. While the plastic is moldable, replace the eminentia and allow the plastic to mold around the outer part of the condyle ball, taking care not to interfere with the centric contact. When the plastic has set, remove the eminentia and grind away any excess of plastic that may have formed down over the sides of the ball, leaving only the plastic that hugs the outer side of the ball.

Replace the eminentia and, with the fossa trunnion set at zero, test the reference of the stylus to the end of the back line on the vertical plate with the articulator in lateral position. If the stylus is above the end of the line, either add more plastic or tip the outer extremity of the trunnion downward a few degrees to make the stylus agree at the end of the line.

If the stylus is below the end of the back line, remove a little of the plastic from the eminentia and test for alignment. This procedure is repeated until alignment is achieved.

At this point, we have adjusted the articulator to the ends of all the tracings. Very probably, however, there will be misses from the centric points to the extremities, and we will now make such readjustments as are necessary to ensure that all the tracings are followed faithfully in their entirety.

GRINDING BENNETT GUIDE FOR BENNETT CURVATURE

Return the articulator to centric position by turning out both jackscrews and move it to a lateral excursion, making sure to ride the ball against the side shift guide. Examine the path of the posterior vertical stylus as it travels over the horizontal side shift tracing, taking care to ride the side shift guide wing against the side shift ball in the direction in which the articulator is being moved. If the stylus cuts across and does not follow the side shift path, it will be necessary to grind the side shift control wing to reproduce the curve of the side shift path (Fig. 348).

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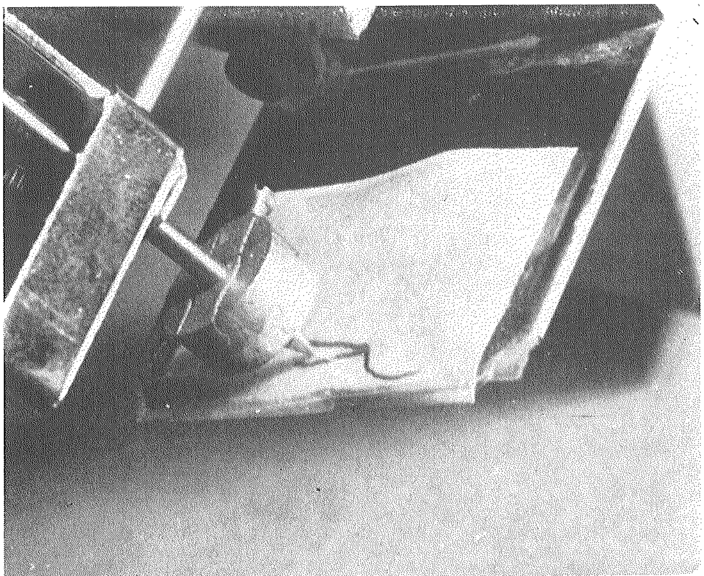

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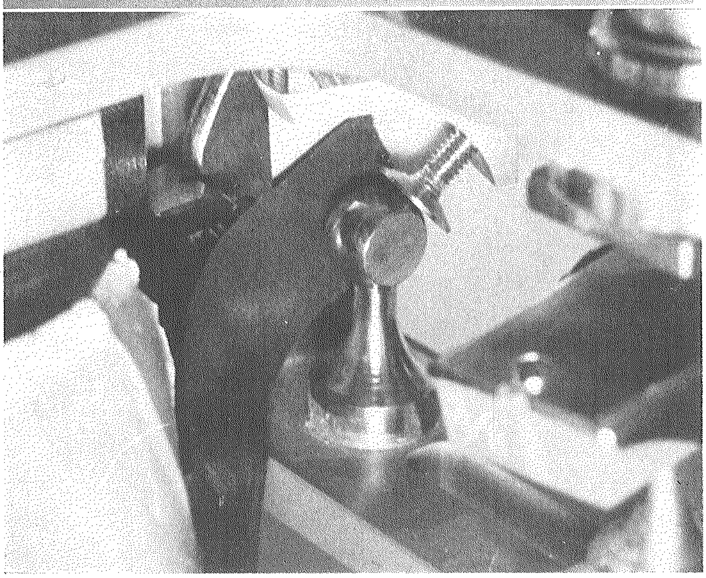
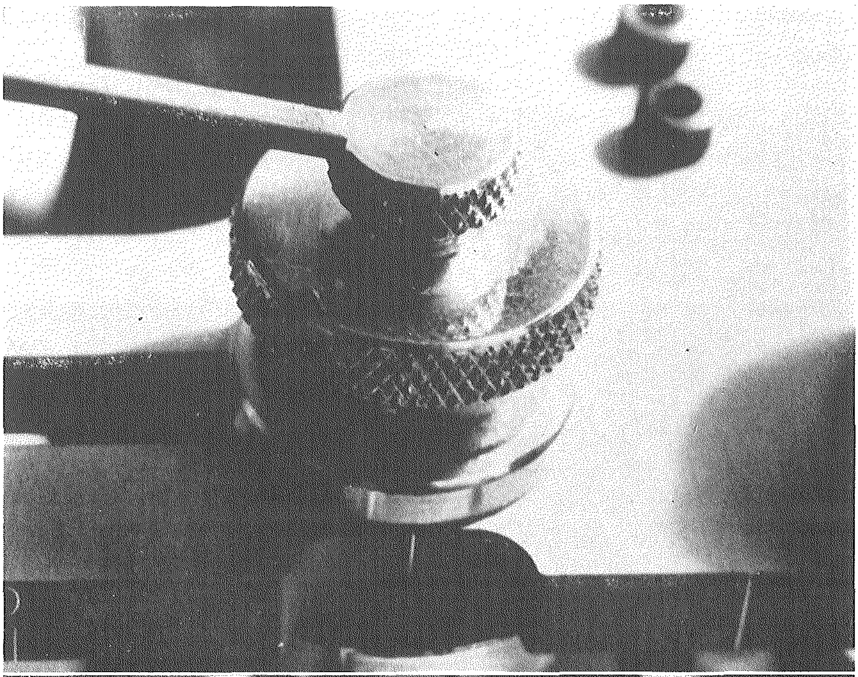


Fig. 348. The recorder stylus on the articulator does not follow the curve (between the beginning and the end) of the Bennett path tracing made by the patient.
Fig. 349. Carbon paper is used to mark the area on the side shift wing, which has to be ground.



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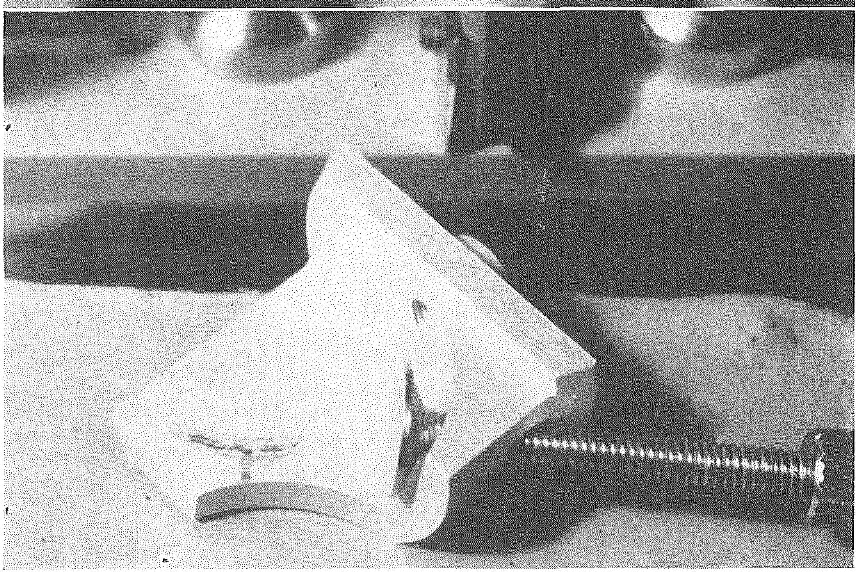

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Fig. 350. The small holding nut at the top of the side shift adjustment nut is loosened.
Fig. 351. The carbon-marked side shift wing is removed.

Carbon paper is placed between the ball and the side shift wing on the sliding condyle side (Fig. 349), and the articulator is moved from the centric to the lateral position. Again, we must make sure that the side shift ball is against the wing. The articulator is moved from where the stylus begins to leave the line to where it resumes on the line. Move it back and forth between these two points, marking the area on the side shift wing that has to be ground.

Next, loosen the small holding nut at the top of the side shift adjustment nut (Fig. 350). This permits removal of the side shift wing without altering the angle of the wing, and it can easily be returned to the same angle after each grinding. With a stone having a ⅜-inch diameter, carefully grind the marked path (Figs. 351 and 352) until the vertical stylus point follows the entire side shift path on

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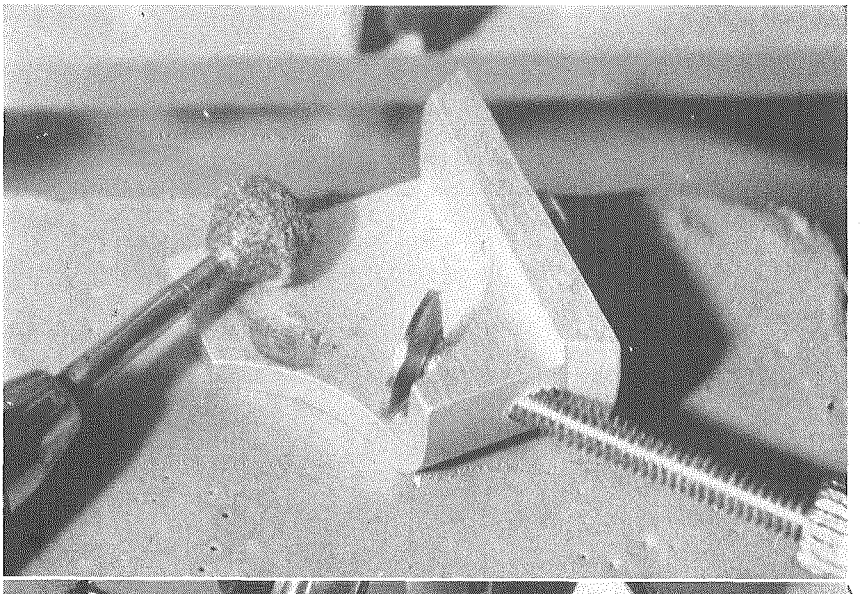

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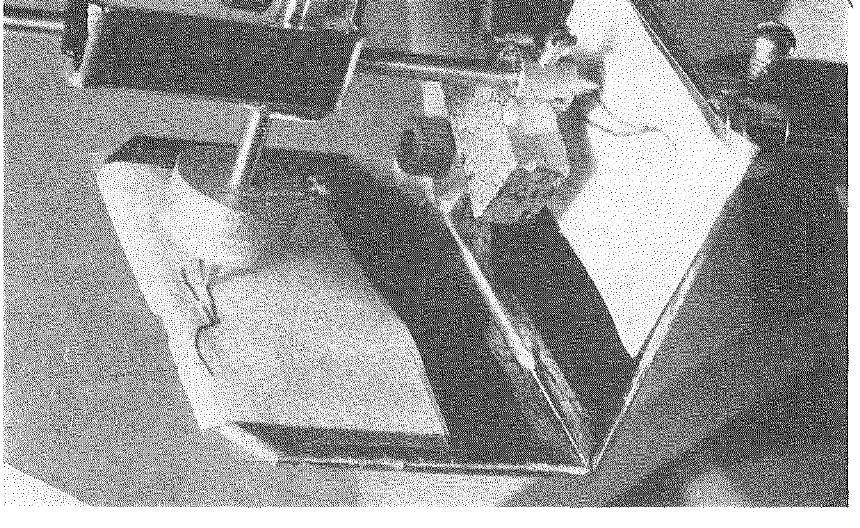
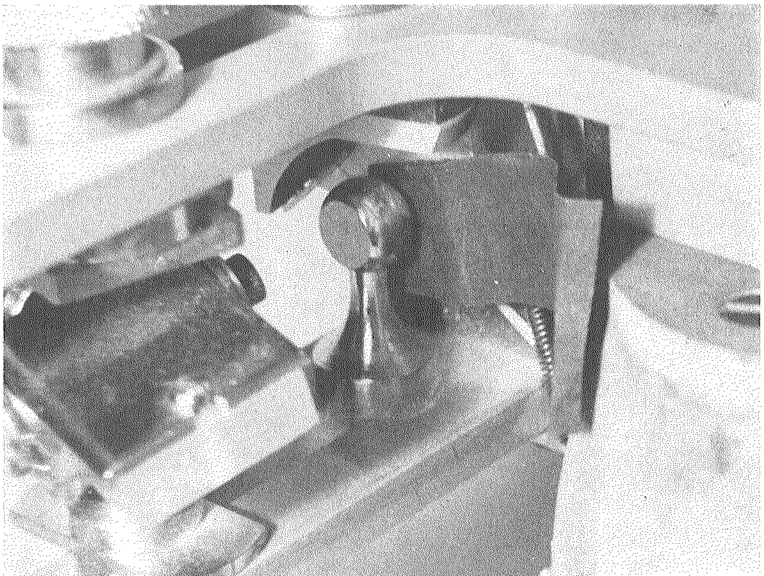


Fig. 352. The side shift wing is ground where marked.
Fig. 353. The ground side shift wing enables the recorder stylus on the articulator to follow the entire Bennett path tracing made by the patient.

the horizontal recording plate (Fig. 353). Be very careful not to grind the start of the path on the side shift wing. If this were carelessly ground, the positive centric guide which is so important would be lost.

These steps are repeated for the other side. To mark the path, carbon paper is placed between the side shift ball and the side shift guide wing of the opposite side (Fig. 354). Loosen the small holding nut at the top of the side shift adjustment nut (Fig. 355), remove the guide wing, and grind along the



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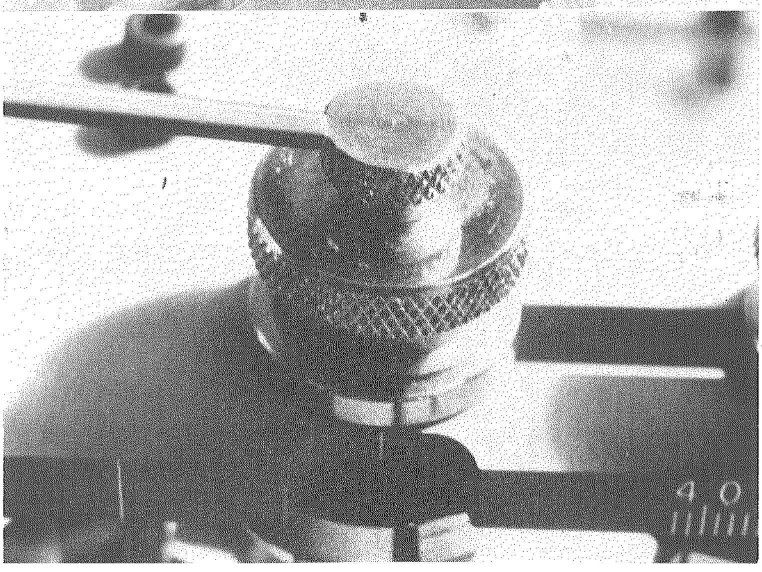

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Fig. 354. The side shift wing on the right side is marked by carbon paper.
Fig. 355. The small holding nut at the top of the side shift adjustment nut is loosened.

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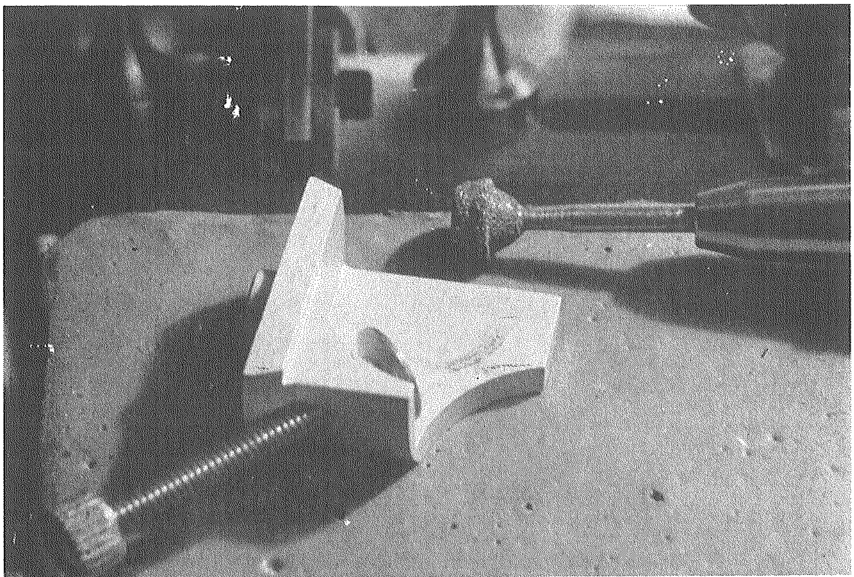

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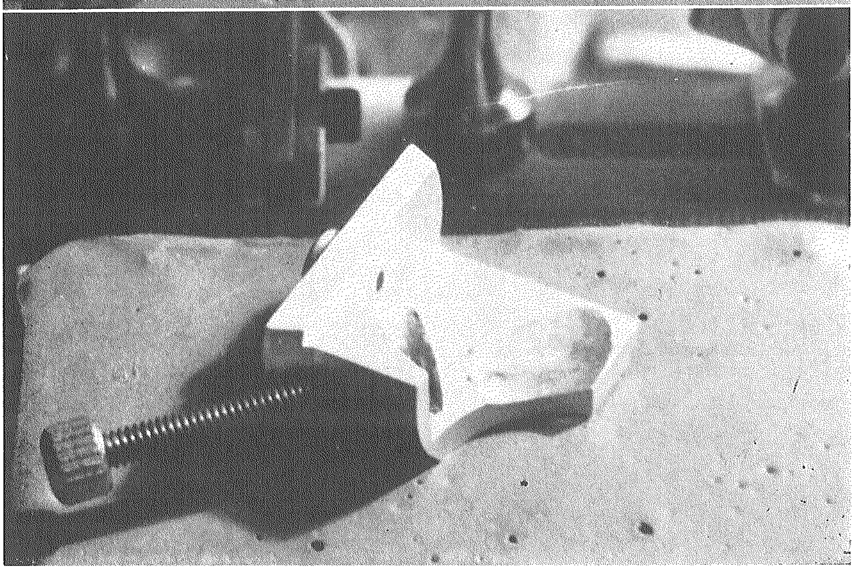

Fig. 356. The carbon-marked side shift wing is removed.
Fig. 357. The side shift wing is ground where marked.

marks (Figs. 356 and 357) until the stylus tip follows the entire side shift path faithfully at every point.

SELECTION OF CONDYLE PATH

The next consideration is the selection of the condyle path. Moving the articulator to a lateral excursion and making sure to ride the side shift ball with the side shift guide wing on the sliding side, examine the relation of the hori-

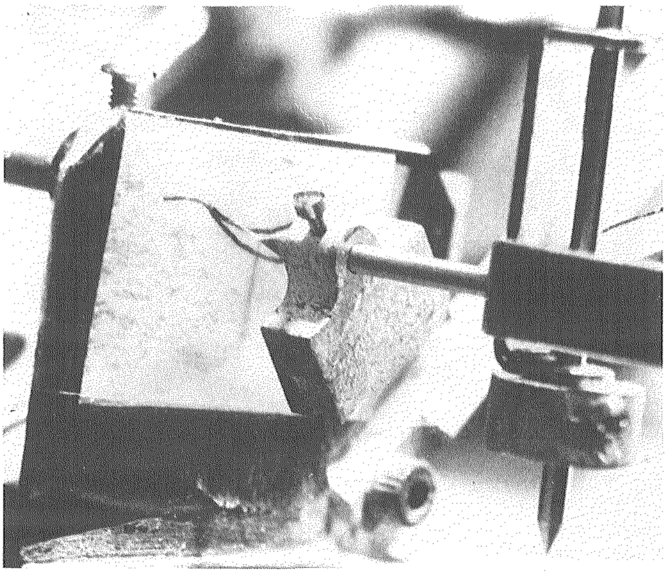

Fig. 358. The recorder stylus on the articulator does not follow the in-between portion of the lateral path tracing made by the patient.

zontal stylus to the lateral condyle path. If the stylus arcs above the patient's tracing and then agrees at the end of the line, as in Fig. 358, it is indicative that an eminentia with less radius of curvature is required. In other words, a steeper path is needed. Several eminentiae should be tried until one is found that produces the closest coincidence along most of the path. Whenever an eminentia is changed, its inclination must be readjusted so that there will again be coincidence at the end of the line.

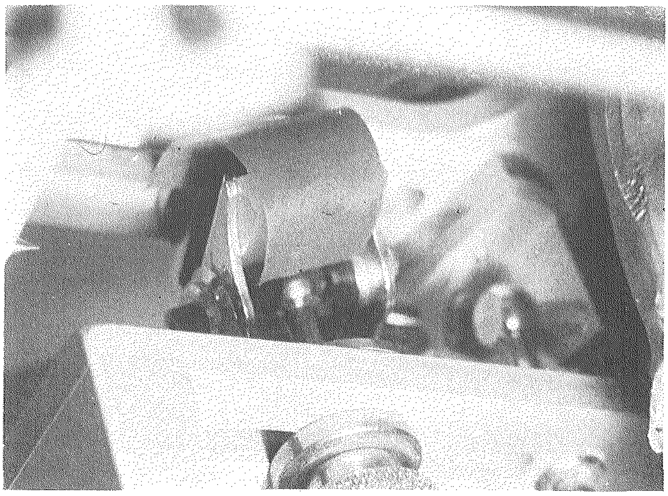

Fig. 359. Carbon paper is used to mark the area on the eminentia where grinding is indicated.

Grinding eminentia for lateral path

If the stylus cuts below the tracing in some area, it will be necessary to grind the eminentia. Use carbon paper, as in Fig. 359, to mark the area to be ground and remove the eminentia by loosening the screw (Fig. 360). Fig. 361 shows the mark on the eminentia made by the carbon paper. Now grind, as in Fig. 362, until the stylus tip follows the entire lateral condylar path (Fig. 363).

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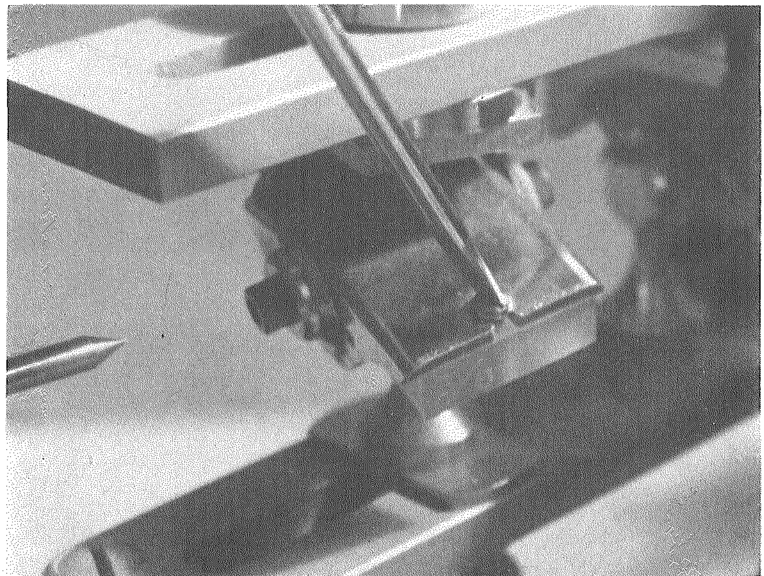

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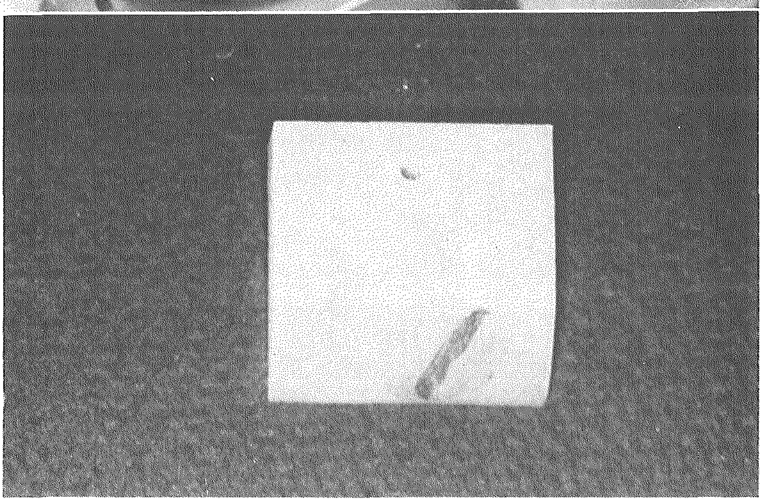
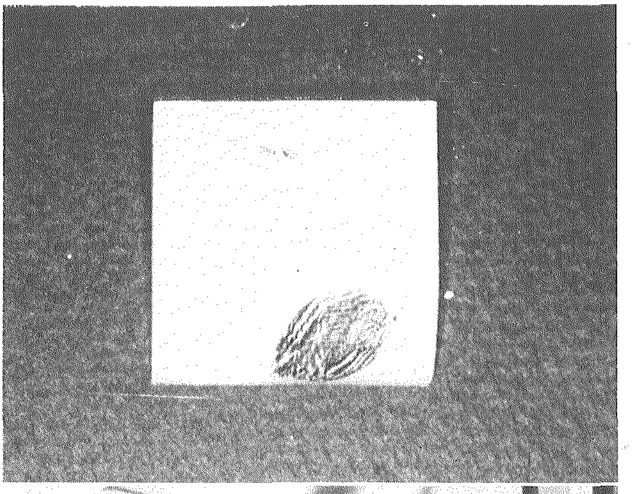


Fig. 360. The screw is loosened to remove the eminentia in order to grind it or replace it with another curvature.
Fig. 361. The eminentia is marked in the lateral excursion.



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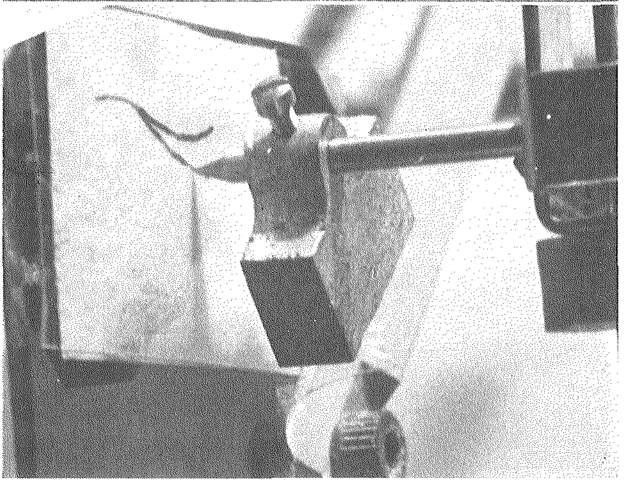

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Fig. 362. The eminentia is ground for the lateral excursion.
Fig. 363. The recorder stylus on the articulator follows the lateral tracing made by the patient in every detail.

Grinding eminentia for protrusive path

The protrusive path, which is usually above the lateral path, will automatically be followed by the stylus after all these adjustments are made. If not, as in Fig. 364, reset the eminentia to a steeper inclination and mark and grind for coincidence along the protrusive path. Fig. 365 shows the carbon marking on the eminentia alongside the lateral marking. Be sure to grind only the protrusive markings. Fig. 366 shows the stylus tip faithfully following the protrusive path after the grinding has been done.

It will now be necessary to remark and regrind the eminentia for the lateral path. This procedure is repeated for the opposite side.

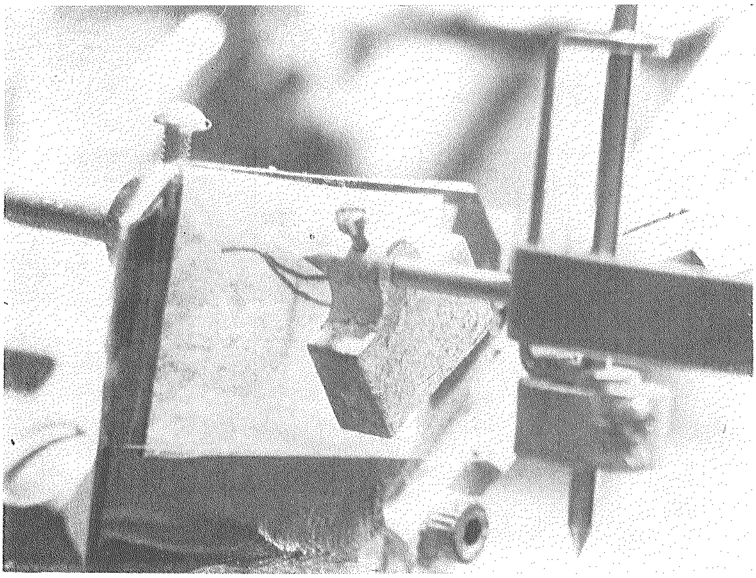

Fig. 364. The recorder stylus on the articulator does not follow the protrusive path tracing made by the patient.

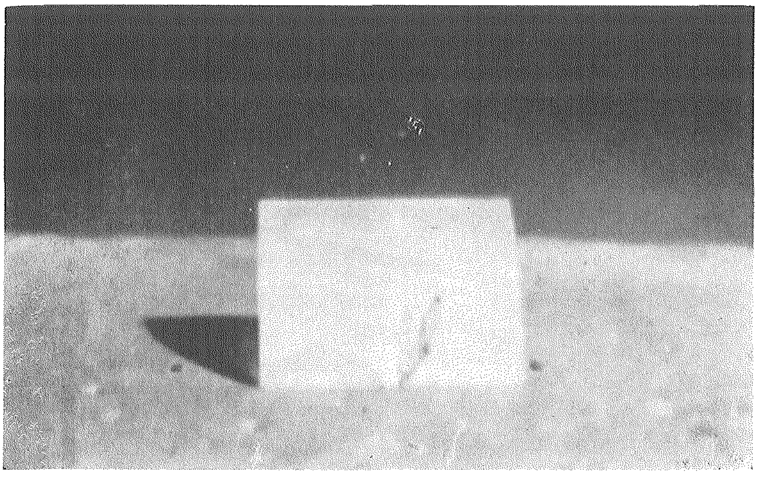

Fig. 365. Carbon marking of the protrusive path alongside the lateral marking.

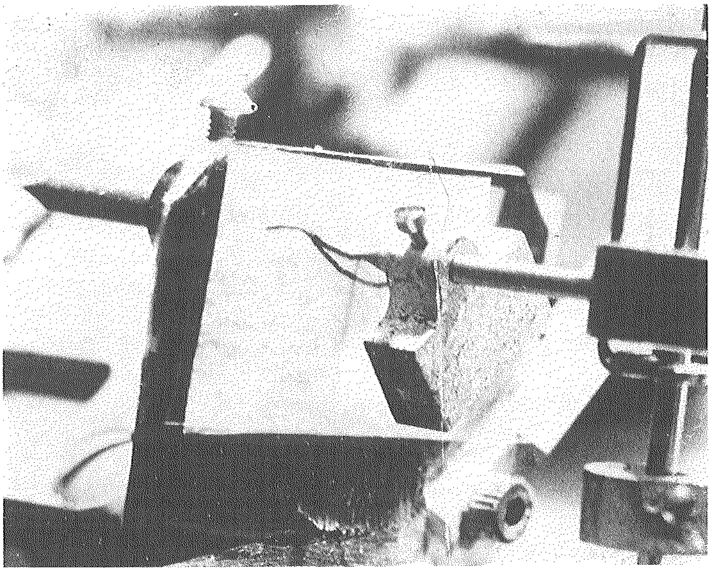

Fig. 366. The recorder stylus on the articulator follows the protrusive path tracing made by the patient.

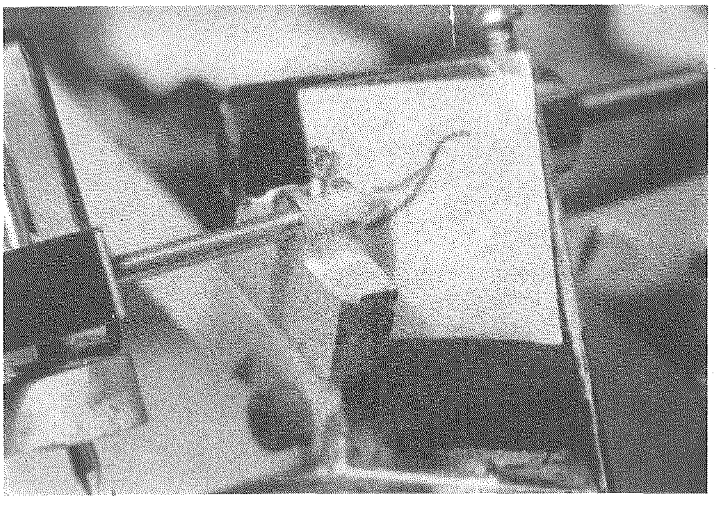

Fig. 367. The recorder stylus on the articulator does not follow the in-between area of the lateral path tracing made by the patient on the left side.

Examine the path of travel of the horizontal stylus tip in relation to the lateral condyle path. If it cuts above the tracing, as in Fig. 367, select an eminentia with a shorter radius of curvature, i.e., a path with more curvature. Fig. 368 shows the eminentia in the articulator when the stylus-tracing relationship was examined. Fig. 369 shows the path that had to be substituted in order to obtain coincidence along the entire tracing. Fig. 370 shows a side view of the eminentia. The horizontal stylus tip now follows the lateral condyle tracing in its entirety (Fig. 371).

In examining the relation of the stylus to the protrusive tracing, however, we find that the stylus is above the tracing (Fig. 372). This means that the inclination of the eminentia must be increased until we are at the end of the protrusive line, and the eminentia is ground until the stylus follows the path in every detail,

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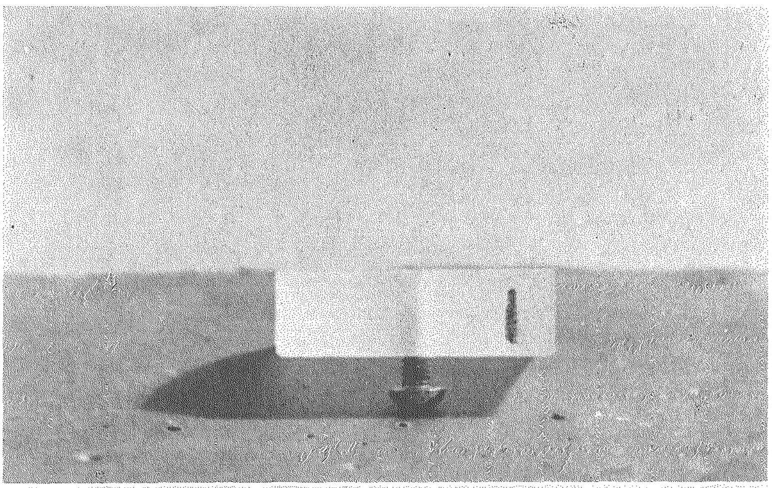

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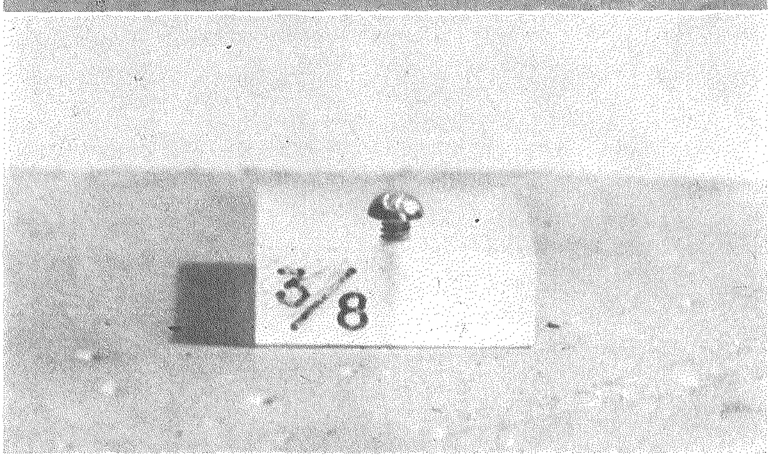
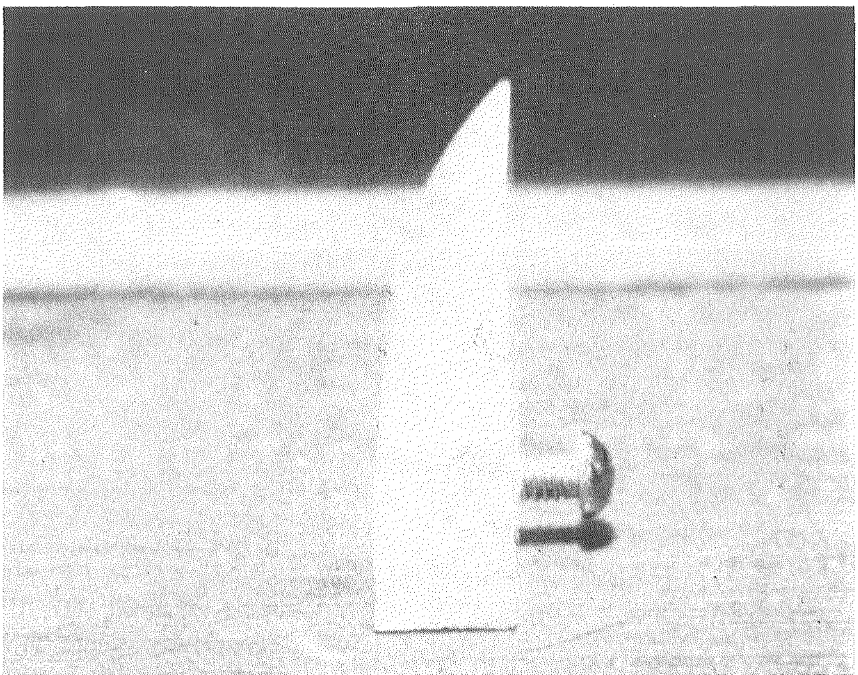


Fig. 368. The eminentia in the articulator when the lateral tracing on the left side was examined.
Fig. 369. The eminentia substituted for the one previously in the articulator.



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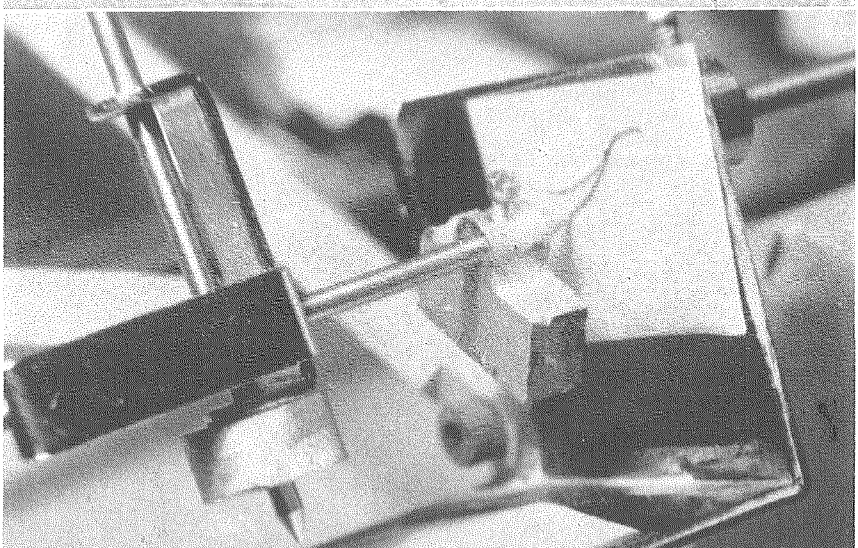

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Fig. 370. Side view of the eminentia used.
Fig. 371. The recorder stylus on the articulator follows the lateral path tracing made by the patient in its entirety.

as in Fig. 373. The lateral path on the eminentia will have to be ground, too, in order that it may again be followed exactly.

In testing the protrusive path, it is advisable to turn both jackscrews in simultaneously, being careful to follow the four vertical styli (two in the front and two in the rear) as they travel on the protrusive tracings. The protrusive path of the horizontal styli should also be checked as they travel over the paths on the horizontal plates at the rear.

When the articulator is completely adjusted, the settings are recorded on the

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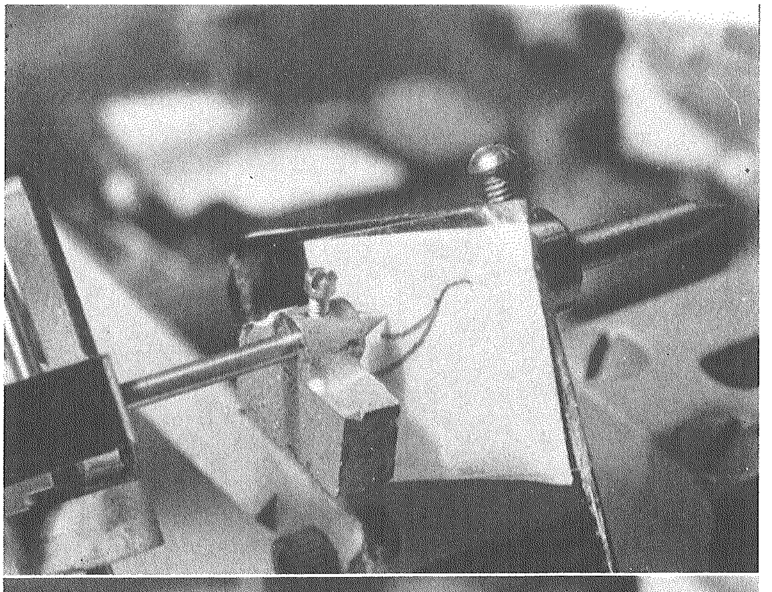

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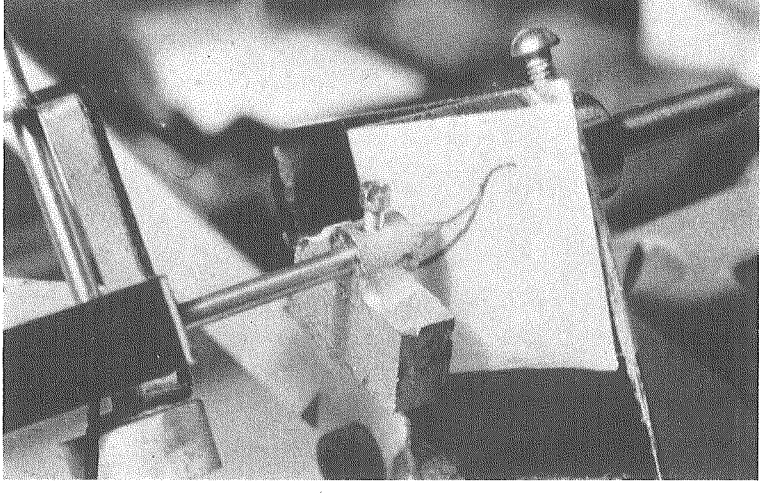

Fig. 372. The recorder stylus does not follow the protrusive path made by the patient.
Fig. 373. After proper adjustment of the eminentia, the recorder stylus on the articulator follows the protrusive path in every detail.

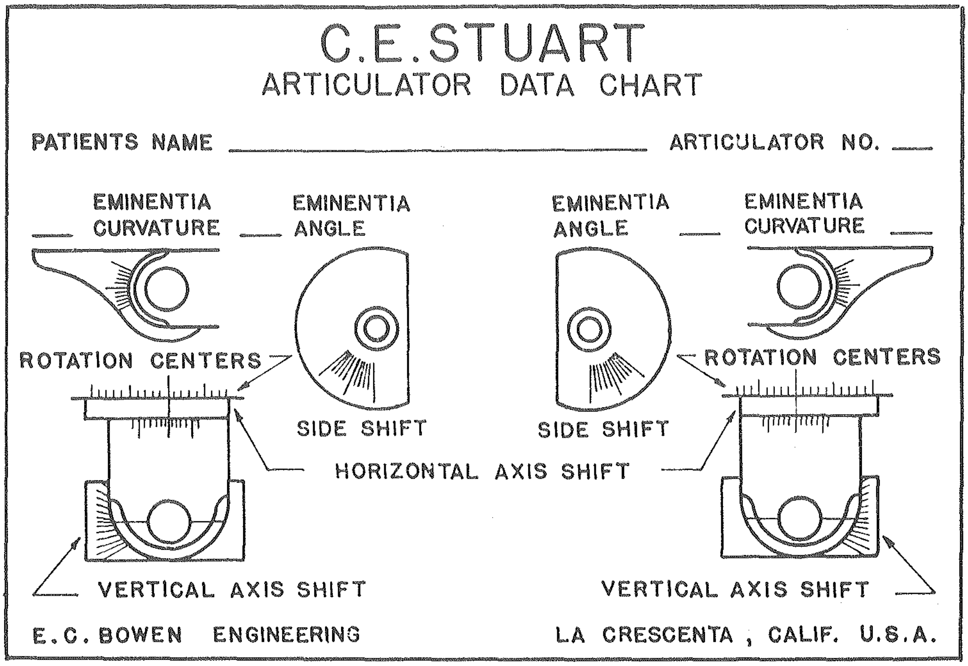

Fig. 374. The chart on which the settings are recorded.

chart (Fig. 374). The patient's name should be engraved on the side shift wings and on the eminentiae, if these were ground. This enables the articulator to be reset and reassembled accurately when the work that is planned is resumed.

Reference

1. Stuart, Charles E.: Instructions for Use of Gnathological Instruments, Ventura, Calif.

CHAPTER 11

The De Pietro articulator*

The first new articulator in years with a fresh design has been developed by Dr. A. J. De Pietro of Philadelphia. The De Pietro articulator† has numerous innovations which will make better dentistry easier. At the moment, it is in the checkbite stage, but it has been designed so that, in the near future, it can very simply and economically be converted to a fully adjustable instrument.

Although we do not endorse any checkbite technique for full-mouth rehabilitation, we feel there is a definite place for its use in the construction of dentures. Moreover, the checkbite sequence is a logical precursor of a fully adjustable technique. Therefore, any beginner in this work would do well to start with a sound checkbite method.

MOUNTING STUDY CASTS

Adequate study casts are mounted on the articulator to an approximate axis and to a good centric relation record. The procedure is quite similar to the temporary mountings on the other articulators, but there are some very important improvements in the technique which simplify this step.

Mounting post

There is no separate mounting frame, but a mounting post (Fig. 375). By means of this post, the face-bow is held in a convenient position on the articulator frame (Fig. 376).

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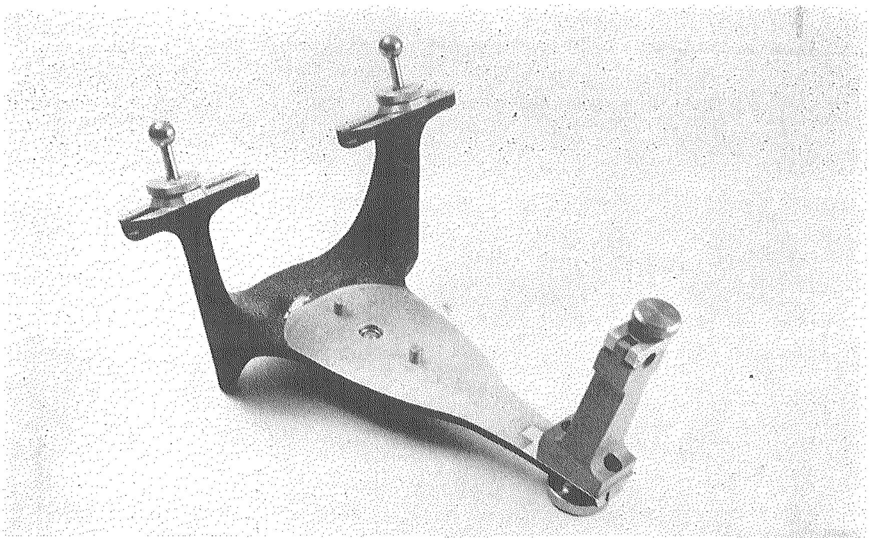
*The photographs for this chapter were taken by Dr. A. J. De Pietro; the text is based on a description of the technique by Dr. G. J. De Pietro.

†Manufactured by The J. M. Ney Company, Hartford, Conn.



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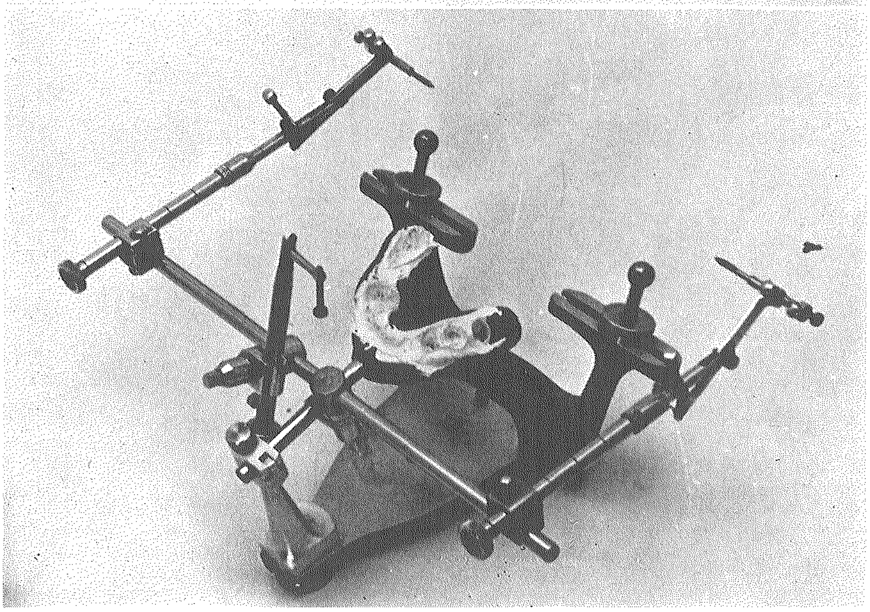

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Fig. 375. The mounting post is positioned on the anterior part of the articulator frame in place of the incisal table.
Fig. 376. The transfer bow is held on the articulator frame by means of the mounting post. *Note* that it only requires a convenient position, not an exact adjustment to anything.

Intercondylar distance setting gauge

The distance between the points of the face-bow rods is measured by means of the intercondylar distance setting gauge (Fig. 377). This enables us to accurately set the location of the condylar assemblies without a process of trial and error.

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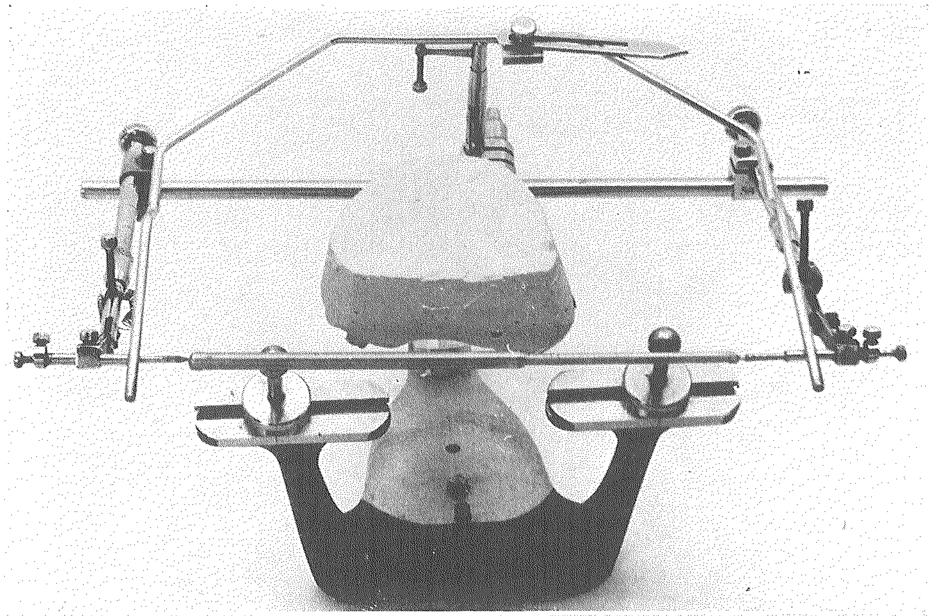

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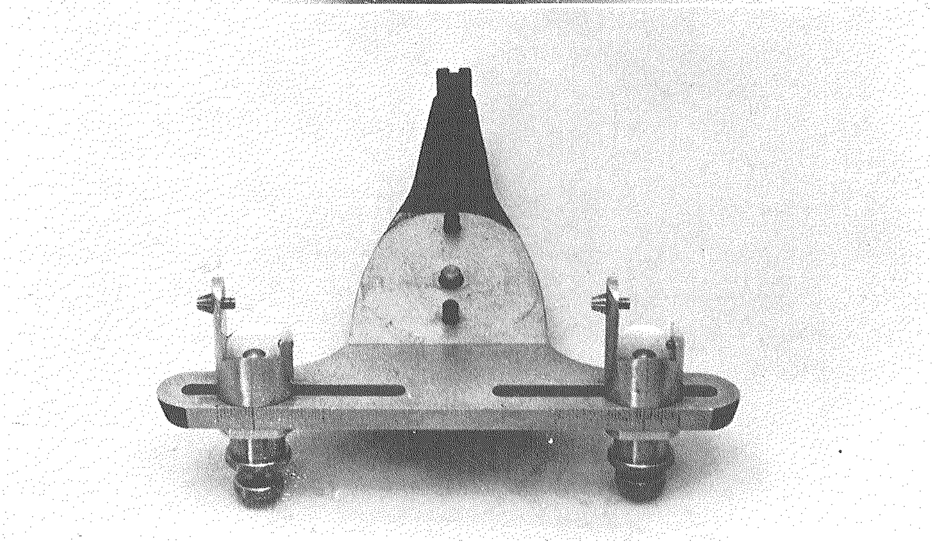
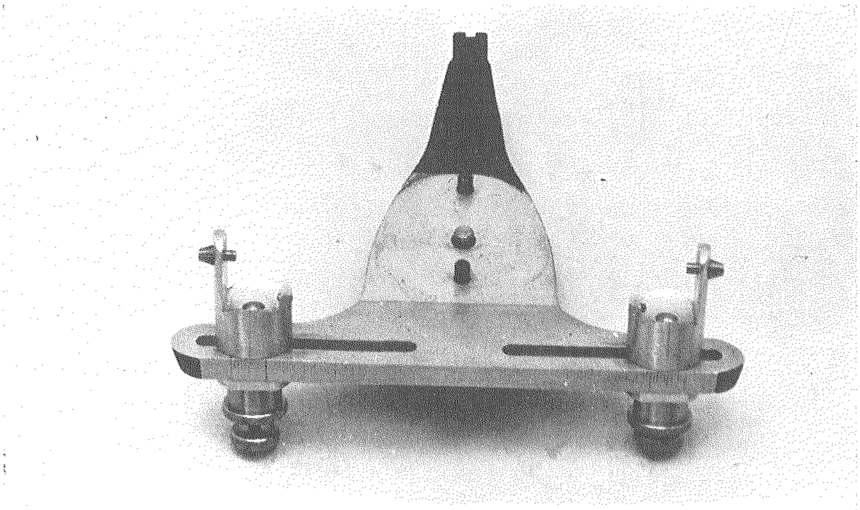


Fig. 377. The intercondylar distance-setting gauge is in position to measure the distance between the transfer bow points.
Fig. 378. The condyle paths are removed from the upper bow in preparation for mounting the upper cast.

The condyle paths (not the assemblies) are removed from the upper bow (Fig. 378). The assemblies are rotated about their longitudinal axis 180° so that the terminal hinge abutments are facing directly outward (Fig. 379). Set the condylar assemblies to the reading obtained by the intercondylar distance setting gauge, replace the incisal guide pin with the axis-orbital rest, and position



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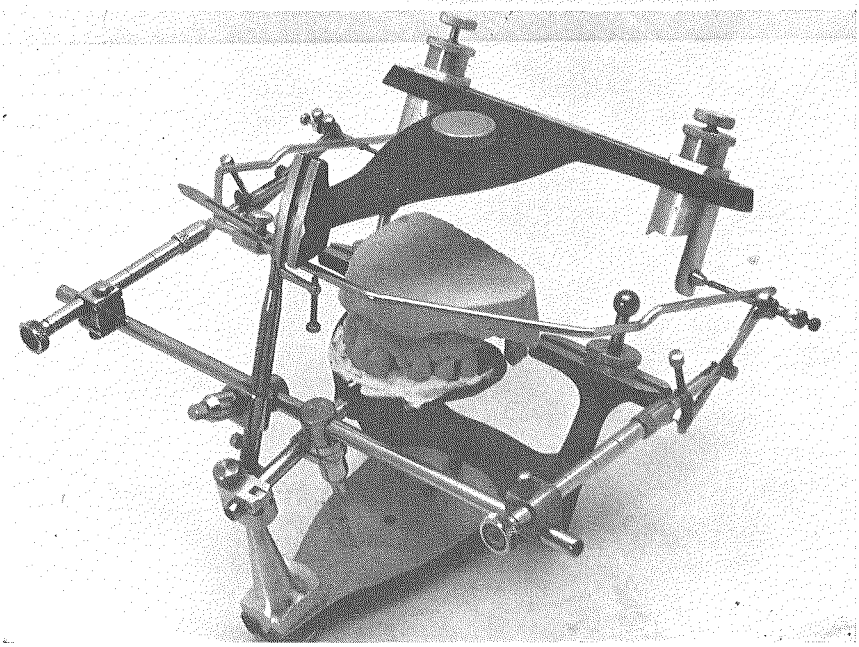

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Fig. 379. The assemblies are rotated so that the terminal hinge abutments are facing outward. The assemblies have been set to the readings obtained from the intercondylar distance-setting gauge.
Fig. 380. The axis-orbital rest is positioned on the upper bow. The upper bow is placed on the transfer bow.

the upper bow on the face-bow (Fig. 380). The upper bow is quickly and accurately related to the transfer bow. Any movement of the transfer bow must take the articulator bow with it, thus maintaining a constant relation.

The upper cast can now be positioned in the face-bow fork indentations and attached to the upper bow of the articulator.

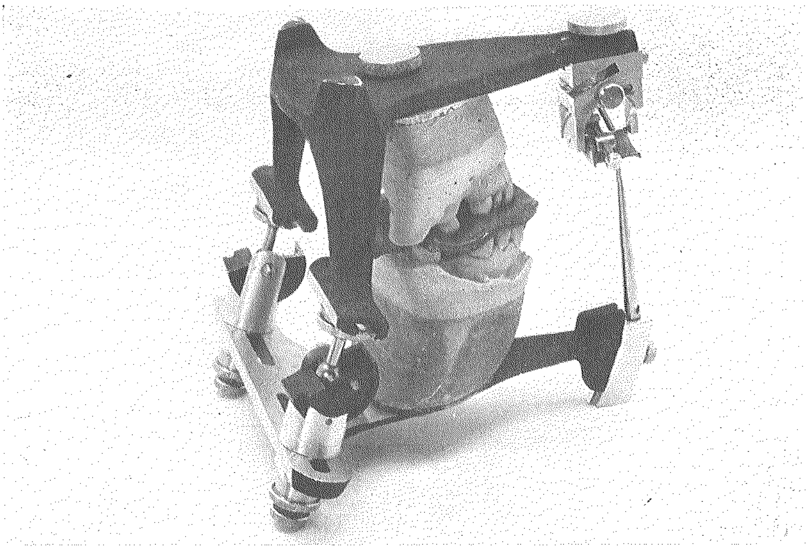


Fig. 381. The lower cast has been related to the upper cast by means of a centric interocclusal record.

After the stone sets, the upper bow of the articulator is removed from the face-bow. The incisal pin replaces the axis-orbital rest; the incisal table replaces the mounting post. Rotate the condylar assemblies back to their normal position, replace the condylar paths, and set at 45°. Reassemble the articulator by placing the upper bow on the lower bow and adjust the intercondylar distance to 55 on each side, both upper and lower.

By means of a centric relation record, the lower cast is attached to the lower frame of the articulator (Fig. 381).

CONSTRUCTION OF CHECKBITE CLUTCHES

Clutches especially designed for checkbites are necessary to secure proper registrations. These can be constructed of self-curing plastic (tray type) on the mounted study casts.

Relief of casts

The casts are prepared for clutch construction by relieving the buccal and lingual surfaces of the teeth with one layer of baseplate wax. The palatal and lingual areas of the casts are blocked out with modeling compound up to *one third* of the height of the teeth. The casts are soaked in water for lubrication.

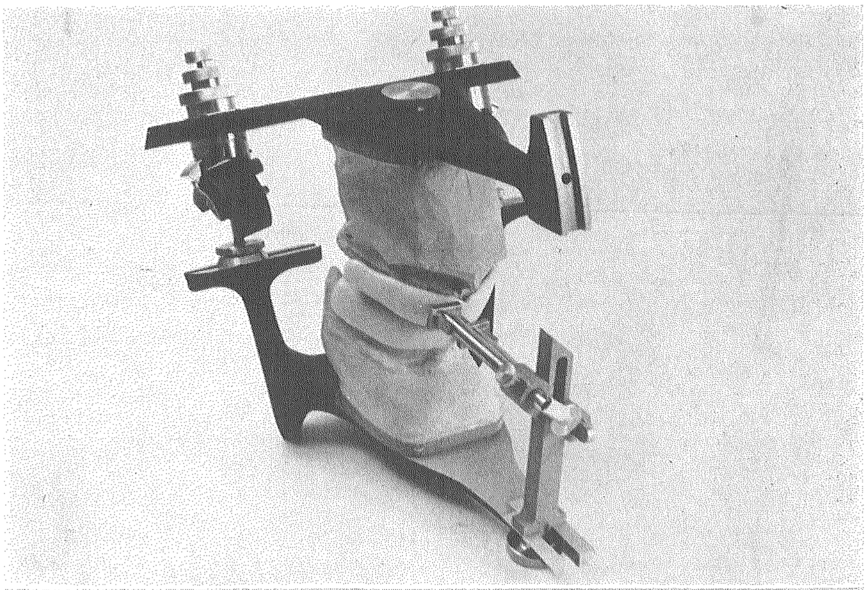
Placement of checkbite plates

The self-curing plastic is adapted to the upper cast, covering the wax relief and the exposed occlusal and incisal surfaces. The maxillary clutch central bearing plate is imbedded in the soft plastic, and the surface of the plate is made even with the occlusal surfaces of the teeth. When the plastic is hard, the maxillary cast and clutch are placed on the articulator.

The mandibular cast is now placed on the articulator and adapted with self-curing plastic. The mandibular clutch central bearing plate is positioned in the soft plastic, and the surface of the plate is made level with the teeth. While the plastic is still flexible, the clutch spacing template is placed in position, and the articulator is closed until the lower clutch plate is parallel to the positioned upper clutch plate. The stylus is placed on the mandibular clutch bearing plate and set to maintain the space established by the spacing template.

Placement of studs

To place the studs on the clutches, the incisal table is replaced with the stud-setting post and the incisal guide pin is removed. The stud-setting post



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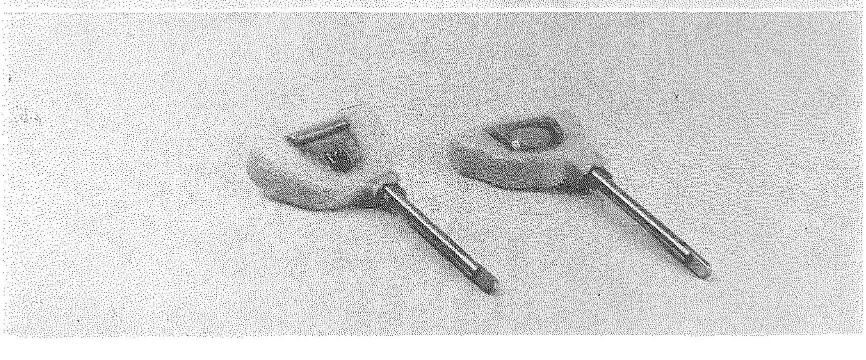

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Fig. 382. The stud-setting post properly spaces and securely holds the studs in place for attachment to the clutches.
Fig. 383. The clutches are trimmed and ready for the patient.

will hold the studs in proper position while they are being attached to the clutches (Fig. 382).

After the studs are fastened to the clutches, check to make sure that the bearing plates are securely attached. Then trim the clutches so that they will be comfortable for the patient (Fig. 383).

TAKING REGISTRATIONS

The first step in securing registrations is the location of the hinge axis (Fig. 384). This procedure is the same as the one described in Chapter 3.

After locating and marking the axis points and the axis-orbital point, remove the face-bow and prepare to secure the necessary checkbites.

The patient is guided into centric relation. Then the protrusive path is scribed by the patient moving freely forward from the centric position. Next, the right and left lateral excursions are made. Make sure that the patient gives the full lateral range. This is checked by repeated lateral excursions. In addition, it may be advisable to help the patient make the lateral excursion by placing the thumb on the side of the mandible and assisting the patient into each lateral excursion.

Now measure 5 mm. from the apex of the Gothic arch along the protrusive tracing and 7 mm. along each lateral tracing, marking these points. With a No. ½ round bur, make indentations on these three marks.

The surfaces of the clutches are lubricated, and the checkbites are taken.

The checkbites are made with accelerated stone. The time of setting is dependent upon the amount of accelerator and should be determined by the operator for each batch of material.

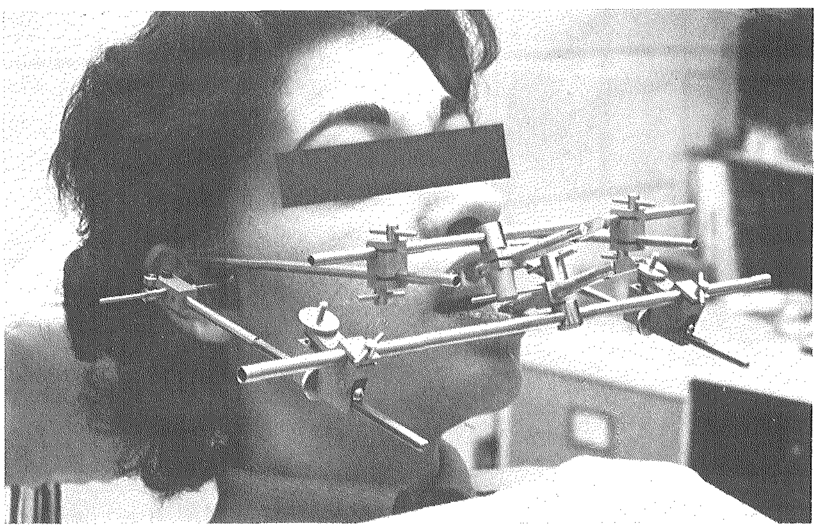


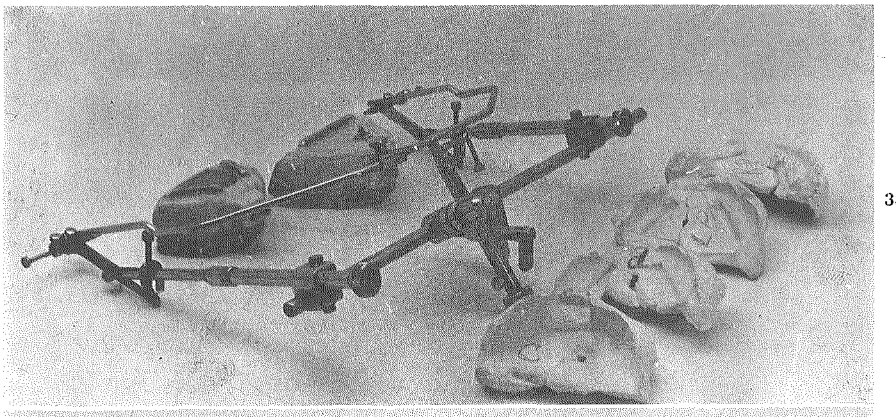
Fig. 384. The hinge axis is located by means of the De Pietro hinge-bow.

The patient is instructed to slide into the protrusive position until the stylus drops into the protrusive hole. While the patient holds this position, the accelerated stone is placed between the clutch plates with either a plaster gun or a plastic bag. When the stone has set, the protrusive checkbite is removed and marked.

The right and left lateral checkbites are obtained in a similar manner.

The patient now opens and closes the jaws in the centric relation position, and a centric relation checkbite is obtained.

Attach the maxillary clutch stud to the maxillary clutch and set the face-bow to transfer the clutch to the articulator in the proper relationship to the axis.



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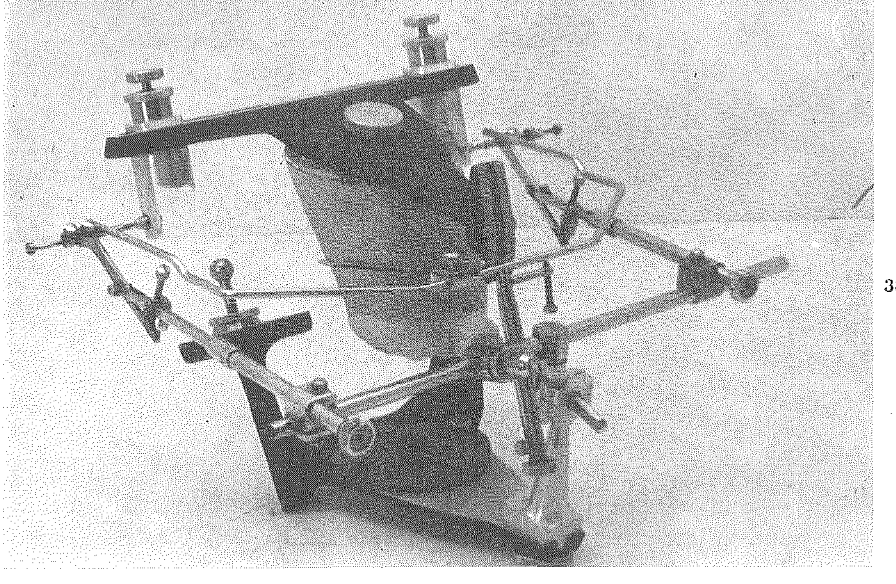

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Fig. 385. The clutches, transfer bow, and checkbites are ready for the articulator setting.
Fig. 386. The transfer bow relates the upper clutch to the upper bow of the articulator.

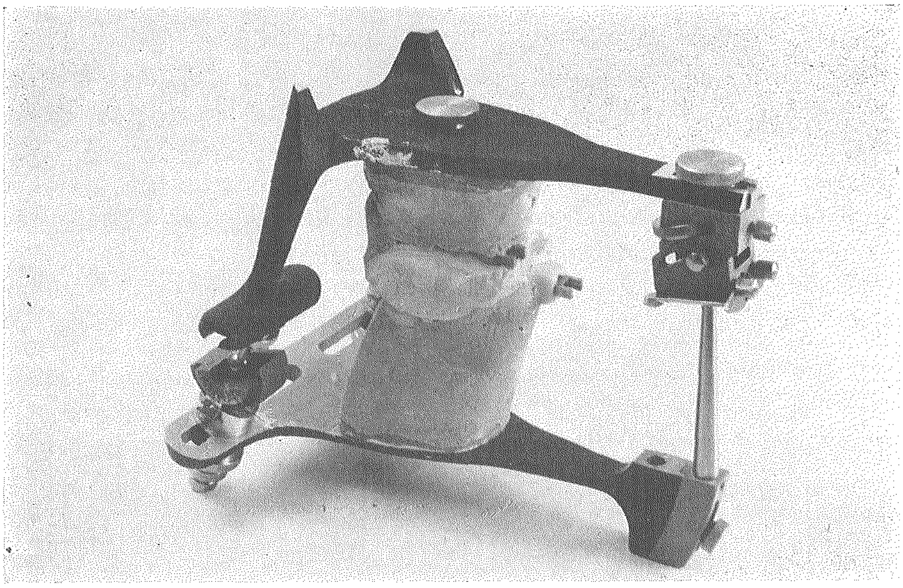

Fig. 387. The centric relation checkbite positions the lower clutch for attachment to the lower bow of the articulator.

All the precautions relative to a face-bow transfer (see Chapter 3) must be observed.

After all the records are secured (Fig. 385), the clutches are mounted on the articulator. This is accomplished by means of the transfer bow (Fig. 386) and the centric relation record (Fig. 387). These steps are exactly the same as those for mounting the study casts, described earlier in this chapter.

After the clutches are properly mounted to the centers of rotation of the articulator, the instrument can be adjusted.

SETTING ARTICULATOR

The incisal guide pin is removed from the upper bow, the condyle path inclination is set at 0°, and the Bennett lock screws are released.

Protrusive setting

Place the protrusive checkbite in position on the mandibular clutch (Fig. 388) and fit the upper bow into the checkbite. Release the condyle path inclination lock screw and adjust the path until the superior surface of the fossa contacts the condyle ball (Fig. 389).

Repeat this setting for the condyle path inclination of the other side (Fig. 390) and record these settings on the chart.

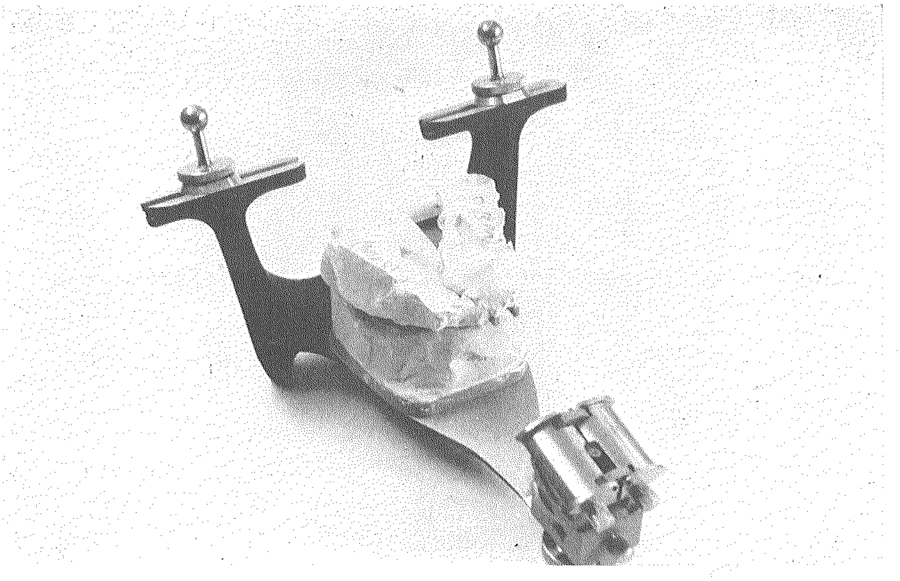

Fig. 388. The protrusive checkbite in position on the lower clutch.

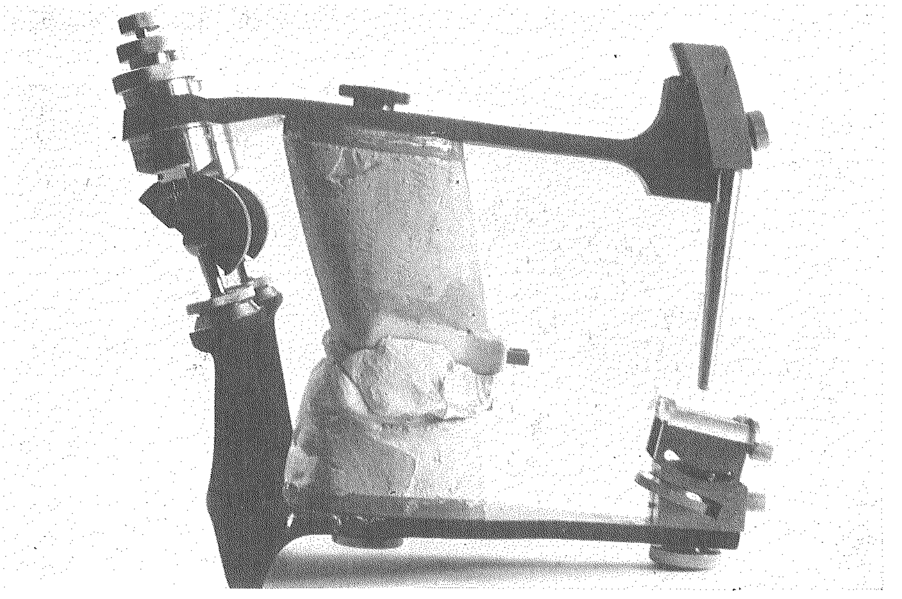

Fig. 389. Protrusive setting of the right condyle.

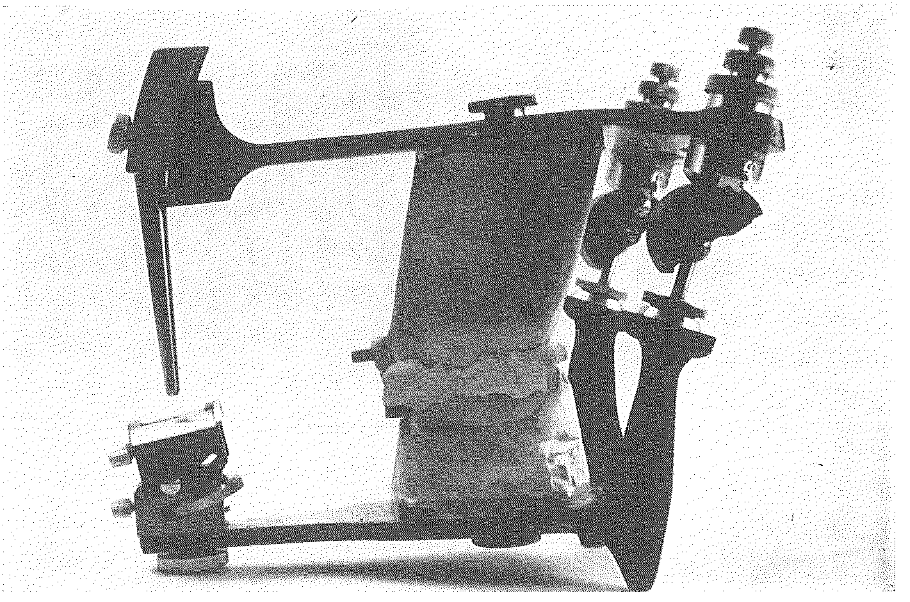

Fig. 390. Protrusive setting of the left condyle.

Left lateral setting

The Bennett lock screw on the right side of the articulator is released. The left lateral stone checkbite is placed in position (Fig. 391), and the upper bow of the articulator is adjusted so that the maxillary clutch fits snugly in place on the

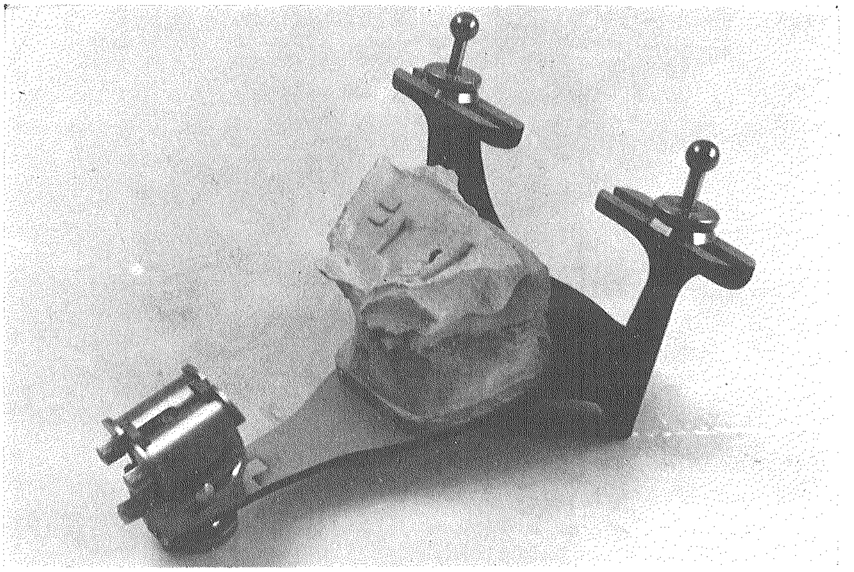

Fig. 391. The left lateral checkbite in position on the lower clutch.

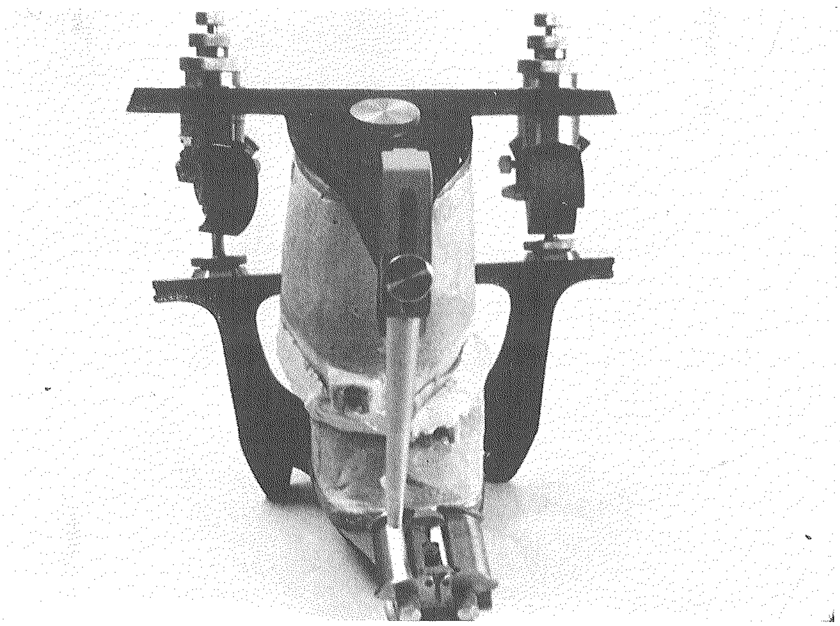

Fig. 392. Upper bow of the articulator placed in position on the left lateral checkbite.

checkbite (Fig. 392). With the left lateral checkbite positioned between the clutches, the left condyle ball is in the working position (retruded in the fossa), and the right condyle ball is in the balancing position (situated along the path of the fossa).

At this point, there may be several conditions apparent which will govern the adjustment.

If the clutches are seated in the checkbite and the working side condyle is contacting the superior and posterior surfaces of the fossa, no adjustment is made in the intercondylar distance at this time.

To check the seating of the ball in the fossa, pressure is applied in the region of the mounting plates. If it is not seated, the condylar assembly will display some movement.

If the clutches are seated in the checkbite, but the condyle ball is not contacting the fossa (Fig. 393), it will be necessary to change the intercondylar distance. The intercondylar distance must be increased in order to bring the ball into the fossa seat (Fig. 394). Be sure to maintain the centricity of the assembly by having the *exact* reading on the upper and lower members. If it is moved too far laterally, the clutches will become unseated from the checkbite.

If the intercondylar distance was too great at the start of the adjustment, the clutches will not seat accurately into the checkbite. This will require reducing the intercondylar distance by moving the upper and lower assemblies of that side medially.

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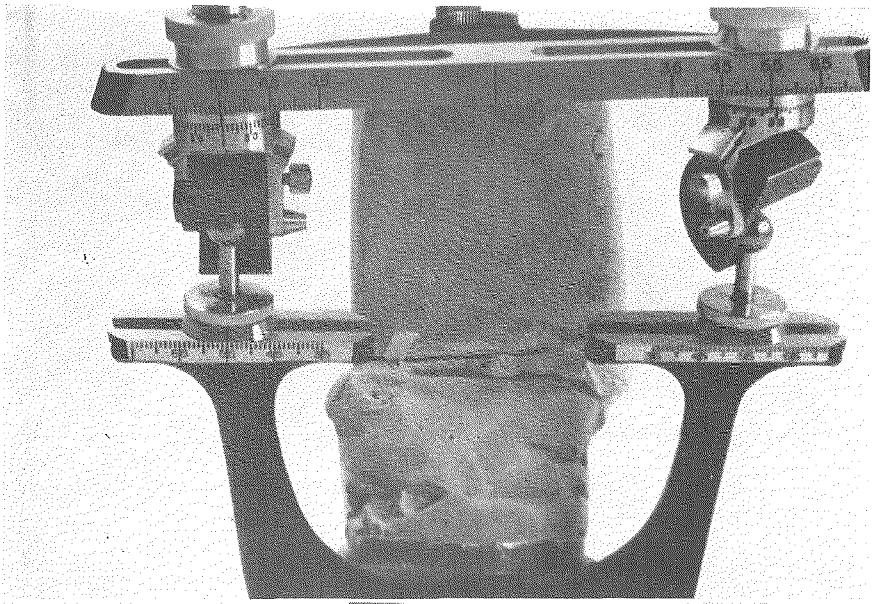

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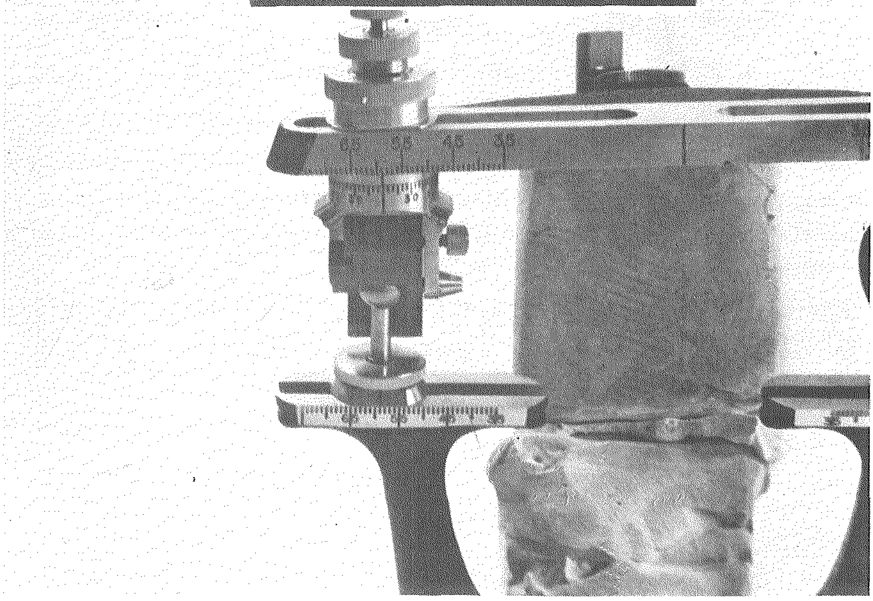
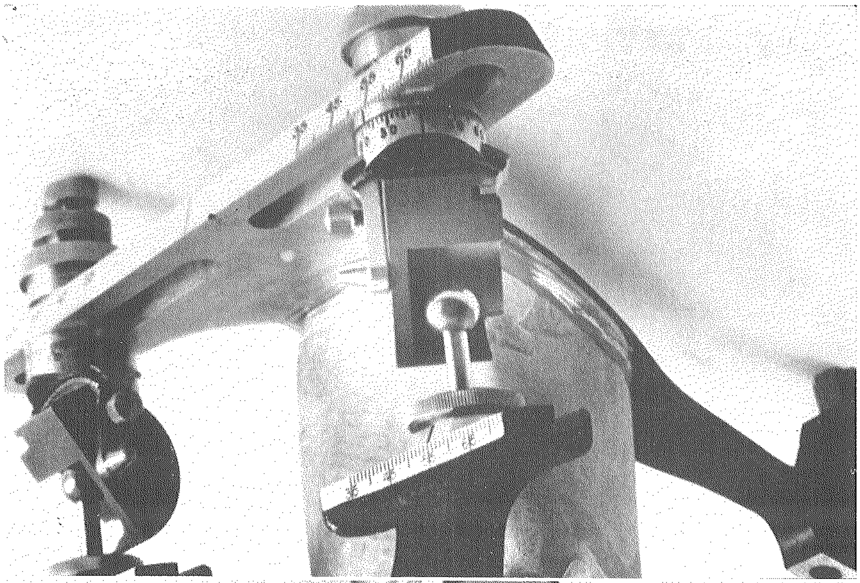


Fig. 393. The left condylar assembly in the neutral position of 55.
Fig. 394. The intercondylar distance is increased to 59 to bring the ball into the fossa seat.

If the clutches are securely seated in the checkbite, release the condyle path axis lock screw on the same side (in this instance, the right side). This permits the axis to be tilted. The condyle path Bennett lock (which allows rotation of the condyle path for the Bennett adjustment) is still free as a result of a previous manipulation (Fig. 395).



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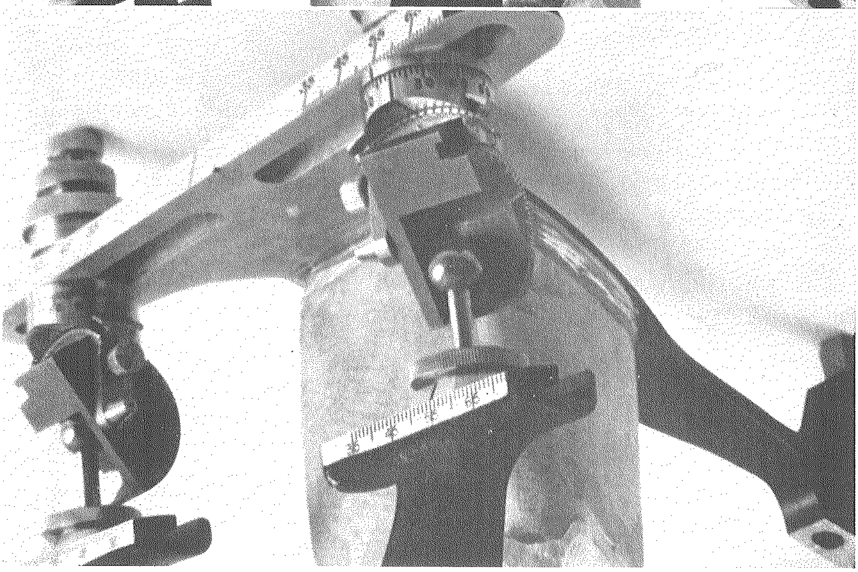

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Fig. 395. The Bennett lock is free as the result of a previous manipulation (right side or balancing side in this instance).
Fig. 396. The condyle ball contacts the medial surface of the fossa, setting the Bennett shift.

Rotate the condylar assembly until the ball contacts the medial surface of the fossa (Fig. 396) and at the same time tilt the assembly until the condyle ball contacts the superior surface of the fossa (Fig. 397). These adjustments must be made simultaneously as one tends to negate the other. After proper adjustment, the lock screws are tightened securely.

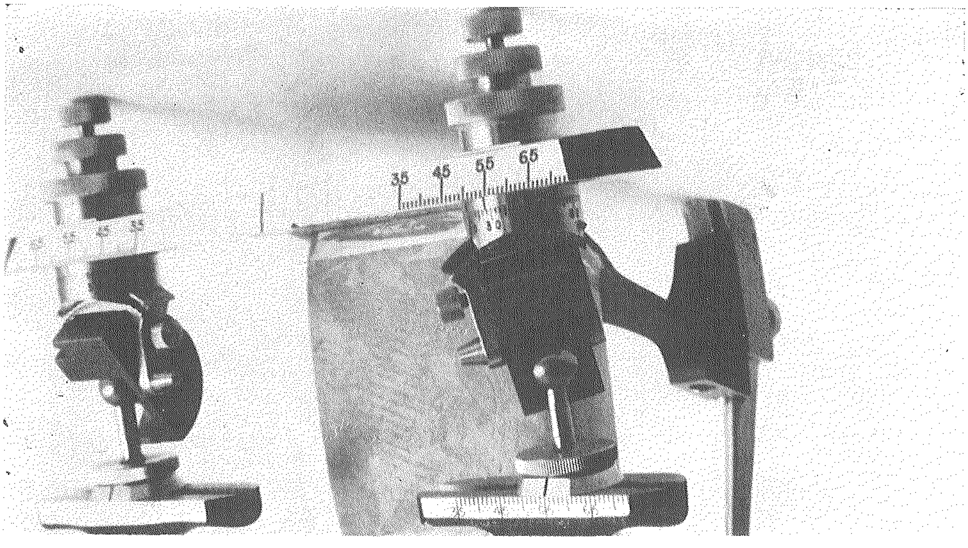

Fig. 397. The assembly is tilted until the condyle ball contacts the superior surface of the fossa, thus setting the axis tilt.

If the clutches are *not* accurately seated in the checkbite, it may be due to the present setting of the axis tilt. The Bennett lock is still open from the previous manipulations. Release the axis tilt lock and tilt the condylar assembly until the checkbite snugly accepts the clutches and the condyle ball contacts the superior surface of the fossa.

Rotate the condyle assembly until the ball contacts the medial surface of the fossa.

The axis tilt is now adjusted and also the Bennett setting. These adjustment locks are secured.

After making the balancing side adjustments, recheck the working side. Make certain that the checkbite fits snugly between the clutches and that the condyle ball makes contact with the superior and posterior surfaces of the fossa. The working side may have to be readjusted.

Right lateral setting

After releasing the Bennett lock screw, position the right lateral checkbite on the mandibular clutch (Fig. 398) and adjust the upper bow of the articulator so that it fits snugly into the checkbite (Fig. 399).

In the right lateral position, the working and balancing sides are reversed from the left lateral position so that now the right condyle ball is in the working position.

The procedure of adjusting the intercondylar distance is repeated for this excursion (Fig. 400). When the condyle ball is against the superior and posterior surfaces of the fossa of the working side, adjust the balancing side (other side).

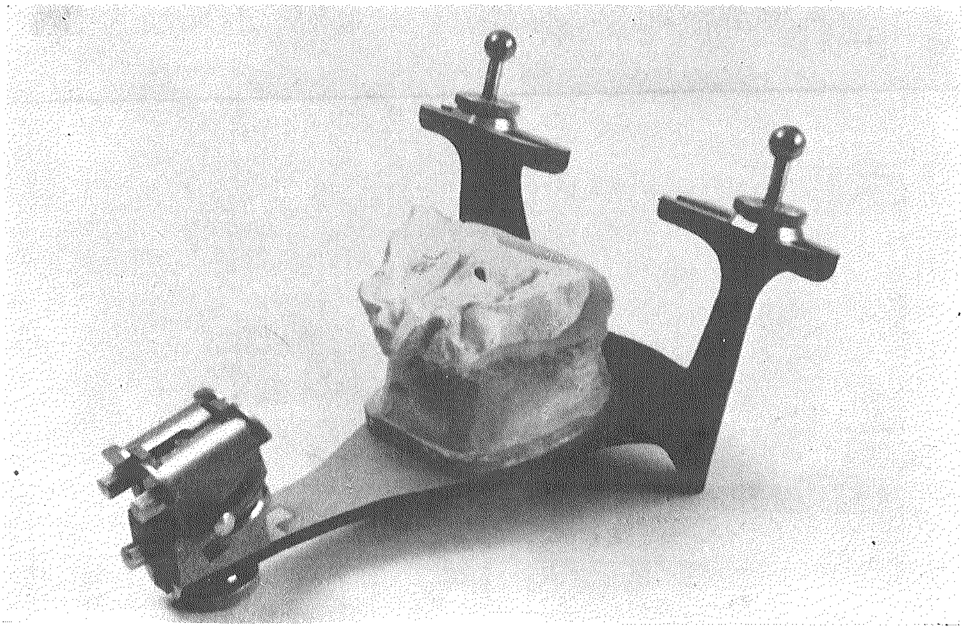

Fig. 398. Right lateral checkbite in position on the lower clutch.

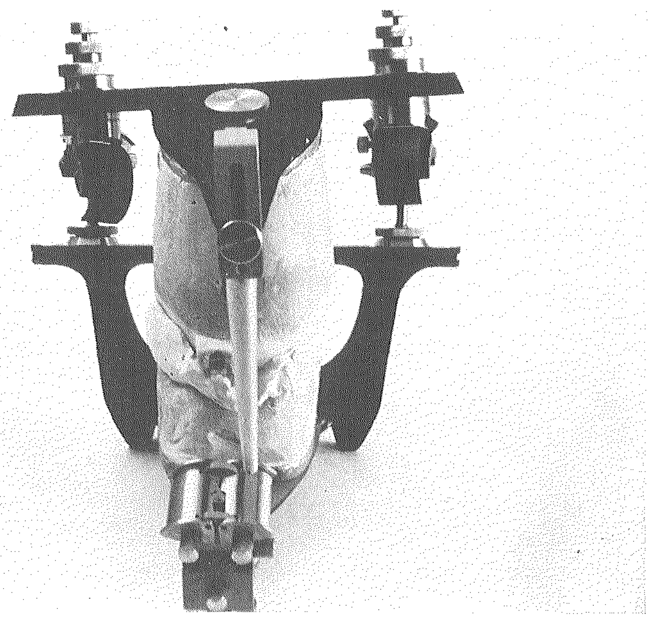

Fig. 399. Upper bow held in right lateral position by the right lateral checkbite.

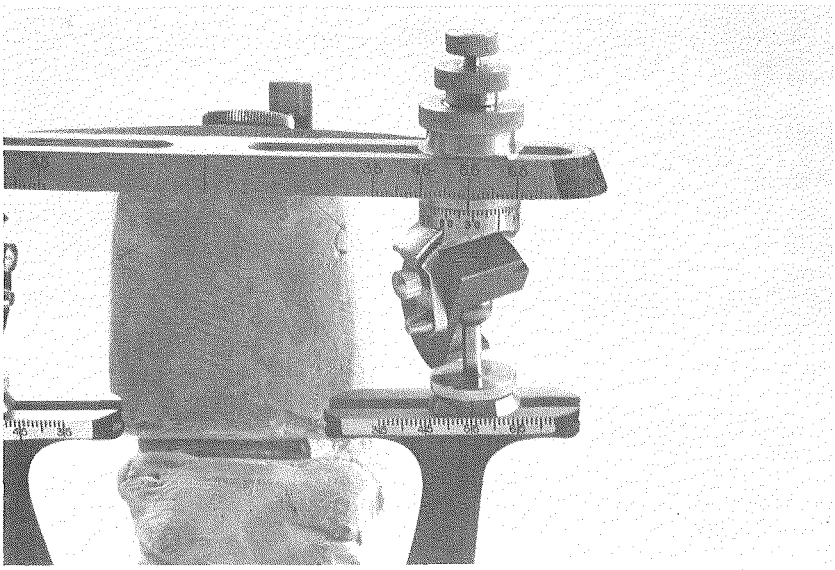

Fig. 400. The intercondylar distance for the right lateral checkbite does not need to be changed (working side on right side in this instance).

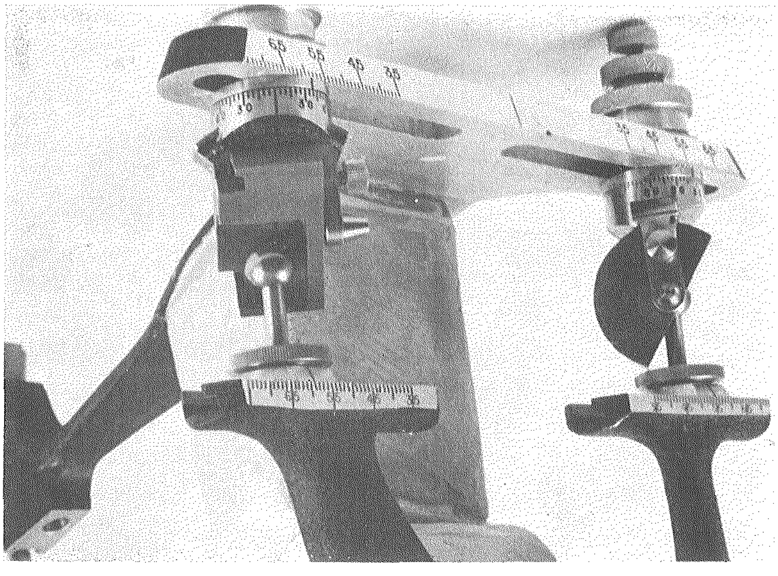

Fig. 401. The Bennett lock on the left side (permitting condyle assembly rotation) is free from the previous manipulation.

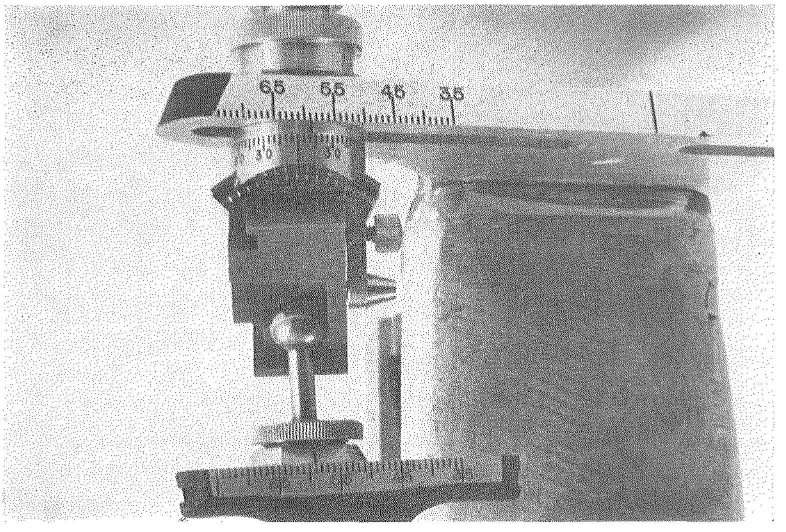

Fig. 402. The condyle assembly is rotated until the medial wall of the fossa contacts the condyle ball. This sets the amount of side shift. On this side there is no need to tilt the axis.

Tilt the condyle assembly at the same time that it is rotated (Fig. 401) until the ball makes contact with the superior surface of the fossa. Rotate the condyle assembly until the ball contacts the medial wall of the fossa (Fig. 402).

After this adjustment, recheck the working side condyle for accuracy of setting.

Now replace the right lateral checkbite with the left checkbite.

A careful examination should be made to determine whether the present settings still maintain the required contact with the condyle balls. It may be necessary to further refine the adjustments by repeating all the previous steps.

The settings are recorded on the chart.

CHAPTER 12

Principles of articulation

DEFINITION AND DISCUSSION

Articulation is the dynamic relationship of the surfaces of the teeth to their opponents during the chewing motions or simulated chewing motions.

Articulation with all its implications is the essence of dentistry, and an understanding of it is basic to every phase of dentistry. Improper articulation is responsible for a great many of periodontal involvements, denture failures, orthodontic collapses, and joint disturbances. The treatment and prevention of such conditions depend upon comprehension of and attention to all the principles of articulation.

To convey a clear picture of articulation is difficult, and sometimes it is advisable to proceed from a study of a malarticulation. A practical beginning is to describe what to look for in a set of teeth when one tries to determine whether good articulation is present. Following this, the various factors involved will be considered, noting how each affects the articulation.

In examining an articulation, it is essential to get the patient's lower jaw in centric relation (see Chapter 7). To do this, the patient must execute a terminal hinge closure. In rehearsing this movement with him, the practitioner must not permit the teeth to come together, and it is a good procedure to use the thumbnail as an anterior stop. When the patient is capable of executing a pure hinge closure, slowly and carefully retract the thumbnail until he contacts a tooth surface or until all the teeth come together evenly. This should occur in the most closed vertical dimension. If a tooth surface contacts before all the teeth are together, that tooth surface is in a premature relationship. If one watches carefully, he will notice a shifting of the mandible into an eccentric position as the rest of the teeth come together. This is malarticulation and has been referred to as the "eccentric slide."

The first requisite, then, of articulation is an even contact or interdigitation of the teeth as a terminal hinge closure is executed, this contact occurring when the jaws are closest together. There is, of course, a definite relationship of cusp to fossa in this position, but these details will be treated later in Chapter 13.

The next test for articulation is to observe one of the eccentric positions or, rather, the articulative path from the eccentric positions to centric relation.

Let us examine the straight protrusive excursion. In the ideal situation, the relationship is such that, as the posterior teeth (on both sides) have the tips of the lower buccal cusps in contact with the crests of the upper buccal cusps, the anterior teeth are in a tip-to-tip arrangement. This is very rare. Actually, in the correction of a malarticulation, the only time we strive for this relationship is when the anterior teeth are periodontally involved. Otherwise, the anterior teeth are in contact in the protrusive position without posterior tooth contact.

The next excursion to examine is the lateral protrusive. In this relationship, the buccal cusps on the side being examined are tip to tip, as are the lingual cusps. The posterior teeth on the opposite side are out of contact. The central, lateral, and cuspid teeth of the examined side are in contact.

In the lateral excursion, on the working side, the cusps of the teeth should pass each other without climbing on one another. The tips of the lower buccal cusps should ride in the sulci and marginal ridges between the upper teeth. The tips of the upper lingual cusps of the posterior teeth should travel in the sulci and marginal ridges of the lower posterior teeth. On the balancing side, the lingual cusps of the upper bicuspids should glide around the lower buccal cusps as the lingual cusps of the upper molars pass through the sulci of the lower buccal cusps of the molars, these cusps maintaining a balance without any displacement of the condyle on that side.

This description is of necessity very sketchy because the purpose here is simply to begin to paint a picture of the articulation. The details will be filled in later in Chapter 13.

FACTORS THAT DETERMINE ARTICULATION

Let us now examine the various factors that determine an articulation and note the effect of each.

Variation in cusp height and width

First to be considered is the reason for the steeper angulation—the increasing height—of the cusps as we go anteriorly in an arch.

In Fig. 403, we see a representation of a condyle path, *AB*. The center of rotation (the head of the condyle) travels from the beginning of the path to the end—from *A* to *B*. The occlusal contact sphere, *C′D′*, of the mandible is concomitant with the occlusal contact sphere, *CD*, of the maxillae in the centric relation. The occlusal contact sphere, *CD*, of the maxillae has a center, *A′*. In the protrusive position, the occlusal contact sphere of the mandible assumes the position *C′D′* because it is attached to the condyle which travels along the path *AB*. The upper and lower spheres contact posteriorly but are forced open

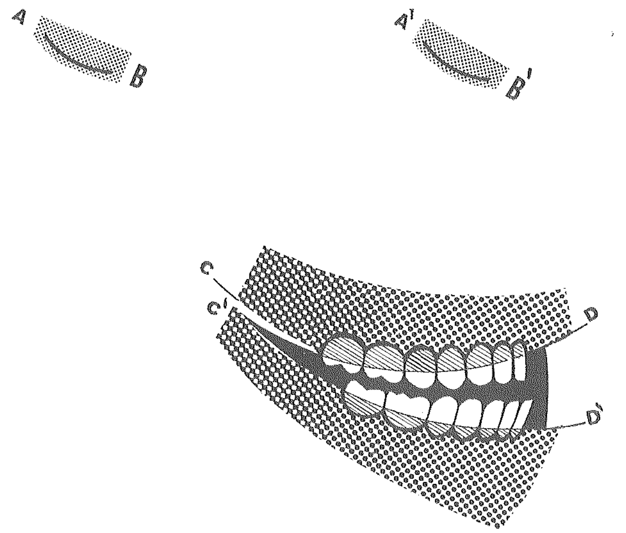

Fig. 403. A diagrammatic illustration of the reason for increasing the cusp heights from the second molar to the cuspid (see text).

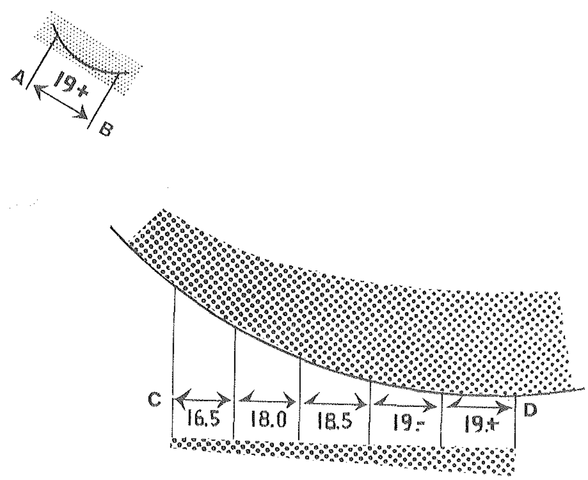

Fig. 404. A diagrammatic illustration of the reason for increasing the mesiodistal cusp widths from the second molar to the cuspid (see text).

anteriorly. Incidentally, the center of the mandibular sphere, *C'D'*, has now travelled to point *B'* in the protrusive position. *A'B'* is parallel to *AB*.

As indicated by this diagram, if a simultaneous contact in the eccentric positions is maintained, it is necessary to have cusps of increasing height (angulation) as we go forward. Actually, the drawing exaggerates the point, for the conditions are modified by other factors of articulation such as the anterior guidance, the curve of Spee, and the plane of occlusion. These will be discussed presently.

In addition to an increase in the cusp height or angulation as we go forward in an arch, there is also an increase in the mesiodistal width of the cusps. This is so because the long axes of the upper teeth are more or less vertical, whereas their occlusal surfaces are on a curved surface. The distance travelled by the lower teeth in relation to the upper teeth is governed by the condyle path. Since the teeth, mandible, and condyles together form one unit, they must travel the same distance. Fig. 404, shows why a given distance travelled on a curve (the condyle path, *AB*) shows variations when measured along a straight line, *CD*. This is why the mesiodistal cusp widths must increase as we go forward if there are to be simultaneous contacts in the various excursions.

Relation of maxillae and mandible

The next factor that must be considered is the relative *size* and *relationship* of the mandible and maxillae. There may be a lack of harmony between these structures which will make for an abnormal relationship of the teeth. If the mandible is larger than the maxillae, there may be a cross-bite relationship with the anterior teeth edge to edge. The maxillae may be much larger than the mandible, as in the case of the "chinless" patient. Or, there may be a combination of these discrepancies which will produce any number of abnormalities. In the treatment of such malarticulations, practical compromises will be necessary. Consequently, these patients require considerable judgment.

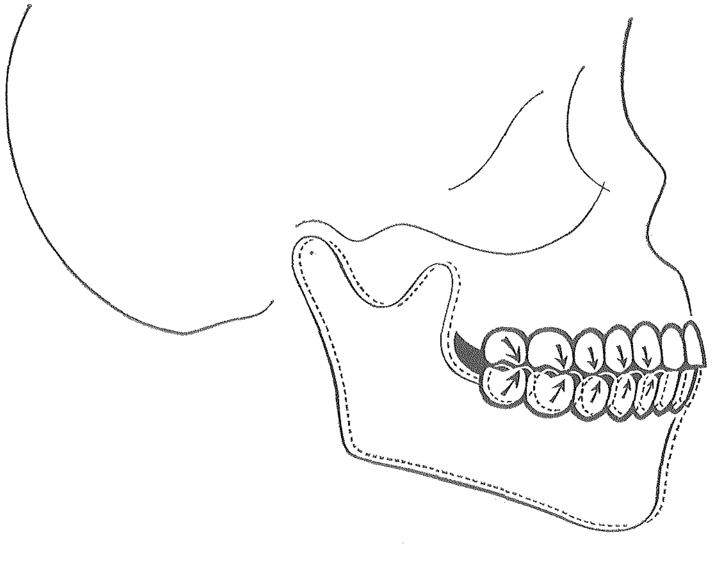

Fig. 405. The effect of incorrect centric relation (missing the bite). These teeth are traumatic in the eccentric excursions as well as in the terminal hinge closure.

Centric relation

The effect of an incorrect centric relation has already been touched upon (Fig. 405). Unless this starting point is properly established, nothing else about an articulation can be correct—hence its importance. Without a proper centric relation, none of the tooth surfaces can be in harmony with the lateral or eccentric movements. Remember that the mandible operates on the hinge axis in each of its positions. Therefore, if the true center of rotation is not located, none of the arcs of closure in any position can be correct. If the teeth do not mesh when the mandible is in centric relation, destructive lateral forces will be set up which will cause damage to the investing structures of the teeth. Proper coordination of the articulating surfaces of the teeth to the closing axis of the jaws will prevent premature wear of the cutting edges of these surfaces.

Hinge axis

The effect of the hinge axis on articulation is very closely allied to centric relation. The one cannot exist without the other. The hinge axis can be located only in the terminal hinge position, which is an important part of centric relation. The opening and closing component of centric relation is related by freezing the terminal hinge action at a convenient level or vertical dimension. If one accurately locates the centers of lateral motion but errs in the location of the hinge axis, the articulation will be out of harmony. The arcs of vertical rotation in the eccentric relations will not be harmonious with the patient's arcs, and lateral stresses will be created. In other words, failure to make use of the hinge

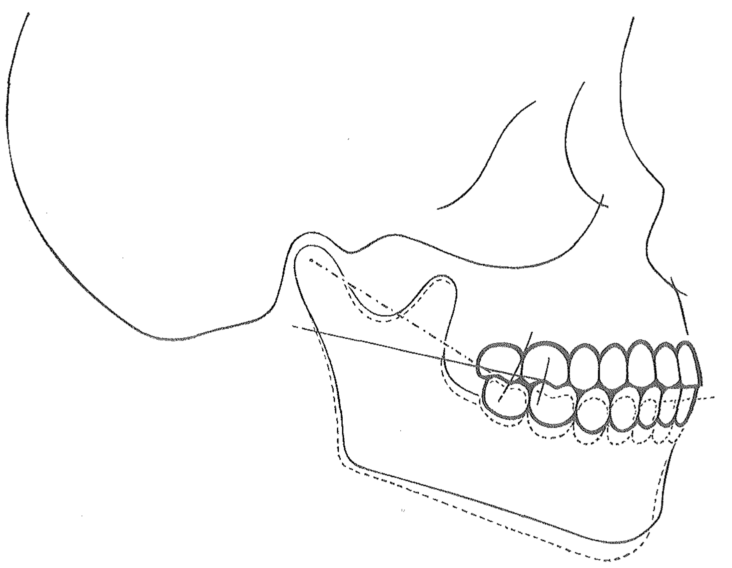

Fig. 406. Restorations (solid dark lines) that are not constructed to the patient's axis will not come together when their closure is governed by the patient's axis (broken lines). The patient cannot close his teeth properly.

axis in an articulation will have the same effect as "missing the bite" (Fig. 406). The forces of articulation will be in a lateral pattern and destructive.

Curvature of condyle path

The curvature of the condyle path is another fixed factor of articulation, for it is necessary to record the condyle path in order to be able to produce an accurate articulation. The curvature of the straight protrusive path may differ from that of the lateral path. The effect of the curvature is evident in the important contacting surfaces located between the extremes of the centric and the eccentric positions (Fig. 407). It is most evident in the balancing side contacts because

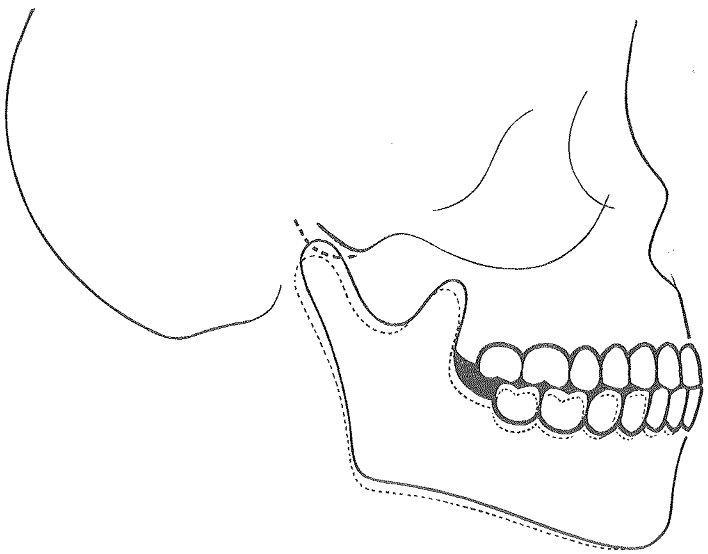

Fig. 407. The *curvature* of the condyle path has an effect on the contacting surfaces between the extremes of centric relation and eccentric relations.

in this excursion the condyle travels along the curvature. The type of curvature may vary from a straight path to one having the curvature of a circle with a ⅝-inch radius. The amount and type of separation in the posterior segment of an articulation depend upon this curvature. To establish an equal contact during the travel of the condyle along this path, it is necessary to have an accurate reproduction of the curvature of the path. Frequently, because the curvature cannot be changed, it is necessary to alter some of the related factors of articulation, such as the plane of orientation and the curve of Spee, in order to arrive more readily at an acceptable articulation.

Inclination of condyle path

The inclination of the condyle path has a somewhat similar effect as the curvature on the posterior segment of the articulation when all the other factors

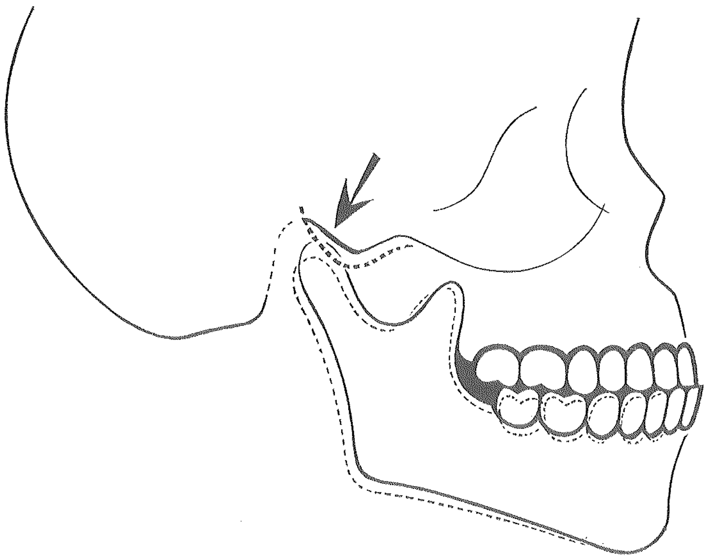

Fig. 408. The *inclination* of the condyle path has an effect on the contacting surfaces at the extremes of articulation.

remain the same (Fig. 408). The difference between the curvature and the slant lies in the areas affected. Whereas the curvature has its greatest effect on the in-between areas of function, the slant has more of an effect on the extremes of the articulating contacts.

An incorrect curvature may return the mandibular teeth to the correct contact at the extreme of function although there are misses in-between, whereas an incorrect slant will separate the areas to a greater extent all along the path. Of course, the reverse may also be true; i.e., it may bring the areas into too severe a contact too soon. In other words, disregarding a lower degree of slant in establishing an articulation will cause premature contacts in the posterior part of the articulation.

Bennett movement

The most important factor to be considered in the articulation of teeth is the Bennett movement. This is described in Chapter 2. Briefly, however, it is the side shift of the mandible in the posterior region as the patient goes into a working occlusion (Fig. 409). It is the movement that is responsible for the lateral chewing stroke and, as such, is the movement during which the greatest amount of lateral force is generated. For this reason, it is extremely important that the articulating surfaces are in strict harmony with this side shift. Any discrepancy in this harmony will result in the most destructive lateral forces encountered in a malarticulation.

The effect of disregarding a patient's Bennett movement is more readily dis-

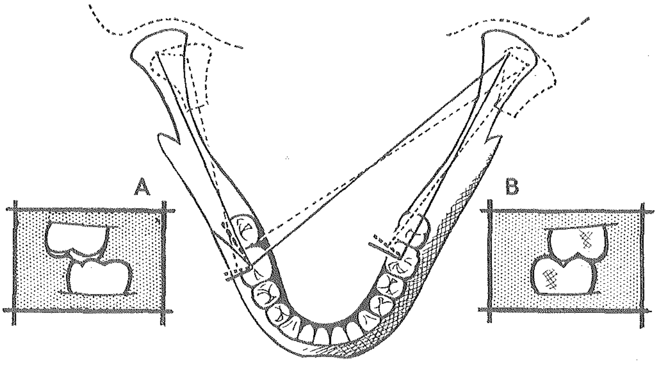

Fig. 409. The effect of the lateral shift of the centers of lateral movement. Note how this shift determines the mesiodistal relation of the paths of travel of the cusps in the various areas.

cernible on the balancing side because the path between the distobuccal and distal cusps of the lower molars is more nearly at right angle to the path of the laterally moving center of rotation on the opposite side. The greatest destruction, however, is evidenced on the working side because the greatest amount of chewing force is exerted in this relation. Unless the cusps have an exact relationship to the marginal ridges and sulci of their opposing teeth, the forces will be of a destructive, lateral nature. Even slight variations will make a tremendous difference in the forces transmitted to the supporting structure.

To phrase it in another way, the Bennett path influences the position of the cusps in their mesiodistal relation to each other on the working side. On the balancing side, the Bennett path influences the height of the cusps as well as their position.

It is important, then, to record the path of the Bennett movement and arrange the cusps of the teeth so that they can pass each other without clashing or climbing upon each other during function. At the same time, we want to maintain a continuous contact of these surfaces in order that they can efficiently perform their function of chewing without damage to the supporting structure.

Thus far, we have considered the so-called "fixed" factors of articulation, pointing out their effect on an articulation. These factors cannot be changed. They cannot be ignored. They are peculiar to each patient and, as such, must be taken into account if we are to observe and study the prevailing circumstances with the intent of correcting them if they are not harmonious. These factors must be considered as carefully as the teeth themselves or the ridges on which the restorations are to be made. Just as great attention is paid to the prepared tooth when it is to be restored, so is equal attention paid to the fixed factors of articulation.

Let us now consider those factors of articulation which are not immutable—those over which we have some degree of control.

Axis-orbital plane

The axis-orbital plane is a plane of reference established by the two hinge axis points posteriorly and a point at the floor of the right orbit (Fig. 410). It is selected as a reference plane because it is nearly horizontal when the patient is erect. When the axis-orbital plane on the articulator corresponds to the axis-orbital plane of the patient, the exact relations of the condyle path, teeth, etc., as they exist in the patient's mouth (Figs. 411 to 413), are obtained.

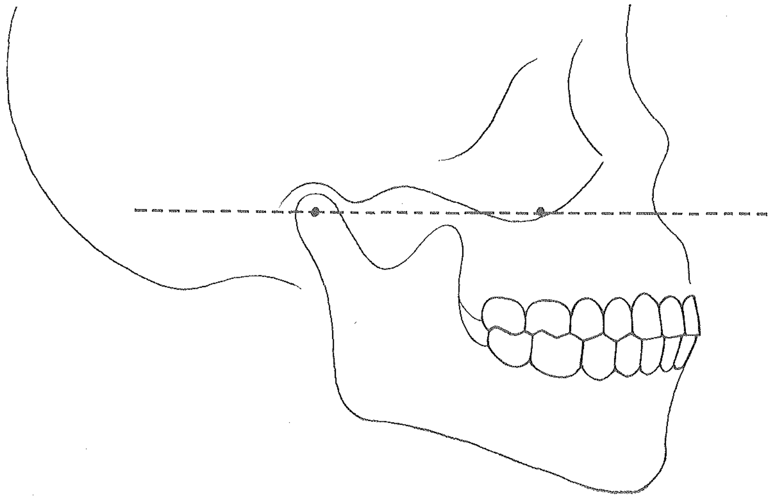

Fig. 410. The axis-orbital plane is determined by the two hinge axis points and a third arbitrary point, the infraorbital notch.

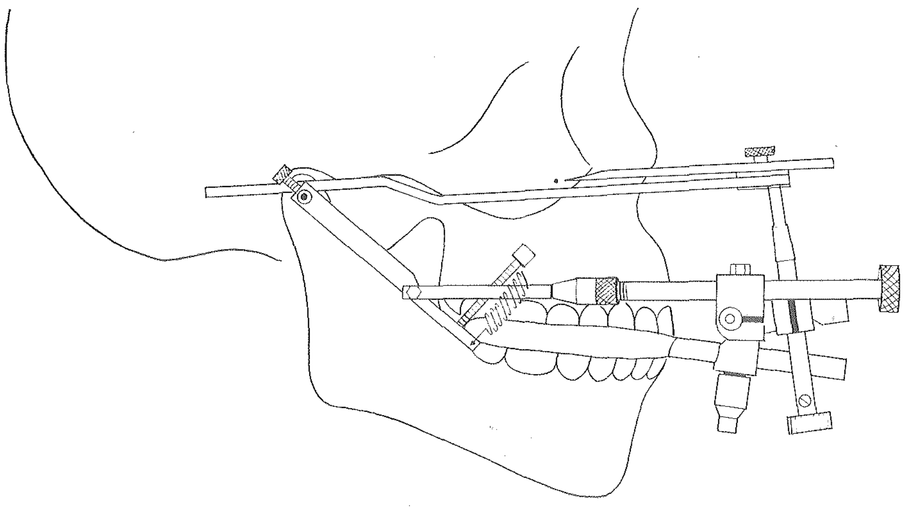

Fig. 411. The transfer bow in position with the axis-orbital plane indicator adjusted to the three landmarks.

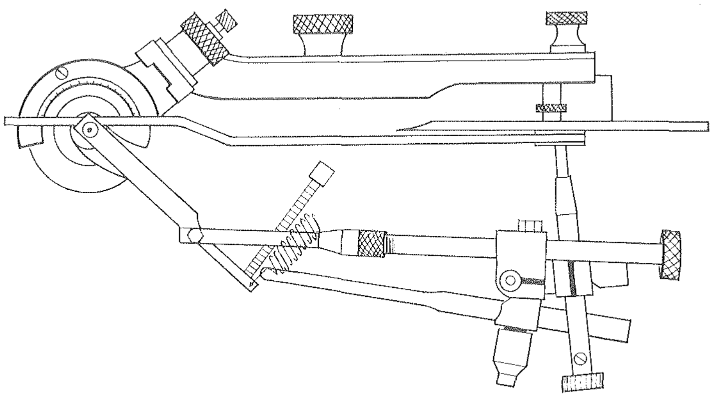

Fig. 412. The transfer bow relates the upper cast (restorations or denture) to the upper bow of the articulator. The axis-orbital indicator makes the upper bow parallel to the axis-orbital plane.

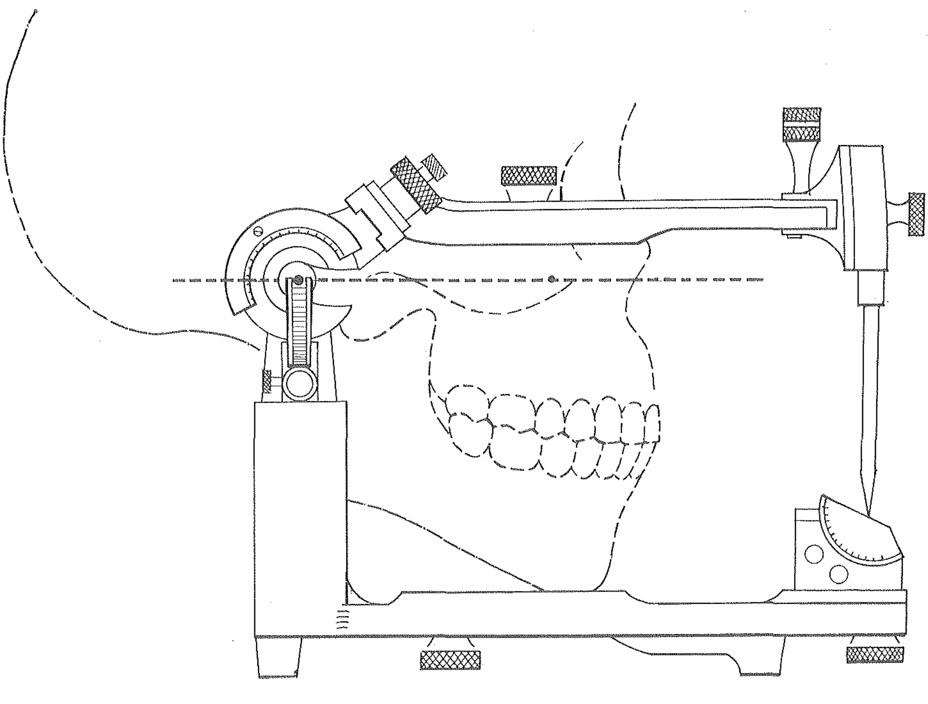

Fig. 413. A composite drawing showing the relation of the axis-orbital plane of the patient to the articulator. Note that the upper bow is parallel to the plane, that the condyle path of the articulator coincides with the condyle path of the patient, and that both are in a definite relationship with the axis-orbital plane.

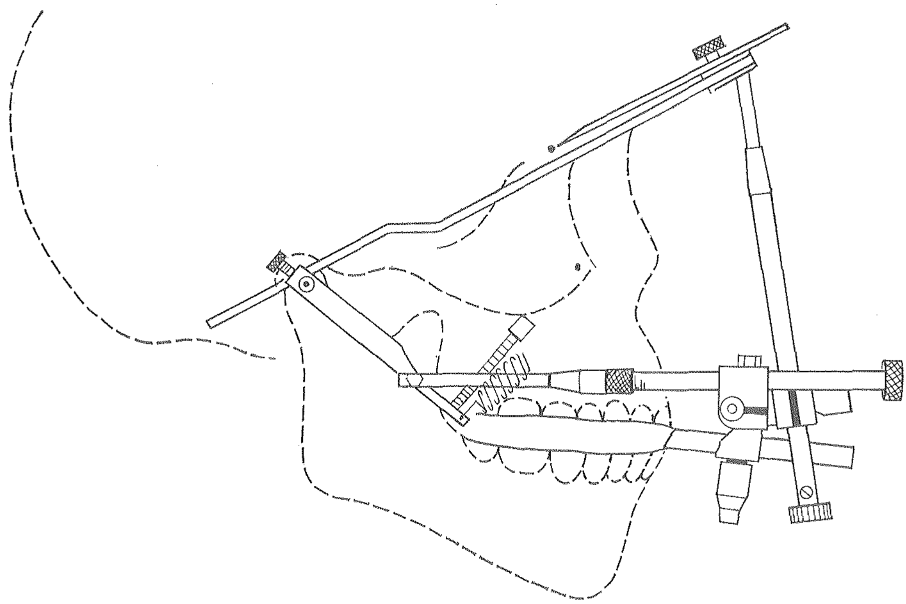

Fig. 414. The third point of the axis-orbital plane is arbitrary and can be selected anywhere. As explained in the text, there are good reasons for using the infraorbital notch.

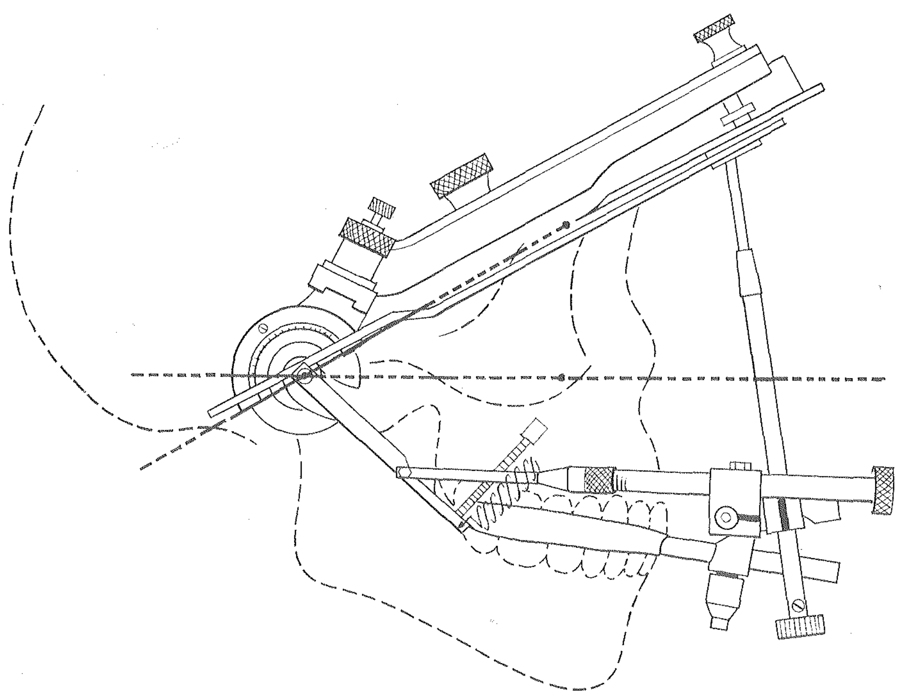

Fig. 415. The relation of the upper bow to the selected plane is maintained parallel by the design of the instruments used.

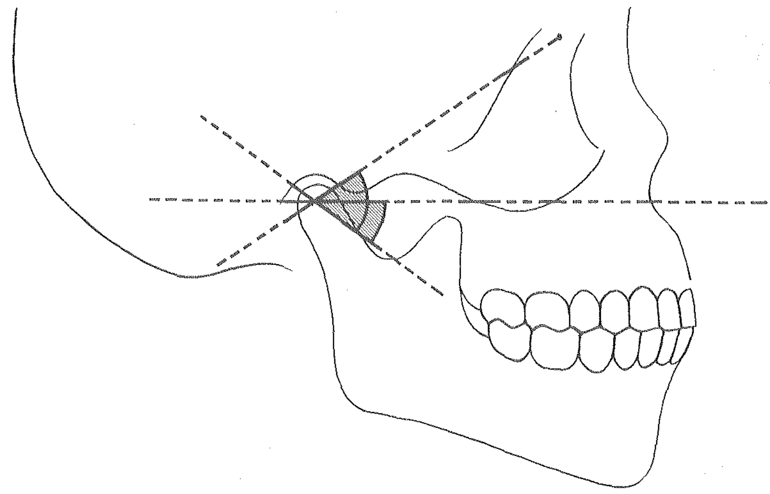

Fig. 416. Note that the patient's condyle path has two entirely different inclinations when another plane of reference is used. It is important to permanently mark this third point of reference and always refer to the same plane in order that the records are constant when used again.

This plane of reference is the base line for the recording of condylar inclinations (Figs. 414 to 416). When a condyle path is said to have a 30° inclination, it is in reference to this plane. By having the axis-orbital plane permanently marked on the patient, it is possible to make subsequent mountings of working casts, restorations, or follow-up models with the assurance that, when the articulator is reset from the record card, it will be exactly the same as when first set. Unless the models were related to a plane of reference, the subsequent articulator settings would be correct only by accident.

The axis-orbital plane is of tremendous help in diagnosis and treatment. The inclination of the long axis of a tooth on a cast means something if the casts are accurately oriented. If the axis-orbital plane is used properly, the correct plane of occlusion may be established—and altered if necessary in order to improve the articulation.

Plane of occlusion

The plane of occlusion is sometimes defined as an imaginary plane which rests on the tips of the lower cuspids and the crests of the distobuccal cusps of the lower second molars. It is convenient to use as a means of orienting the teeth in the skull or the articulator.

In practical treatment involving natural teeth, there is a certain degree of control over the plane of occlusion. By preparing the teeth and planning the restorations, one can within certain limits raise or lower the plane of occlusion in, say, the posterior region. The amount of change which can be imposed, of course, is circumscribed by the position of the teeth and the relation of the

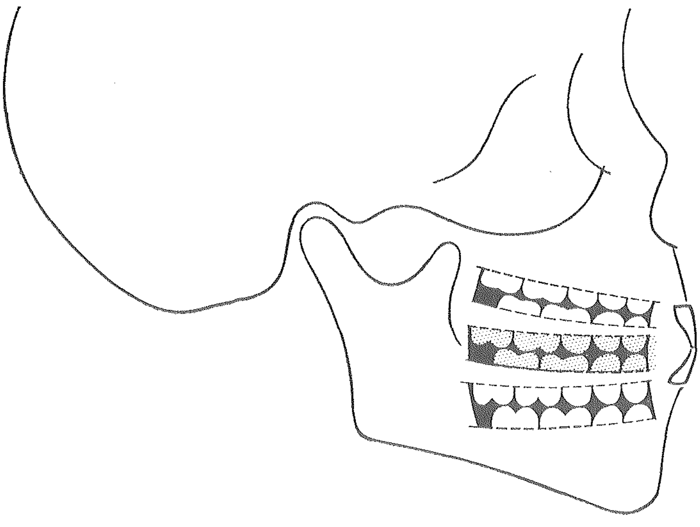

Fig. 417. The relation of the plane of occlusion to the condyle path has an effect on the angulation of the cusps required to maintain a simultaneous contact. The more parallel the plane of occlusion is to the condyle path, the flatter will be the cusps.

pulps to the plane of occlusion. Sometimes it becomes necessary to sacrifice a pulp or a tooth in order to obtain a better relation of the cusps in an articulation. To a certain extent, then, the plane of occlusion is one of the factors of articulation over which we can exert limited control.

In full denture construction, there is considerably more control over the plane of occlusion. As the occlusal plane approaches parallelism with the condyle path, the average cusp height decreases. The greater the angle between the occlusal plane and the condyle path, the steeper are the cusps (Fig. 417).

Curve of Spee

The teeth are not set on the plane of occlusion, but rather on a curve—the curve of Spee. Variations in the curve of Spee have an effect on the relative heights of the cusps to each other. In other words, for a given plane of occlusion there is an average cusp height. Changes in the relative heights of the cusps to each other can be brought about by changing the radius of the curve of Spee—making the curve sharper or flatter (Figs. 418 and 419).

By judicious use of these two factors—the curve of Spee and its chord, the plane of occlusion, a variety of cusp heights can be produced. The amount of change possible in a restoration involving natural teeth is limited by the tooth position and the relation of the pulps. In artificial dentitions, however, there is considerable leeway.

What are some of the conditions which would dictate taking advantage of these two practically controllable factors of articulation?

In a given patient there is a certain condylar inclination and curvature. (For

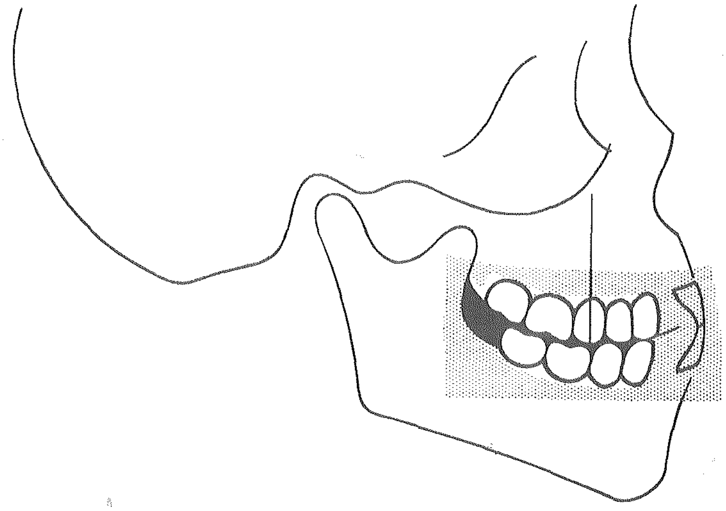

Fig. 418. An abrupt (short radius) curve of Spee requires abnormally flat cusps posteriorly and abnormally steep cusps anteriorly.

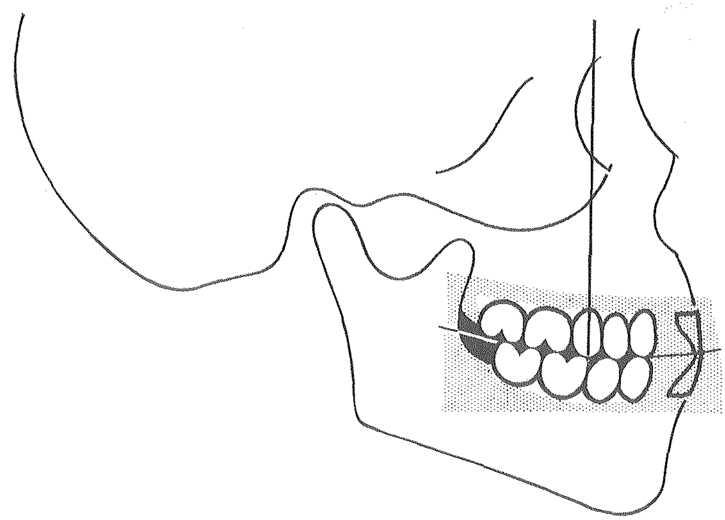

Fig. 419. A flat (longer radius) curve of Spee requires steep cusps posteriorly, which is not a normal condition for a healthy mouth.

the purpose of simplification, we will not consider this example in the three dimensions.) There is a given anterior guidance. This factor will be discussed later, but for the present example let us say that the anterior guidance cannot be altered. The teeth are positioned in a certain occlusal plane and with a particular curve of Spee. In other words, all the factors of articulation are fixed—the condyle path, the anterior guidance (in this case), and the curve of Spee and its chord (the plane of occlusion). Planning a set of cusps that will produce a satisfactory articulation is begun. Before the plan goes too far, it is discovered that the cusps on the bicuspids are going to be excessively steep. Those in the molar region are quite steep, too. Having assumed that the anterior guidance cannot be changed, what is to be done? We know that the cusp relationship as it is developing is not ideal.

By preparing the teeth—overpreparing the second bicuspid and first molar of the upper and overbuilding the lower second bicuspid and first molar—we can flatten the curve of Spee. This will alter the relative cusp heights of the teeth in that there will be a more gradual change of cusp height from anterior to posterior. Now by raising the plane of occlusion in the posterior region—shortening the upper molar preparation and overbuilding the lower molar restoration—we can decrease the average height of all the cusps. As a result of these two procedures, the curve of Spee has been flattened and the plane of occlusion raised in the posterior region. There is now a more desirable cusp relationship—a more normal relationship in which the cusps decrease in height as they go from anterior to posterior. This effects a better relationship of the cusps to the supporting structures.

Anterior guidance

In the patient just considered, there was another factor which could have been used to some advantage, namely, the anterior guidance. This is the one factor of articulation which has probably caused the most confusion, possibly because of a misunderstanding of the incisal guide of an articulator. The incisal or anterior guide of an articulator is merely a mechanical convenience which permits the articulator to be moved without damaging the anterior teeth on a cast or without knocking out the artificial teeth on a set of dentures while one is establishing the articulation in the posterior region.

The anterior guidance, on the other hand, is the relationship of the anterior teeth, i.e., the relation between the extent to which the upper teeth jut over the lowers and the extent to which the upper teeth hang down over the lowers. In other words, an angle is formed by the overjet and overlap of the upper anterior teeth to the lower anterior teeth (Fig. 420). In the ideal arrangement of an articulation, the anterior guidance is a resultant of the posterior cusp arrangement. That is to say that the amount of cusp rise of the posterior teeth produces or requires a certain anterior guidance in order for the two segments of the articulation to be harmonious. In actual practice the procedure is sometimes reversed, and it is perhaps this fact that causes the confusion.

Frequently, the anterior teeth are not involved in a rehabilitation, or if they are, they are usually treated last. We therefore arrive at a situation in which the fixed factors of articulation are recorded and duplicated on an instrument. The casts are properly related to these factors, and the restoration is analyzed or its construction is actually begun.

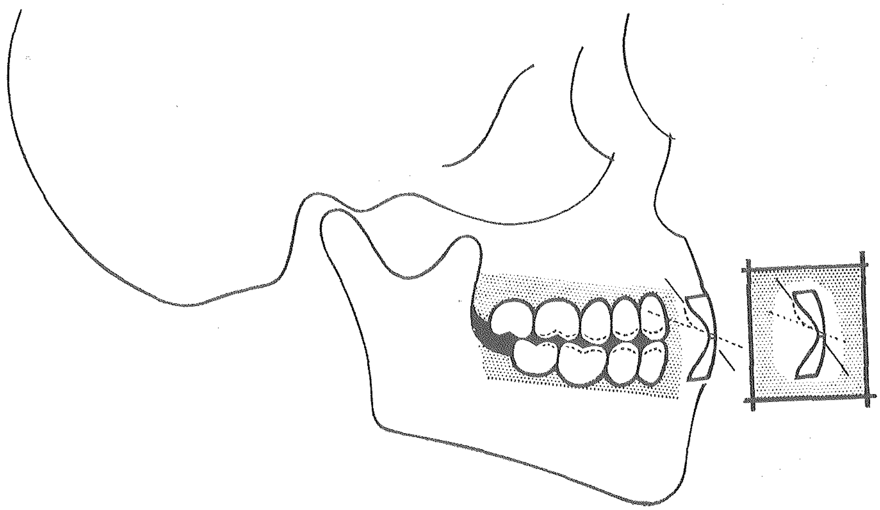

Fig. 420. The effect of changing the anterior guidance. The cusp height is decreased from back to front as the anterior guidance is reduced.

A certain anterior tooth relation is established and also, as the articulator is moved into the various excursions, a certain posterior separation of the prepared teeth. This, of course, is dictated primarily by the curvature and slant of the condyle path. The relation of the anterior teeth causes either an increasing or a decreasing separation as we go anteriorly in the posterior teeth. The angle of the anterior guidance is responsible for this. It should be obvious that where there is a very steep anterior guidance and a relatively steep condyle path, it will be necessary to build excessively high steeples if a simultaneous contact of the tooth surfaces is maintained throughout the excursions. It is known that the condyle path is fixed and cannot be altered. The curve of Spee and the plane of occlusion are used as much as possible to reduce the cusp heights. Then we turn to the anterior guidance.

There are several ways in which one can take advantage of the mutability of the anterior guidance. The interarch distance can be increased slightly, which will have the effect of decreasing the anterior guidance and immediately reducing the cusp rise in the bicuspid region where it is usually excessive under these given conditions. Or, if this change unduly increases the clinical crown so that the crown-root ratio is unfavorable, one can then operate on the anterior teeth so as to reduce the anterior guidance without any increase in vertical dimension. This may necessitate shortening the lower anterior teeth and preparing the upper anterior teeth for veneer crowns.

By a combination, then, of all these factors—changing the anterior guidance and altering the curve of Spee and the inclination of the occlusal plane—it is usually possible to arrive at the best set of cusps for producing the most suitable articulation for the restoration.

Vertical dimension

Vertical dimension is another important factor of articulation about which there has been considerable misunderstanding. In the hope of clarifying some of the confusion surrounding the term, let us analyze in detail just exactly what it is.

Vertical dimension may be defined as a measurement from a fixed maxillary landmark to a fixed mandibular landmark when the teeth (natural or artificial) have stopped the vertical jaw closure. The selection of the fixed landmarks is of little concern and important only as a means for future comparisons.

An essential consideration of the tooth stop is the position of the lower jaw (and teeth) when contact is made with the upper teeth. That is to say, the contact may be in an eccentric relation, in which case some complications are immediately introduced. It must be obvious that if a patient brings the teeth together in a protrusive relationship, the vertical dimension will be different than if he closes them in a centric occlusion interdigitation. It will also make a considerable difference if, when he brings the teeth together in a centric occlusion interdigitation, the mandible is not in centric relation. From this it can be seen that some basis for an intelligent discussion of vertical dimension must be established—some standard conditions must be set up.

As a beginning, let us consider vertical dimension with centric relation. Centric relation has been defined as the terminal hinge closure. If this terminal hinge closure is stopped at a certain point in its arc of closure, this may be called vertical dimension. Now we can speak about a certain *degree* of opening because we are dealing with a movement that has a center—the hinge axis. In a normal situation, then, the terminal hinge closure is stopped when the lower teeth contact the upper teeth. This is vertical dimension.

Let us now correlate this with the treatment of a practical case—a full-mouth reconstruction.

With very few exceptions, most mouths that require reconstruction are not in centric relation. The first step is then to mount some study casts on an articulator in centric relation. Examination of these mounted casts will tell us a great deal. As the casts are brought together, observe how the teeth contact. Usually a cusp will be the stop as the casts close on the arc of closure. The rest of the teeth, including the anterior teeth, will be open to some degree. Sometimes this degree of opening is astounding. Obviously, it is not desirable to make the restorations to such a degree of opening; therefore, preparations are planned so that the vertical dimension can be closed. By tooth preparation (cutting the stone cast), it is possible to achieve a condition in which the anterior teeth have a more normal relationship. Other factors must now be considered, such as the proximity of the pulp, the crown-root ratio, and the amount of overlap and overjet.

Let us now consider the reverse condition, i.e., a restoration in which there is a very deep overlap with very little overjet. Such restorations usually require an increase in vertical dimension.

Again, with properly mounted master and study casts, the restorations are planned. At first, it might seem necessary to build excessively steep cusps in order to establish a correct articulation. This is not desirable. One might also consider changing the anterior guidance by preparing the anterior teeth. Sometimes, however, this is not feasible because of pulpal involvements. The logical approach is to increase the vertical dimension slightly since this will automatically improve the anterior tooth relation. It may be necessary to combine several factors. For example, in addition to a slight increase in the vertical dimension, some alteration of the anterior guidance and the moderately steep cusps may be indicated.

In practical full-mouth rehabilitation, the problem is seldom one of having to worry about increasing the vertical dimension. Usually the difficulty lies in being able to prepare the teeth adequately so that the patient can close the jaws sufficiently to allow the anterior teeth to function. The problem arises because a certain amount of room is needed in specific areas to permit the cusps to contact properly in centric relation. The malrelation of the teeth generally contributes to this problem, for very often the required space must be created right in the middle of a tooth, which is usually where the pulp is located. Why, it may be asked, cannot the vertical dimension be increased in such patients? Again, all the factors must be considered: the crown-root ratio, and the anterior tooth function which must be established without having to create monstrously large anterior teeth.

Up to now, rest position, interocclusal distance, and muscle length and their relation to vertical dimension have not been mentioned. Let us consider these one at a time.

Rest position. Rest position, "the position of the mandible when the jaws are in rest relation,"* concerns us to the extent that we must not build restorations that would in any way interfere with it. When dealing with natural teeth, this is hardly possible to do if good judgment is exercised with respect to such factors as the crown-root ratio and the anterior guidance. With edentulous patients, it is possible to encroach upon the rest position, but not for long! Nature will not tolerate such violence and will reduce the supporting structures until the rest position is recreated.

Interocclusal distance. It is difficult to separate rest position and interocclusal distance (free-way space). The latter is the space between the teeth when the mandible is in rest position. Again, as a practical matter, it is almost impossible in dealing with natural teeth to eliminate the interocclusal distance so long as good judgment is used with respect to the factors of articulation. An exception

*From Academy of Denture Prosthetics: Glossary of Prosthodontic Terms, J. Pros. Den. (Part 2) **10**:33, 1960.

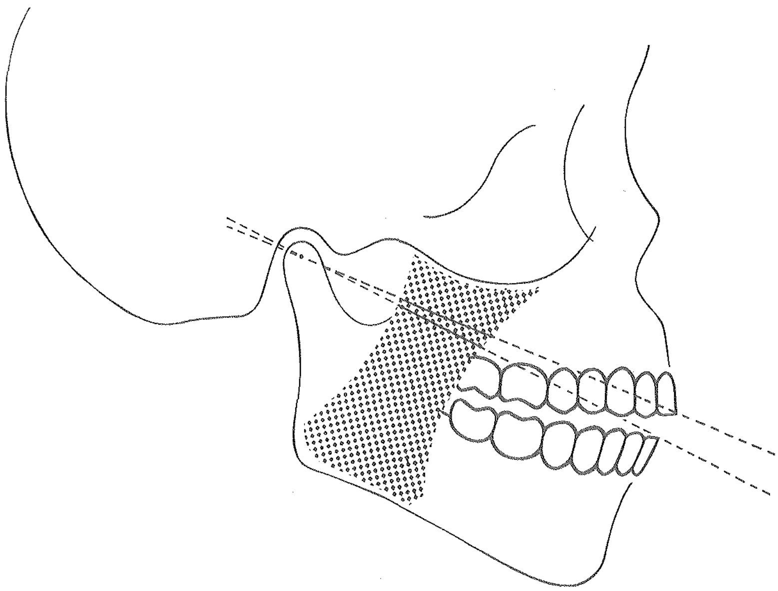

Fig. 421. The mandible is opened a given degree (measured in the anterior region) around the hinge axis. The degree of masseter muscle stretch is designated by the wedge made by the broken lines.

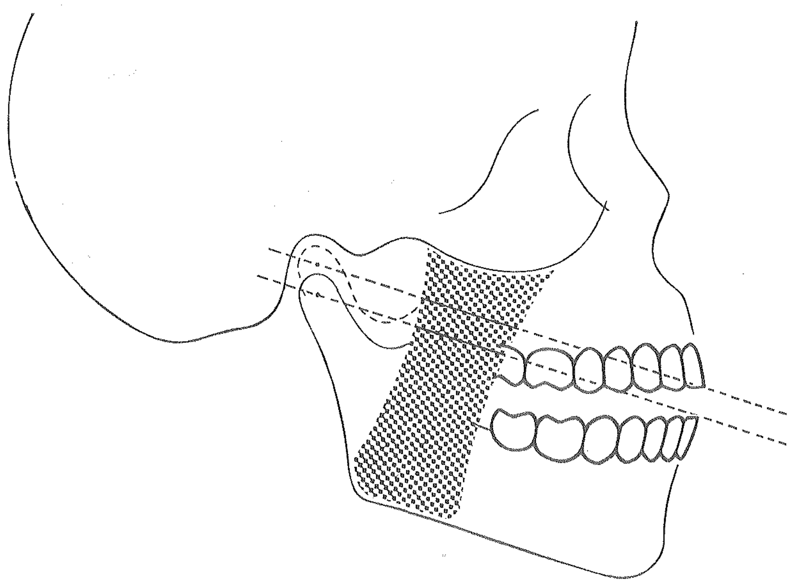

Fig. 422. A possible rest position with the degree of opening in the anterior region is the same as in Fig. 421. Compare the degree of muscle stretch as indicated by the broken lines.

is the spastic or the clamper patient, in which case nothing can be done to create or maintain an interocclusal distance.

Muscle length. Muscle length, of course, is one of the determining factors of rest position and interocclusal distance. Again, it is hardly conceivable to have to increase the vertical dimension to such an extent that the muscles would be lengthened excessively, provided that the jaw is opened from centric relation and not from the rest position. Several diagrams will clarify this point.

In Fig. 421, the lower jaw is opened a given degree. The degree of opening is measured in the region of the anterior teeth and indicated by dotted lines. Note that this opening is produced by the hingelike action of the lower jaw and has the hinge axis as its center. The degree of muscle stretch created is depicted by the wedge made by the dotted line across the masseter muscle.

In Fig. 422, the same degree of anterior separation is maintained, but the mandible is allowed to assume what might be a rest position. Note now the extent of stretch in the fibers of the masseter muscle. Remember that the anterior opening is identical to that in Fig. 421. If this relationship is accepted as centric relation and the vertical dimension is then increased, it is conceivable that too great a vertical dimension is being established.

Let us assume that the conditions of Fig. 422 have been changed by decreasing the vertical dimension, and the condition in Fig. 423 has resulted. The anterior teeth are in contact, but there is a space between the posterior teeth. This is easily arrived at by recording a physiological rest position, as some men advocate,

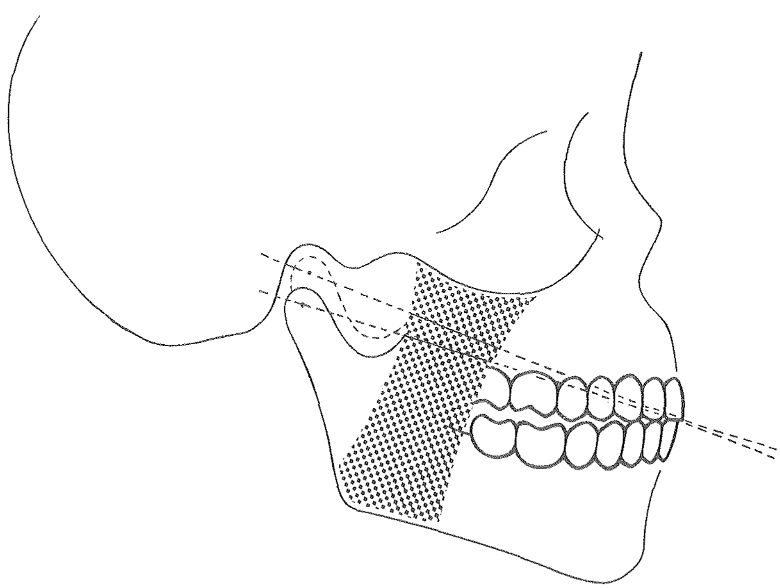

Fig. 423. The vertical dimension has been decreased from the rest position until the anterior teeth contact.

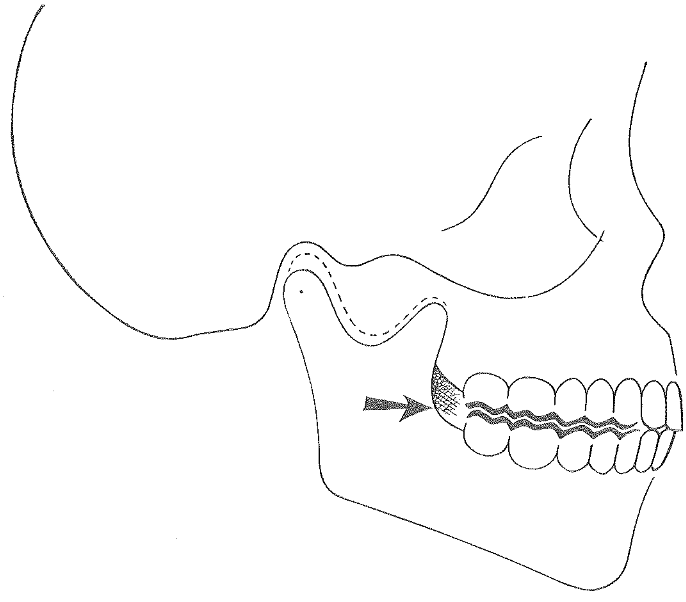

Fig. 424. Restorations are constructed for this condition to balance the bite.

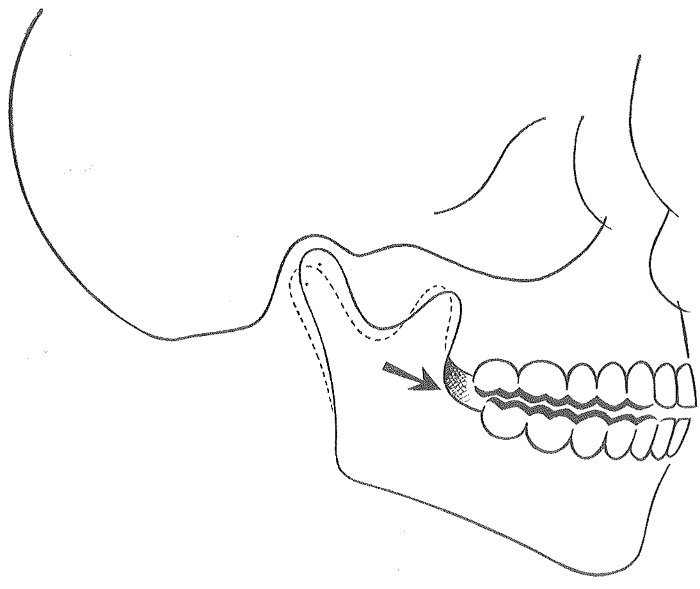

Fig. 425. The result when the patient attempts to function with these restorations.

and then decreasing (or increasing) the vertical dimension until the anterior teeth are in the desired relationship to each other.

If, in Fig. 423, the decision were made to construct onlays to "balance," "open," or do "something" to the "bite," the condition shown in Fig. 424 would result.

However, if the patient tried to function with these restorations, the result would very likely be the condition shown in Fig. 425. This may be exaggerated for the purpose of illustration, but remember that a discrepancy of 1/1,000 of an inch in the mouth will feel as bad as this condition looks.

Guides to vertical dimension. When dealing with artificial dentures, there are a number of guides one must use to determine vertical dimension.

Phonetics is one reliable test. The patient's ability to produce certain sounds, letters, and words without eliminating the interocclusal distance is a gauge for verifying vertical dimension.

The face of the patient can be another clue, for a normal, unstrained appearance is indicative of proper vertical dimension. As a rule, if correct vertical dimension has been established, the face can be divided into equal thirds by means of a face scale. This is a valid test for an average face. It cannot be applied, however, when one third of a patient's face is disproportionate to the other parts.

For patients with no pre-extraction records, a pre-extraction photograph can be a valuable aid in establishing the vertical dimension. Setting up a simple direct ratio from areas in the photograph to corresponding areas on the patient will give the unknown vertical dimension that is sought.

Usually esthetics are developed with the twelve anterior teeth. Some attention must be paid to the vertical dimension at this stage. However, the final decision is made after the denture bases are on the articulator and the articulation is to be developed. The same procedures are followed as in natural tooth reconstruction, but there is more control over the mutable factors of articulation.

Curve of Wilson

There is one other factor of articulation to consider, and that is the compensating curve or the curve of Wilson. This is a transverse curve made by the lingual inclinations of the lower posterior teeth. The degree of lingual inclination and, consequently, the degree of curvature depend upon the level of the occlusal plane. The greater the distance of the occlusal plane from the condyle path and the axis-orbital plane, the greater will have to be the compensating curve. The greater the severity of the Bennett movement, the greater will be the lingual inclination of the lower teeth and the compensating curve required. This, of course, is of primary concern in the articulation of artificial teeth.

When an articulation with natural teeth is established, the lowering of the occlusal plane (where necessary) will require a slight increase in the compensating curve. This is usually worked out automatically as the occlusal plane level is established.

In Chapter 1, it was pointed out that the objective of mouth rehabilitation is to produce a set of conditions which will distribute the forces of mastication over as great an area as possible in order that the tissues can tolerate these stresses and maintain a state of health. In the effort to obtain articulation, we are striving to fulfill this objective.

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CHAPTER 13

Carving an articulation

The procedure of carving an articulation can be accomplished only on an articulator. Obviously, if the carvings are to be custom-made, the articulator must duplicate the patient's movements. Therefore, at this point, there must be a fully-set instrument on which the master casts have been carefully mounted to the correct centers of rotation. The casts have been immersed in oil under a vacuum in order that the wax patterns will not adhere to them.

It is now necessary to make a decision about the anterior guidance. It must be decided whether the anterior teeth are to remain as they are, whether they are going to be prepared for restorations, or whether they can be satisfactorily adjusted by grinding and shaping. Also, we must make a decision about vertical dimension. In Chapter 12 the relationship of vertical overlap and horizontal overjet to the other factors was described, and it was indicated that it might be necessary to alter the anterior guidance. The alterations could consist of restorations on the upper anterior teeth, grinding and reshaping the upper and lower anterior teeth, or increasing the vertical dimension to reduce the steepness of the anterior guidance. It might be necessary to combine several of these measures in order to arrive at the best conditions possible for the restoration. Such changes as are indicated should be made before the wax-up is begun. If a wrong decision is made, it will be necessary to adjust the carvings, as is frequently the case. Only after considerable experience will one learn how to avoid having to retrace some of the steps.

SETTING ANTERIOR GUIDE

Assuming that the anterior tooth relationship is satisfactory for the conditions of the case, one sets the mechanical anterior guide of the articulator. Some anterior guides are adjustable, and by tilting the table and raising the wings one can produce the necessary anterior cusp rise. However, more frequently than not, an anterior guide for the particular restoration must be made. On the anterior guides designed by McCollum and Stuart this can be done quite simply with self-curing acrylic. All that is actually needed to make a guide is a table on which some self-curing plastic can be attached. It will have to be adjusted to the particular restoration, but this is easily accomplished by marking the acrylic with carbon paper and grinding the marked areas with a bur or a mounted stone.

The procedure for adjusting the table is as follows. After setting the incisal pin to contact the incisal table in centric relation, move the upper bow of the articulator to the protrusive position. This is determined by the edge-to-edge relationship of the anterior teeth. When the articulator is in this position, fill the space between the tip of the incisal pin and the incisal table with quick-curing acrylic. A rounded slope is created from this cusp height to the bottom of the centric location of the incisal table. Carry out the same procedure in the lateral excursions, using the cuspid for guidance. When the table has been properly made and adjusted, it should be possible to move the upper bow of the articulator in every excursion, with the anterior teeth just contacting. When the articulator is in centric position, the "centric hole" should allow the correct vertical dimension.

It is also possible to make the incisal table by starting with a block of plastic, carving out the centric hole, and adjusting the length of the incisal pin until the conditions just described are satisfied.

AREAS THAT WORK TOGETHER IN VARIOUS EXCURSIONS AND POSITIONS

There are many ways to carve a balanced articulation, and each technician has worked out his own system. The end results, however, should all be the same. Therefore, we are going to describe the finished product, rather than try to illustrate the different methods of achieving it.

In carving and developing the articulation, it is important to add as little wax as possible at each application, for it is much easier to add wax where needed than to have to carve away an excess. It is easier to build up than to carve out. For applying the wax, a thin spatula, an explorer, or a pair of thin college pliers should be used. Bear in mind that the articulator is used as a measuring instrument for determining whether sufficient wax has been added in the right places. It is not to be used to rub the teeth together where cuspal relations are being established. In the refining process which comes later, the articulator is moved through the excursions to locate interferences, but in establishing the cusps, the articulator is opened and closed in the desired position to determine whether the amount of wax is correct and in the right position.

Contacts in lateral protrusive position

When an articulation is being examined on an articulator, it is necessary to have the instrument in the proper movement. In the lateral protrusive position, for example, the articulator must be held in the full Bennett movement, as well as in a protrusive position on the side being examined.

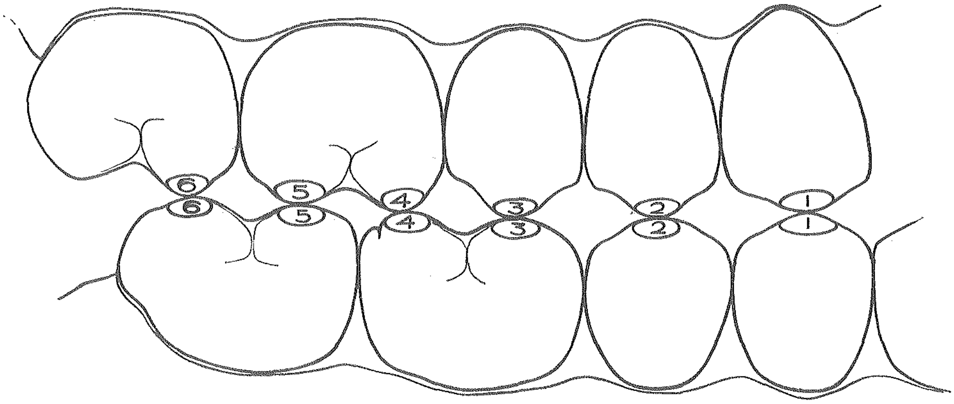


Fig. 426. The lateral protrusive position of the posterior teeth.

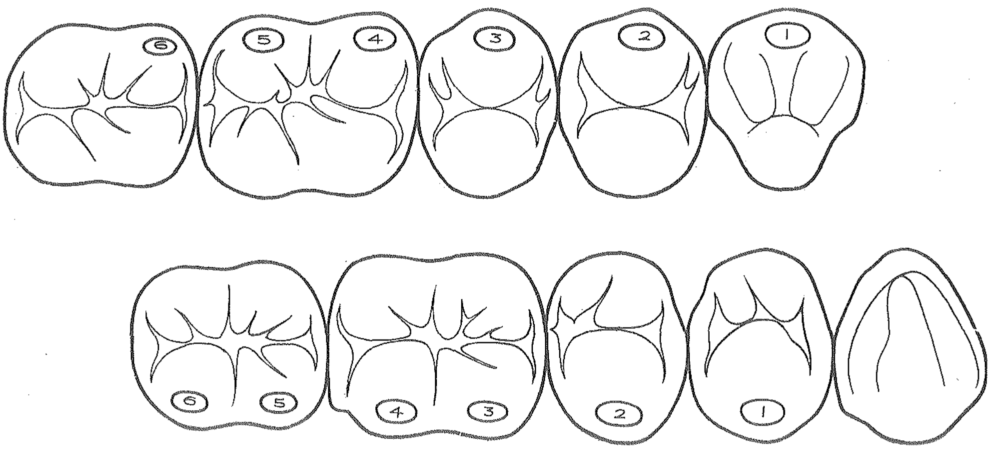


Fig. 427. The areas which are involved in lateral protrusive contacts.

When the teeth are in the lateral protrusive position, the contacts are as in Figs. 426 and 427. The tips of the upper buccal cusps make contact with the tips of the lower buccal cusps—the tip of the upper cuspid contacting the tip of the buccal cusp of the lower first bicuspid, the tip of the buccal cusp of the upper first bicuspid contacting the tip of the buccal cusp of the lower second bicuspid, etc., as in the drawing.

Notice that there is a gentle curve from the tip of the upper cuspid to the tip of the distobuccal cusp of the upper second molar.

Contacts in protrusive position

In the protrusive position, the lower teeth are brought forward an equal degree on each side.

The contacting areas of the upper and lower teeth in this excursion (Fig.

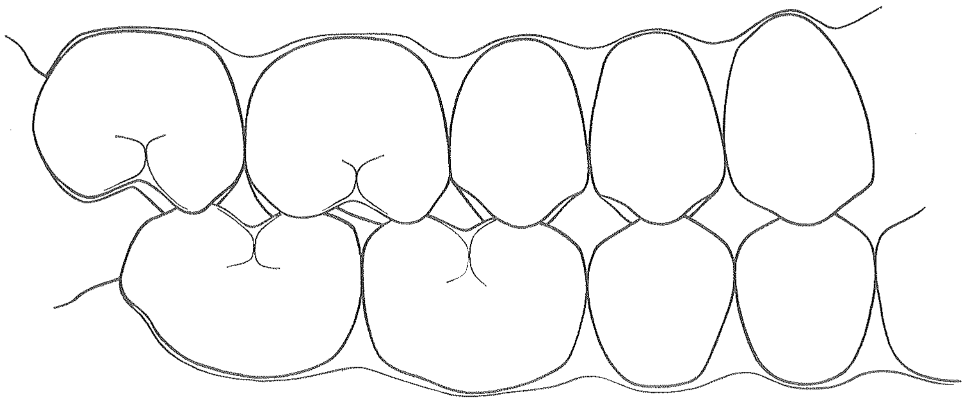


Fig. 428. The protrusive position of the posterior teeth.

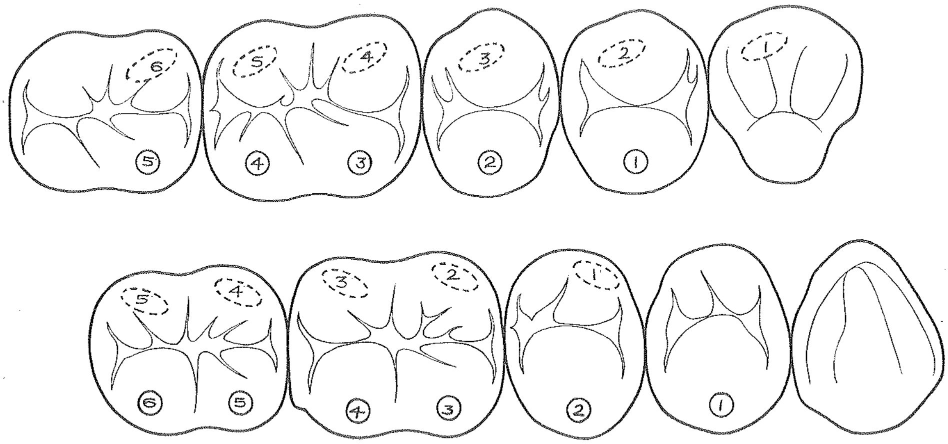


Fig. 429. Areas that contact in the protrusive position.

428) are shown in Fig. 429. The tip of the buccal cusp of the lower first bicuspid makes contact with the upper cuspid from the distal marginal ridge to the crest of the lingual surface. The tip of the buccal cusp of the lower second bicuspid contacts the upper first bicuspid from the distal marginal ridge to the buccal transverse ridge.

In the ideal restoration, the tip of the lingual cusp of the upper first bicuspid contacts the lower second bicuspid from the mesial marginal ridge to the crest of the lingual tranverse ridge. The tip of the lingual cusp of the upper second bicuspid contacts the lower first molar from the mesial marginal ridge to the crest of the mesiolingual transverse ridge.

In like manner, the molars make similar contacts in the protrusive position, as shown in the drawings (Figs. 428 and 429).

Contacts in lateral balance

In the extreme or border position of lateral balance, contact is made between the tips of the upper lingual cusps and the tips of the lower buccal cusps, as in Fig. 430. The tip of the lingual cusp of the upper first bicuspid contacts the tip of the buccal cusp of the lower second bicuspid. The tip of the lingual cusp of the upper second bicuspid contacts the tip of the mesiobuccal cusp of the lower first molar.

The molar cusps make similar contact, as shown in Figs. 430 and 431.

Fig. 432 illustrates the relationship of the cusps as the lower jaw assumes the midway position between centric relation and full lateral balance.

Contact is made between the tips of the lingual cusps of the upper teeth and

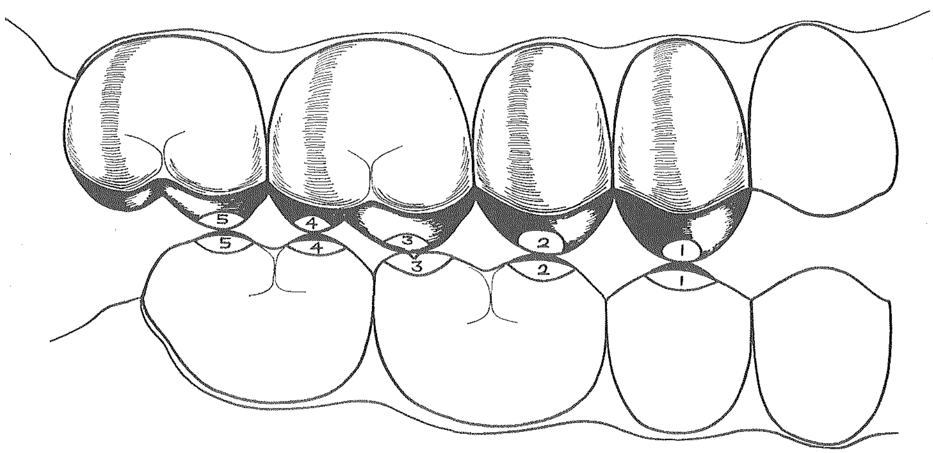


Fig. 430. The extreme balancing position.

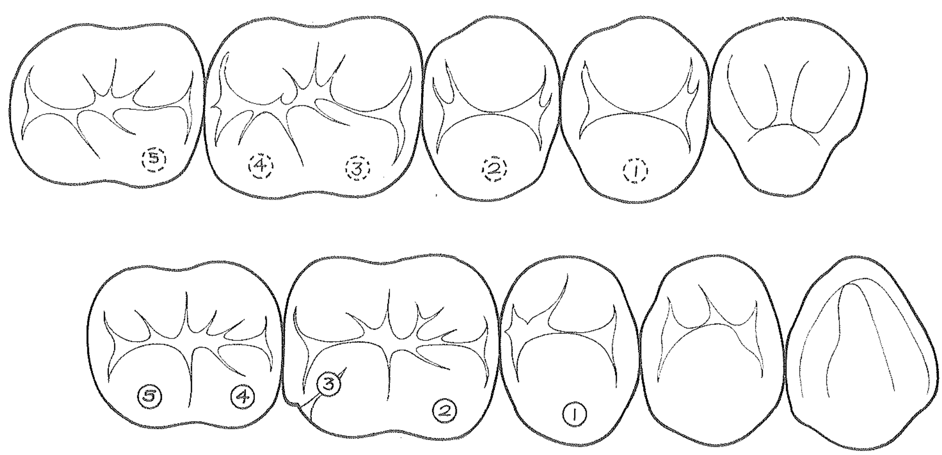


Fig. 431. Areas that contact in the extreme balancing position.

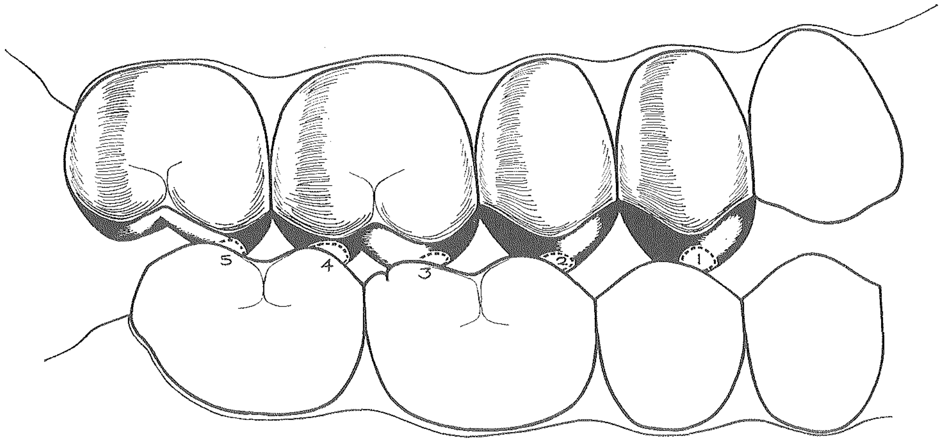


Fig. 432. The balancing position between extreme balance and centric relation.

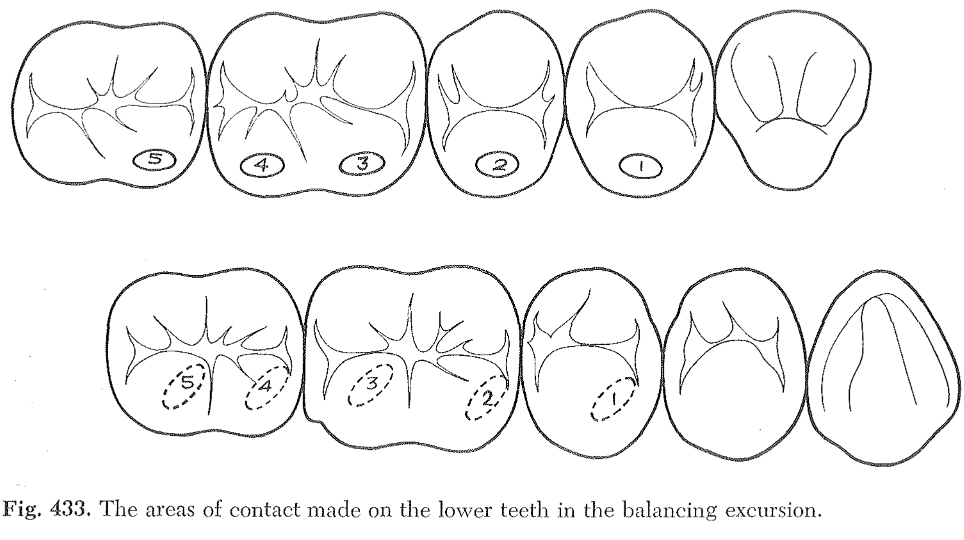


Fig. 433. The areas of contact made on the lower teeth in the balancing excursion.

the mesiolingual surfaces between the mesial marginal ridges and the crests of the transverse ridges of the lower buccal cusps, as in Fig. 433. For instance, the tip of the lingual cusp of the upper first bicuspid contacts the lower second bicuspid from the crest of the transverse ridge of the buccal cusp to the mesial marginal ridge in the area shown in Fig. 433 as the patient moves from the extreme lateral balancing position to centric relation.

The remaining upper lingual cusp tips make similar contacts with the corresponding areas of the lower teeth, as shown in Fig. 433.

While the contacts indicated in Fig. 433 are being made, there are additional balancing contacts between the tips of the lower buccal cusps and the distobuccal areas of the lingual cusps of the upper teeth (Fig. 434). Contact is made, for

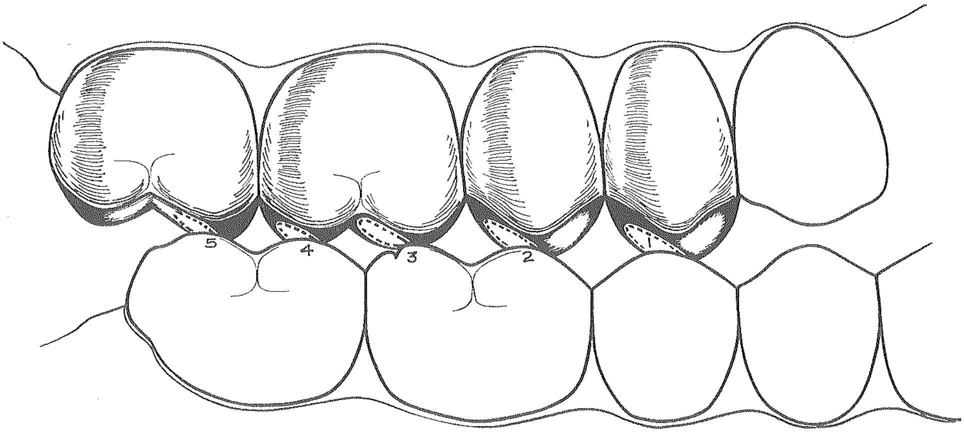


Fig. 434. The balancing position between extreme balance and centric relation.

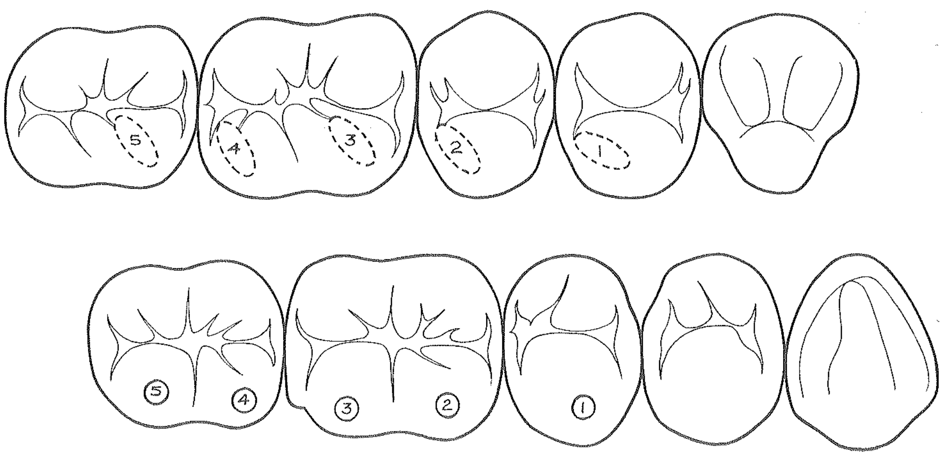


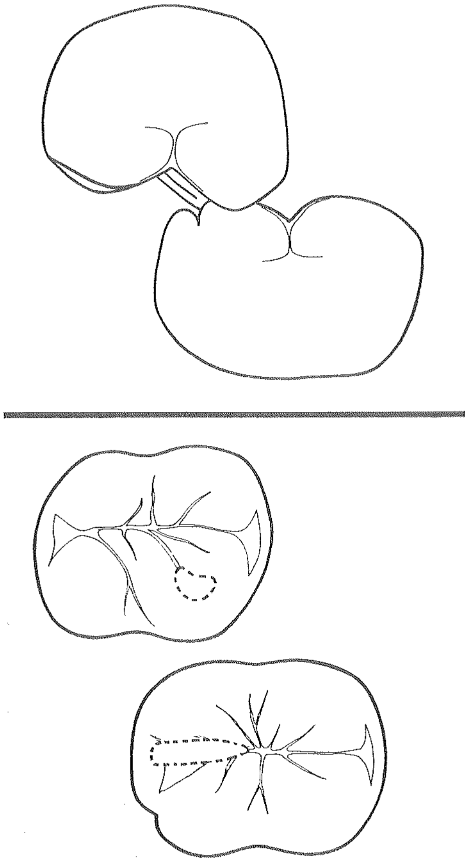
Fig. 435. The areas of contact made on the upper teeth in the balancing excursion.

instance, between the tip of the buccal cusp of the lower second bicuspid and the area between the distal marginal ridge and the transverse ridge of the lingual cusp of the upper first bicuspid (Fig. 435).

The remaining lower buccal cusp tips make similar contact with the corresponding areas of the upper lingual cusps, as in Fig. 435.

Contacting areas of mesiolingual cusp of upper first molar

The mesiolingual cusp of the upper first molar is probably the most important cusp in the articulation. Its action is slightly different from that of the other upper lingual cusps and should be examined separately.



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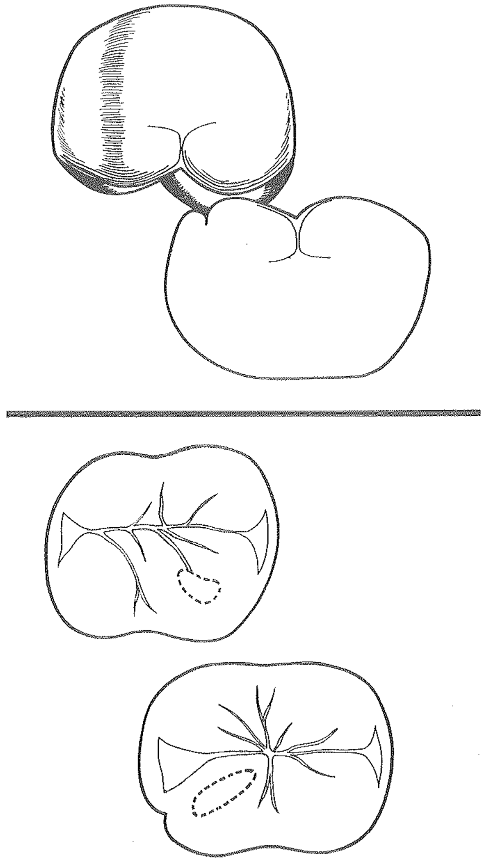

437

Fig. 436. The protrusive position and the area of contact on the lower first molar by the mesiolingual cusp of the upper first molar.
Fig. 437. The balancing position and the area of contact on the lower first molar by the mesiolingual cusp of the upper first molar.

In the protrusive excursion, the tip of the mesiolingual cusp of the upper first molar contacts the distobuccal cusp of the lower first molar (Fig. 436).

In the balancing excursion, the same tip of the mesiolingual cusp of the upper first molar travels through the groove formed by the buccal and distobuccal cusps and maintains contact with the sides of this groove, as in Fig. 437.

Working occlusion contacts

In the working relationship (Fig. 438), the contacts are made between the mesial and distal slopes of the upper buccal cusps and the mesial and distal slopes of the lower buccal cusps. The slopes of the lower cusps are actually on the buccal surfaces of the cusps, whereas the slopes of the upper buccal cusps are on the lingual surfaces of the upper buccal cusps (Fig. 439).

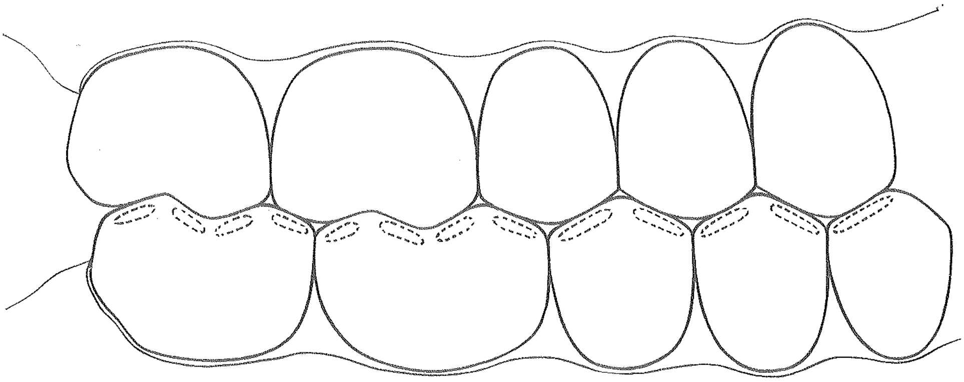

Fig. 438. The working occlusion position of the upper and lower teeth.

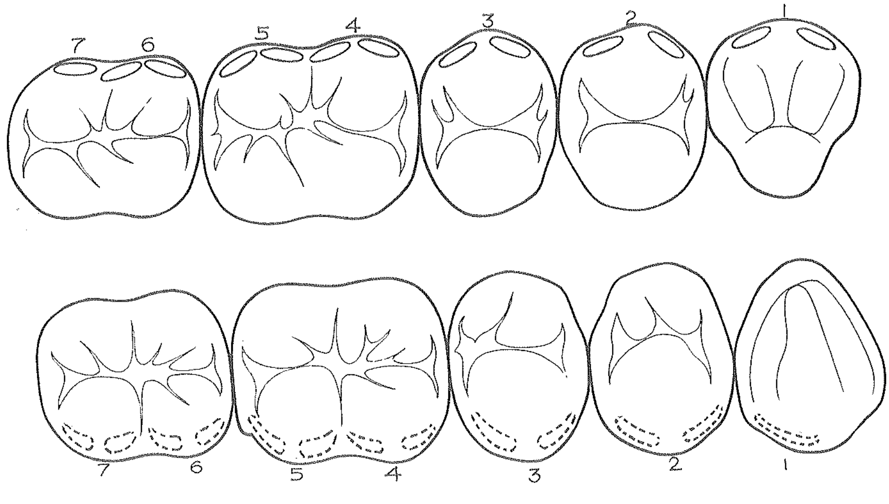

Fig. 439. The buccal areas of contact in the working occlusion.

For instance, the mesiobuccal slope of the lower first bicuspid makes contact with the distolingual surface of the upper cuspid (Figs. 438 and 439). The distobuccal slope of the lower first bucuspid makes contact with the mesiolingual surface of the buccal cusp of the upper first bicuspid. The remaining mesial and distal slopes of the upper cusps make similar contact with the lower buccal cusp slopes (Figs. 438 and 439).

Also in the working occlusion, the mesial and distal slopes of the upper and lower lingual cusps make contact, as in Fig. 440. For instance, the lingual surface of the mesial slope of the lingual cusp of the upper first bicuspid makes contact with the buccal surface of the distal slope of the lower first bicuspid (Fig. 441). In like manner, the lingual surfaces of the mesial and distal slopes of the upper lingual cusps make contact with the buccal surfaces of the

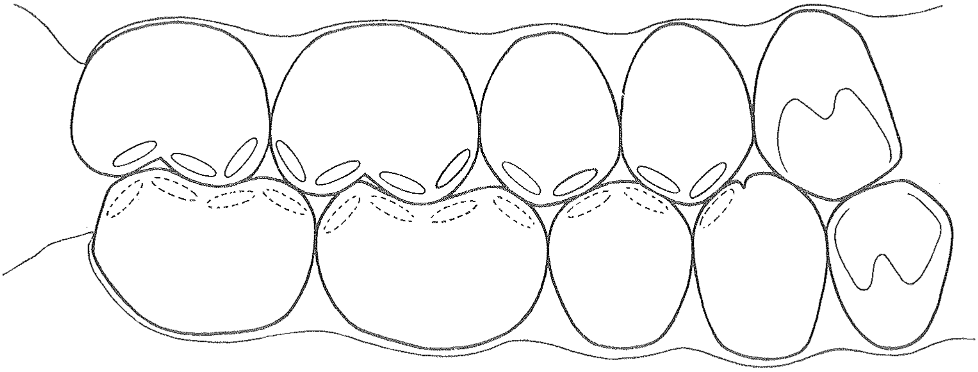

Fig. 440. The working occlusion position of the upper and lower teeth as viewed from the lingual aspect.

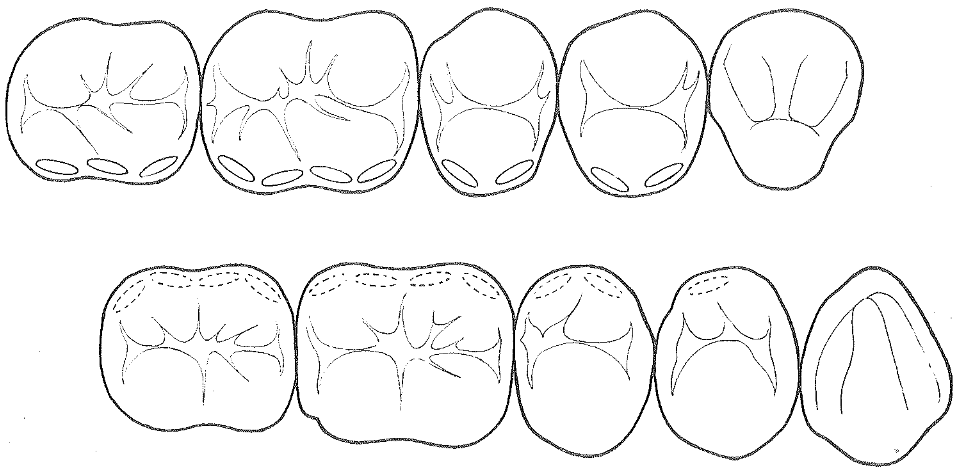

Fig. 441. The lingual areas of contact in the working occlusion.

mesial and lingual slopes of the lingual cusps of the lower teeth (Figs. 440 and 441).

Centric relation contacts

The centric relation contacts are the most important. They should occur in the most closed relationship.

The tips of the upper lingual cusps make contact on the marginal ridges between the lower teeth, with the exception of the molar mesiolingual cusp tips which contact the central fossae of the lower molars. The tips of the lower buccal cusps make contact on the marginal ridges between the upper teeth, with the exception of the distobuccal cusps of the lower molars which contact the central fossae of the upper molars (Figs. 442 and 443).

For instance, the tip of the lingual cusp of the upper first bicuspid contacts

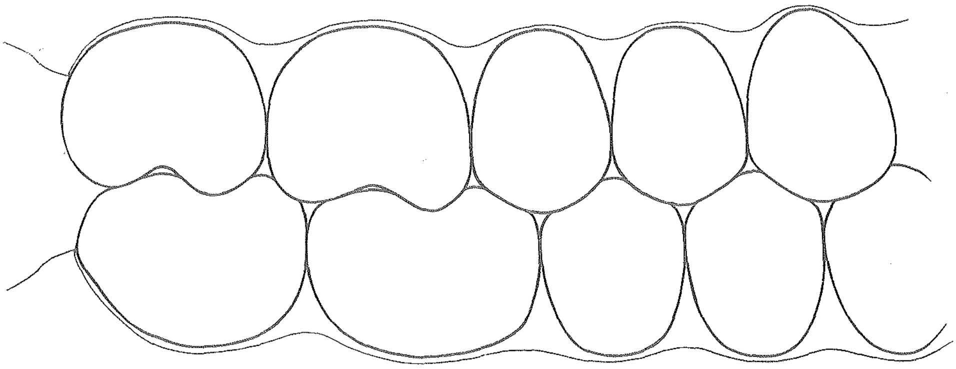

Fig. 442. The centric relation position of the upper and lower posterior teeth.

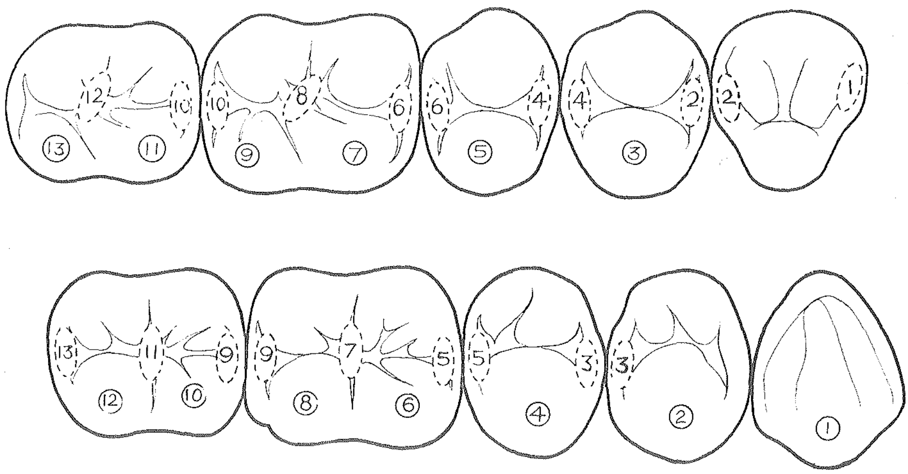

Fig. 443. The areas that are in contact in the centric relation position of the teeth.

the marginal ridges of the lower first and second bicuspids, while the tip of the buccal cusp of the lower first bicuspid contacts the marginal ridges of the upper cuspid and first bicuspid. Similar contact is made by the tips of the upper lingual cusps and the corresponding areas of contact of the lower teeth and by the tips of the lower buccal cusps and the corresponding areas of contact of the upper teeth (Figs. 442 and 443).

ESTABLISHING RELATIONSHIP OF ANTERIOR TEETH FOR BALANCED ARTICULATION

In the majority of patients, the anterior teeth are treated after the posterior articulation has been established. This means that the posterior restorations have already been cast, tried in the mouth, remounted, and adjusted. The remounting and adjusting may have been done several times. Thus, when the posterior restorations are in the final stage, the anterior teeth are treated. This treatment may involve only slight grinding, shaping, and polishing. It may involve pin-ledges in all the anterior teeth. It may involve complete jacket crowns. In most patients, the cuspids have to be treated.

There are various ways of carving an anterior restoration, depending upon the requirements of the patient.

If the restorations are pin-ledges, they may be carved directly in the mouth, or a master cast may be made and mounted on the articulator for the carving of the lingual surfaces.

The lingual surfaces should be carved so that they are in harmony with the cusp rise of the posterior teeth. Whenever possible, there should be slight contact in centric relation. From centric relation, the lingual surfaces should maintain an equal contact as the posterior teeth travel through their various excursions. As the anterior teeth approach their incising position, they should make definite contact without any posterior guidance. This permits incision without posterior interference.

If the restorations are to be veneer crowns, they have to be carved on an articulator. Master casts in stone or a combination of stone and metal dies will be required. In addition to the lingual contours, the labial and proximal contours must be established to incorporate all the principles of periodontal tissue protection. After the crowns are completely carved in wax, they are corrected for marginal adaptation, and the windows are established.

When the anterior teeth are to be fabricated in porcelain, it is advisable to try the biscuit-baked jackets in the mouth and correct the articulation. Although these biscuited jackets could be remounted and corrected, there is always the possibility of breakage. As a rule, it takes only a few minutes to make the necessary corrections in the mouth before final baking.

In some patients the upper anterior teeth jut considerably over the lower anterior teeth. If it is possible to overbuild the lingual surfaces of the upper teeth to make contact, this should be done. However, if the overjet is too great, sometimes the upper anterior teeth can be retracted until contact is made. This can usually be done if the upper anterior teeth have been pushed out or fanned.

When they cannot be retracted nor lingual contact established, it is still possible to keep these teeth healthy if the patient is able to make incisive contact with them and uses them sufficiently. As a last resort in patients in whom lingual contact cannot be established and sufficient protrusive function is lacking, it may be necessary to splint the upper six anterior teeth with pin-ledges or veneer crowns. By this method it is usually possible to obtain contact with the cuspid, and the splinting will keep the four incisors in place and healthy.

The cuspids are extremely important teeth, and their articulation requires special handling. Because of its location in the corner of the mouth, the cuspid acts as a guide to the movements of mastication. Its proprioceptive mechanism acts as a guide to the range of movement of the lower jaw in function. It has the longest and strongest root of any of the teeth. Thus, when the supporting structures are healthy, it frequently can be built to a slightly heavier contact in the excursions than the buccal cusps of the posterior teeth. When this is done, the proprioceptive mechanism of the cuspid serves as a protection against any malfunction of the posterior teeth.

When the cuspid is periodontally involved with the other teeth, however, as is often the case, then it is wisest to give it only its normal share of the work. In these instances, all the members have to share the forces of function, thereby (it is hoped) prolonging their survival.

Thus far, we have more or less taken for granted an ideal situation in which there are well-positioned teeth and onlay preparations. Often, however, we are confronted with patients with poorly related teeth and edentulous areas. These must be treated, too.

When edentulous areas are present, the wax is built to the height of the adjacent teeth and shaped into tooth forms. The waxing and carving are carried out just as though natural teeth were involved.

When complete crowns are involved, buccal and lingual contours become a problem. In handling such restorations, it is best to apply a thin layer of wax to the entire crown. As the cusps are developed, one will be able to determine how the crown should be contoured so as best to protect the periodontal tissues.

There are some advantages and disadvantages in developing the articulation in a restoration requiring full crowns. One advantage is that the cusps can be warped more easily without showing too much gold. Also a better cusp distribution is possible, thus resulting in a more natural-looking restoration. On the other side, however, is the problem of deciding how best to divide the available space both vertically and mesiodistally.

These are some of the problems encountered in treating practical patients. To describe all the possibilities would require several lifetimes. Every patient presents different problems, and sound judgment based on fundamental principles and past experience is the only real guide. Even after years of experience, it is not unusual for a dentist to have to change an entire wax-up after its development. Even then, he may finish with what he had the first time! There is no way of determining beforehand just exactly how the cusps are going to develop. Every patient represents a compromise, for the ideal patient never has to be treated. However, to be able to make the most intelligent compromise, we must be thoroughly familiar with all the details of an ideal patient.

When the development of the articulation on the master casts is completed, the wax patterns are separated and transferred to individual dies for the final adaptation of the margins. Here will be appreciated the importance of having models which, though free of surface oil, are so well lubricated that the patterns can be separated and removed without fracture.

If there are edentulous areas, a stone index is made so that the carvings can be preserved while the wax is carved from the underside. Since the occlusal surfaces must be thin, it is very easy to warp or break them when their thickness is reduced in wax. This would be disastrous if there were not a stone matrix which could be used to re-establish the carvings.

When the wax patterns are removed from the master casts, they must be transferred very carefully to the individual dies. The greater the care in seating the patterns onto the dies, the fewer will be the adjustments on the castings after remounting. The margins are carefully adapted, and the contact points are established from the quadrant casts.

In order not to negate the many hours spent thus far in developing the articulation, an accurate investing and casting technique is now required.

STEPS IN CARVING MUTUALLY PROTECTED ARTICULATION AS TAUGHT BY THOMAS, STUART, AND STALLARD

About 1950, some of the original proponents of balanced occlusion began to question the desirability of cross-mouth balance. Dr. Charles E. Stuart, Ventura, California, and Dr. Harvey Stallard, San Diego, California, making use of the observations of the late Dr. D. M. Shaw and of Dr. Angelo D'Amico, Stockton, California, began to advocate instead the desirability of cusp-to-fossa balance and mutual protection.

General observations

From the first lectures on this subject to the present, there have been many interpretations and misinterpretations. Some of the latter have stemmed from the fact that there have been revisions in the original concepts. Unfortunately, these misinterpretations have caused considerable confusion.

In the pages to follow, a sincere effort has been made to correct the misunderstanding that exists and to clarify these newer concepts. Much of the information has been obtained directly from Stallard, Stuart, and Thomas. The observations are based on experiences with practical restorations up to the present time (1961) and are subject to change as more experience is gained.

Desirable and undesirable features of full cross-mouth balance

Personally, I have been building restorations to full cross-mouth balance for twelve years and for twenty years have observed such restorations built by others. The majority have been very successful. Patients have been comfortable, their periodontal condition has improved, and joint disturbances have disappeared. A very small percentage were successful for perhaps five to ten years and then began to show signs of trouble. There appeared a lack of harmony between the centric relation and the centric occlusion—the very thing that I had started out to correct when the patients were first treated. I had no explanation for this difficulty.

Stuart and associates reported somewhat different experiences. They claimed that the majority of their restorations built to cross-mouth balance were unsuccessful. They reported that their failures were due to excessive wear and that the finely articulated surfaces became traumatic just as soon as any wear took place.

There are other effects and features of full cross-mouth balance which are undesirable in some patients:

1. The cusp-to-fossa relationship exists only in part of the molar contacts. The bicuspid cusps function in the opposing embrasures, making wedging and tooth drifting possible.
2. There are large areas of tooth contact and broad occlusal surfaces.
3. In such a "tight" occlusion, slight changes produce a readily visible discrepancy.
4. Errors in full-mouth balance are errors of commission, not omission.
5. When a restoration is fully balanced, incision is frequently difficult.
6. In order to produce a full balance, it may be necessary to increase the vertical dimension to a dangerous degree.

Stallard makes the following statement: "Periodontists, perhaps with a good deal of clinical justification, believe that the prosthetic principle of cross-mouth occlusal balance applied to natural teeth is not only unnecessary but harmful. They say, and so do some of the reconstructionists, that some patients who have had their mouths so reconstructed complain that the long lingual cusps of the upper bicuspids, during lateral chewing, foul the closure."*

This, however, is obviously an admission that the restorations were improperly executed. It is impossible to cause any cuspal "fouling" in a properly balanced articulation. Fouling is an indication that the restoration is not balanced.

Still, the few restorations that did not maintain themselves were enough to cause me to study the new Stuart approach carefully.

Desirable and undesirable features of mutually protected articulation

Many points deserve serious consideration. Others are open to question.

What are some of the points worthy of serious consideration?

The cusp-to-fossa relation advocated by Stuart, Stallard, and Thomas is the strongest factor in favor of their concept. This definitely prevents any spreading of the teeth such as is possible in balanced occlusion when the cusps are in the embrasures. It also prevents any plunger action of the cusps against the embrasures.

This cusp-to-fossa relationship produces an interlocking of the upper and

*From Stallard, Harvey: The Good Mouth. In Stuart, Charles E., and Stallard, Harvey (editors): A Syllabus on Oral Rehabilitation and Occlusion, Postgraduate Education, School of Dentistry, University of California, San Francisco, Calif., 1958.

lower components, thereby giving maximum support in centric relation in all directions. The force is clearly closer to the long axis of each tooth.

A minimum amount of tooth contact is involved, and this makes for better penetration of the food. Because the tips of the cusps do not function against surfaces (neither the base of the fossae nor broad occlusal surfaces), there is less likelihood of rapid wear. This permits a built-in tolerance.

A better incisive action is possible when the anterior teeth are not fully balanced with the posterior teeth. This may also have a tendency to discourage bruxism.

The importance of the cuspid is brought into proper light. It is not a cuspid lift but rather a proprioceptive guard which permits accurate location of the jaw when it is close enough to the maxillae to make its first contact. The timing of the Bennett movement—the rate at which the side shift occurs as the balancing condyle advances—must be very carefully built into the cuspid restoration. The disengaging of the posterior teeth by the cuspid is a matter of guiding, not lifting. It must allow a normal cyclic movement to the masticatory stroke.

The arrangement of the marginal, transverse, and oblique ridges so that they have a shearing action makes for a much more efficient chewing apparatus. Less force is required to prepare the food for digestion.

Most impressive is the report of the ability to complete a restoration after one remounting. In my office it has not been possible to do this with very many restorations built to full balance.

The preceding factors are all desirable considerations in mouth rehabilitation. However, under certain circumstances, some are undesirable. Let us examine these circumstances.

In many of the patients that we are called upon to treat, the cuspids are either missing, very badly involved periodontally, or so mutilated that they could not possibly be used in a "mutually protected" arrangement. What are we to do with these patients? I have had many such patients to treat, and the majority have been successful with fully balanced articulation.

In a patient in whom the cuspid is periodontally involved, the proprioceptive mechanism is destroyed in direct proportion to the destruction of the supporting bone and periodontal membrane. Hence, its effectiveness as a guard is reduced beyond usefulness. If the cuspid has to be splinted to the adjacent teeth, again the proprioception is reduced and of little value. If the cuspid is replaced by a pontic attached to the adjacent teeth, the same condition exists—insufficient proprioceptive protection. If the relation of the upper cuspid to the lower cuspid and bicuspid is adverse to the extent that it cannot be restored to a "mutually protective" position, here again is a condition that must forgo such an arrangement.

For a "mutually protected" occlusion, there must be firm cuspids and anterior teeth. Patients in whom the cuspids are missing, periodontally involved, or malrelated are perhaps better treated with full balance.

Frequently we have patients in whom one segment (either the anterior or the posterior) is more severely involved from a periodontal standpoint. In these patients, it is possible that the stronger segment should be made to protect the weaker. For instance, in some patients the six anterior teeth are severely involved, but the posterior teeth are quite firm. Here, balance of the posterior teeth will protect the anterior teeth. Other patients might have firm anterior teeth but severely involved posterior teeth. Here, the "mutual" or "cuspid protection" arrangement would be more advantageous.

It seems logical that there may be a place for both systems of occlusion. This possibility points up the need for more careful diagnosis. More time and greater effort should be expended in evaluating all the factors of a restoration before proceeding to treatment. It may even be advantageous to use both techniques on the same restoration—the balance as a treatment, because experience shows that it will ameliorate the conditions, and the mutual protection as a conclusion of the restoration to ensure its permanence.

Because of the many promising features of the "mutually protected" system, it is appropriate here to describe how it is established. In doing this, I shall draw on my own limited personal experience with the technique and on the information gained from Stuart, Stallard, and Thomas.

Setting the anterior guide

Casts of the prepared teeth are mounted on the adjusted articulator. The relationship of the upper and lower anterior teeth is carefuly examined in order that the anterior guide of the articulator may be properly established.

If the anterior teeth are ideally positioned (which is rare), the anterior guide is set (or ground if a plastic table is used) so that the anterior teeth just touch in the various excursions. The purpose of the anterior guide on the articulator is to preserve the relationship of the anterior teeth on the casts—so that they will not be rubbed away during the waxing process.

If the cuspids are to be restored (which is usually the case), the relation of the upper cuspid to the lower cuspid and first bicuspid is determined by the vertical overlap and horizontal overjet of the incisor teeth. The cuspid contact may be waxed up to assist in setting the anterior guide. Usually the cuspid is restored after the posterior restorations are fitted and adjusted. By this procedure, there will be less adjustment to the cuspid in the finished restoration.

In any event, the object of a mutually protected articulation is to have the upper cuspid guide the mandible in the lateral and protrusive excursions by its proprioceptive reflex, stimulated by the upper cuspid's contact with the lower cuspid and lower first bicuspid. Soon after a lateral or protrusive excursion begins, the posterior teeth are disengaged.

The procedure about to be described is based on the directions of Dr. Thomas at the Wasatch Dental Seminar in November, 1959, and on a special demonstration by Dr. Stuart in my office on March 16, 1960.

The casts are impregnated with oil under vacuum to facilitate the removal of the wax patterns when the waxing is complete. As a substitute for oil immersion, a good separating medium such as Microfilm* or Slikdie† may be used.

Wax is applied in a thin layer over the prepared upper teeth and joined interproximally so that the patterns will not become displaced in the ensuing procedures. At this point, there is no wax in the prepared lower teeth.

Placement of upper buccal cusp cones

The proper placement of the cusp tips is the first step in establishing a mutually protected articulation. It is an extremely important step and must be carried out with care and judgment.

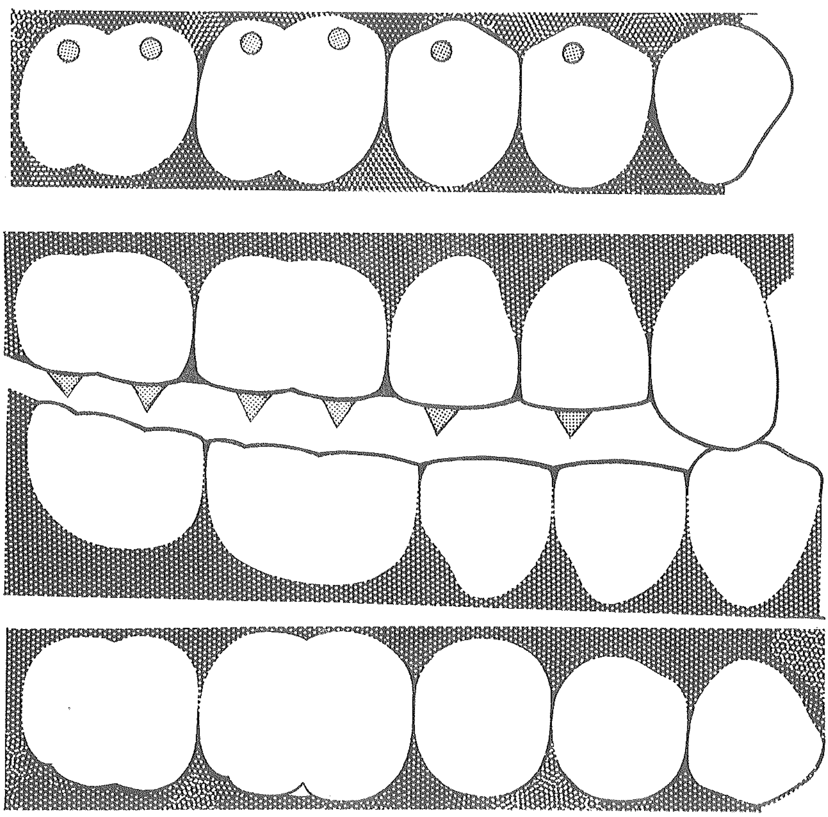

Fig. 444. The placement of the buccal cusp cones (dotted areas) of the upper teeth. Each cone is carefully placed so that it has the correct length, mesiodistal position, and buccolingual position (see text).

Wax is applied in very small amounts with a fine spatula, explorer, or a pair of college pliers. Begin by placing a small amount on the upper buccal cusp tips, starting with the first bicuspid and proceeding to the last molar.

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*Kerr Manufacturing Company, Detroit, Mich.

†Slaycris Laboratory, Portland, Ore.

The upper buccal tips must be placed so that they have the correct buccolingual position, length, and mesiodistal position (Fig. 444).

1. Correct buccolingual position. This can be determined by visualizing the lower buccal cusps and allowing for a normal buccal overjet.

2. Proper length. A gentle curve of Spee may be established by eye. Another method is to use a semaphore flag and a pair of calipers for examining the anteroposterior curve. With the hinge axis as a center and a suitable radius, an arc is scribed on the adhesive tape on the semaphore. With the same radius but the incisal edge of the upper anteriors as a center, the first arc is intersected. Now with this as a center and a radius starting from the tip of the cuspid, a suitable arc may be developed. It may be necessary to change the center on the semaphore along the arc scribed from the hinge axis. This is an approximate procedure and merely an aid in establishing a gentle curve of Spee.

3. Correct mesiodistal position. This is tested by moving the articulator in the working relation for the side being examined. The buccal cusp tips of the upper bicuspids should pass distal to the visualized lower buccal cusps with ample clearance. The buccal cusps of the upper molars should pass through the opposing embrasures between the visualized lower molar buccal cusps.

The length and position of the upper buccal cusp tips must now be checked to ensure clearance with the visualized lower buccal cusps when the articulator is moved into the protrusive and lateral protrusive relations.

Placement of upper lingual cusp cones (Fig. 445)

1. The lingual cusp tip of the upper first bicuspid is placed so that it will fall into the visualized distal fossa of the lower first bicuspid. This cusp tip will be slightly shorter than the upper buccal cusp tip.

2. The lingual cusp tip of the upper second bicuspid is placed so that it will fall into the visualized distal fossa of the lower second bicuspid. Its length is about the same as that of the upper buccal cusp tip.

3. The mesiolingual cusp tip of the upper first molar is placed so that it will close into the visualized central fossa of the lower first molar. This cusp tip will appear to be between the buccal cusp tips of the upper first molar when viewed from the buccal aspect. It is slightly longer than the buccal cusp tips.

In the working relation, the mesiolingual cusp tip of the upper first molar will pass between the visualized lingual cusp tips of the lower first molar. In the balancing relation, the mesiolingual cusp tip will pass between the visualized buccal and distobuccal cusp tips of the lower first molar. In the protrusive and lateral protrusive relations, it will clear the visualized cusp tips of the lower first molar.

4. The distolingual cusp tip of the upper first molar is placed so that it will close into the visualized distal fossa of the lower first molar. It is a little shorter than the mesiolingual cusp tip of the same tooth.

In the working relation, this cusp tip will pass distal to the visualized disto-

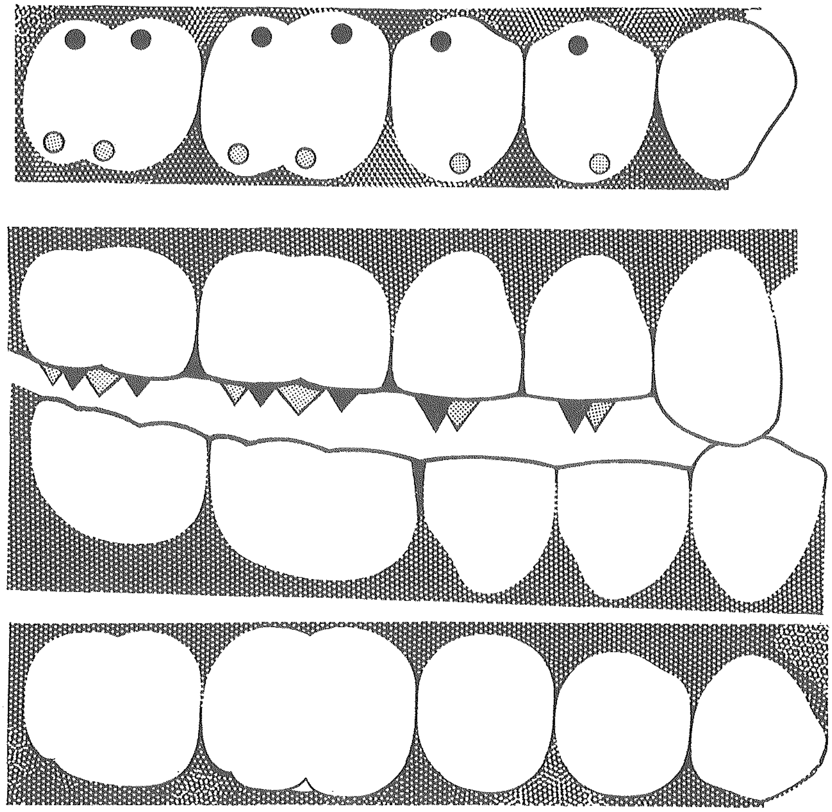


Fig. 445. The upper lingual cusp cones (dotted areas) are carefully placed as to length and position (see text for exact locations and relations to the other cusps).

lingual cusp tip of the lower first molar. In the protrusive and lateral protrusive relations, it will clear the visualized mesiolingual cusp tip of the next molar behind. In the balancing relation, it will clear the visualized mesiobuccal cusp tip of the next molar behind.

5. The mesiolingual and distolingual cusp tips of the upper second molar are placed exactly the same as the corresponding cusp tip of the upper first molar.

Before proceeding to the prepared lower teeth, re-examine the upper cusp tips. There should be a gradual curve anteroposteriorly (the curve of Spee) and a smooth curve buccolingually from side to side (the curve of Wilson). Any necessary changes should be made.

Placement of lower buccal cusp cones

A thin coating of wax is applied over the prepared teeth and joined interproximally to prevent their dislodgement.

1. The buccal cusp tip of the lower first bicuspid is placed so that it will

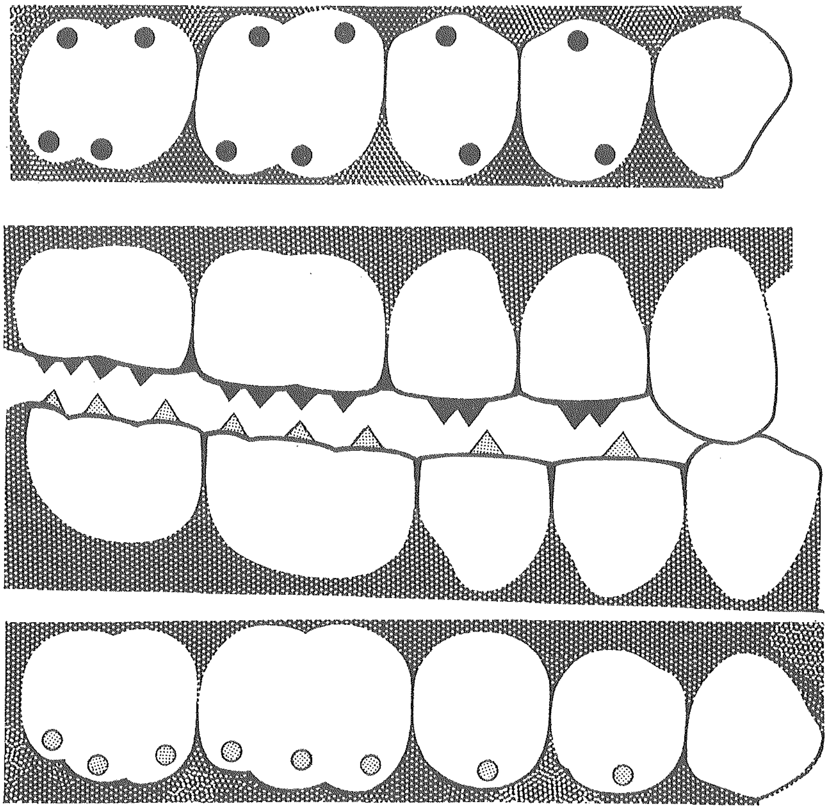


Fig. 446. The lower buccal cusp cones (dotted areas) are carefully placed and checked for length and position. Their relation to the previously established upper cones is extremely important (see text).

close into the visualized mesial fossa of the upper first bicuspid (Fig. 446). There must be enough room distal to the upper cuspid to permit the mesial marginal ridge of the upper first bicuspid to be placed in front of the buccal cusp tip of the lower first bicuspid. The length of the lower first bicuspid cusp tip is tested by moving the articulator into the protrusive and lateral protrusive relations. This cusp tip should contact the upper cuspid in the protrusive relation as a balancing relationship. In the working relation, it should pass mesial to the upper first bicuspid cusp tip without contact.

2. The cusp tip of the lower second bicuspid is placed so that it will close into the visualized mesial fossa of the upper second bicuspid. In the protrusive and lateral protrusive relations, it will clear the upper first bicuspid cusp tip. In the balancing relation, it will have clearance beneath the lingual cusp tip of the upper first bicuspid. In the working relation, it will pass mesial to the buccal cusp tip of the upper second bicuspid without contact.

3. The mesiobuccal cusp tip of the lower first molar is placed so that it will seat in the visualized mesial fossa of the upper first molar. This means that it

must be far enough distally to allow room for the mesial marginal ridge of the upper first molar to be in front of it. There is no contact of the mesiobuccal cusp tip of the lower first molar with any cusp tips of the upper teeth in any relation.

In the working occlusion, this cusp tip is mesial to the mesiobuccal cusp point of the upper first molar.

4. The buccal cusp tip of the lower first molar is placed so that it closes into the central fossa of the upper first molar. There is clearance with the upper cusp tips in all the relations. In the working relation, the mesiobuccal cusp tip of the upper first molar passes between the mesiobuccal and buccal cusp tips of the lower first molar. In the balancing position, the mesiolingual cusp tip of the upper first molar is distal to the buccal cusp tip of the lower first molar.

5. The distobuccal (fifth cusp) cusp tip of the lower first molar is placed so that it will close into the visualized distal fossa of the upper first molar. There must be room for the distal marginal ridge of the upper first molar to be developed so that it will be behind the newly placed distobuccal cusp of the lower first molar.

There is clearance with the opposing cusp tips in every relation. In the working position, the distobuccal cusp tip of the upper first molar is between the buccal and distobuccal cusp tips of the lower first molar. In the balancing position, the mesiolingual cusp tip of the upper first molar is between the buccal and distobuccal cusp tips of the lower first molar.

6. The buccal cusp tips of the lower second molar are placed in the same manner as those of the lower first molar.

Placement of lower lingual cusp cones (Fig. 447)

1. The lingual cusp tip of the lower first bicuspid is small and provides a lingual point for the lingual marginal ridge. In the working position, this cusp tip will be mesial to the lingual cusp tip of the upper first bicuspid.

2. There may be one or two tips to the lingual cusp of the lower second bicuspid, depending upon its shape. These cusp tips are slightly longer than the lingual cusp tip of the lower first bicuspid, but not so long as the lingual cusp tips of the lower first molar. Thus the gentle curves of the occlusal plane are formed. These cusp tips do not touch the tip of the lingual cusp of the upper first bicuspid in the protrusive position. In the working position, the tip of the lingual cusp of the lower second bicuspid will be under or in front of the tip of the lingual cusp of the upper second bicuspid.

3. The mesiolingual and distolingual cusp tips of the lower first molar are placed and continue to carry out a gentle curve to the plane of occlusion. There is clearance in all the relations. The mesiolingual cusp tip of the upper first molar is in-between these two lingual cusp tips of the lower first molar in the working position. The distolingual cusp tip of the upper first molar is distal to the distolingual cusp tip of the lower first molar in the working position.

4. The mesiolingual and distolingual cusp tips of the lower second molar are placed in the same manner as those of the lower first molar.

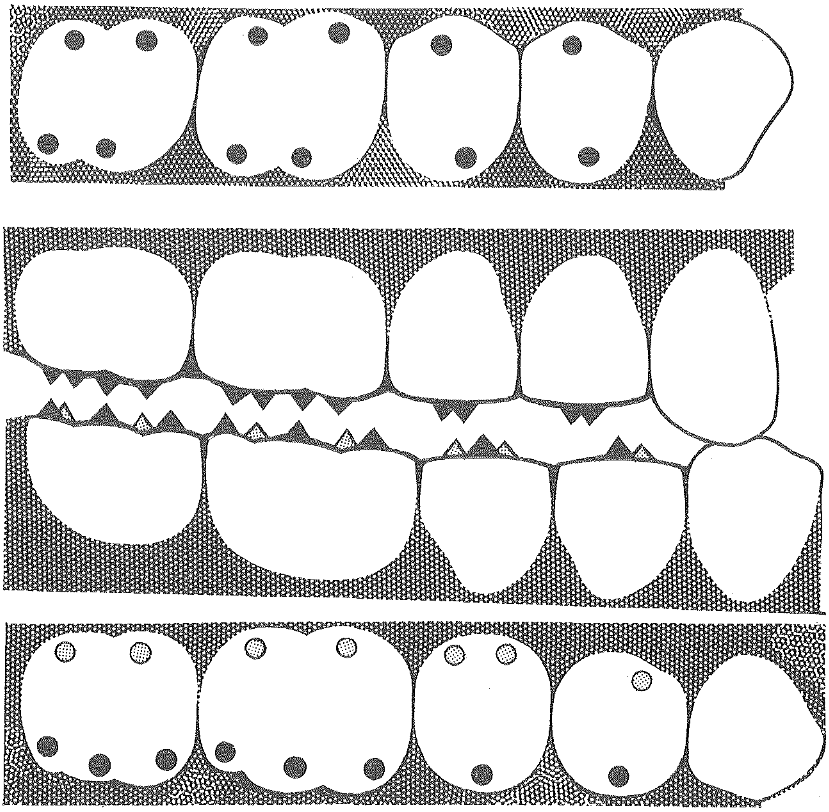


Fig. 447. The lower lingual cusp cones (dotted areas) are carefully placed and checked for length and position. Their relation to the previously placed cones is extremely important (see text).

All the cusp tips are now placed. Because they are extremely important, it is advisable to re-examine the relations very carefully to determine whether any improvements can be made.

Placement of marginal ridges of upper teeth (Fig. 448)

1. To form the mesial marginal ridge, a thin ridge of wax is applied from the buccal cusp tip of the upper first bicuspid to the lingual cusp tip, following the contour of the visualized occlusal surface. This marginal ridge will be mesial to the buccal cusp tip of the lower first bicuspid when the articulator is closed in centric relation. It forms the mesial wall of the fossa of the upper first bicuspid. There should be clearance with the tip of the buccal cusp of the lower first bicuspid in the various excursions.

2. The distal marginal ridge of the upper first bicuspid is placed from the tip of the lingual cusp to the tip of the buccal cusp. Clearance with the buccal cusp tip of the lower second bicuspid should be checked in the various excursions.

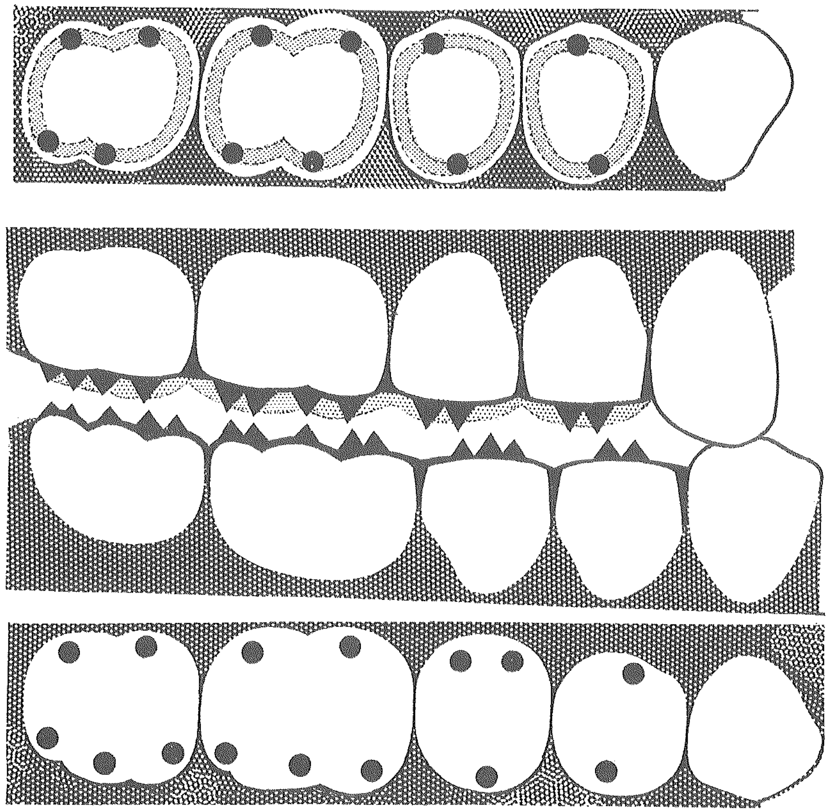


Fig. 448. The upper marginal ridges (broken lines) are placed from cusp cone to cusp cone and in definite relationship to the lower cusp cones.

The buccal and lingual contours are placed from the marginal ridges to the edges of the preparations on the casts. The occlusal surface of the upper first bicuspid should now resemble the open mouth of a fish.

3. The mesial and distal marginal ridges of the upper second bicuspid are placed in the same way, with clearance in all relations between these ridges and the tip of the buccal cusp of the lower second bicuspid and the tip of the mesiobuccal cusp of the lower first molar. The buccal and lingual contours are finished to the edges of the preparations.

4. The mesial marginal ridge of the upper first molar is established from the mesiobuccal cusp tip to the mesiolingual cusp tip. This ridge will be in front of the mesiobuccal cusp tip of the lower first molar when the jaw is in centric relation. The lingual marginal ridge of the upper first molar is next established from the tip of the mesiolingual cusp to the tip of the distolingual cusp. The working position should be checked to ensure clearance between this ridge and the distolingual cusp tip of the lower first molar. The distal marginal ridge of the upper first molar is established from the distolingual cusp tip to the distobuccal

cusp tip. In centric relation, this marginal ridge is distal to the distobuccal cusp tip of the lower first molar. Clearance of this ridge with the distobuccal cusp tip of the lower first molar should be checked in the various relations. The buccal marginal ridge of the upper first molar is now established from the distobuccal cusp tip to the mesiobuccal cusp tip. In the working relation, the buccal cusp tip of the lower first molar is between the two upper buccal cusp tips without contact.

The buccal and lingual contours are finished to the edges of the preparations on the cast.

5. The marginal ridges of the upper second molar are built in the same manner and with the same clearances as the marginal ridges of the upper first molar.

Placement of marginal ridges of lower teeth (Fig. 449)

1. The mesial marginal ridge of the lower first bicuspid is formed by applying a thin ridge of wax from the buccal cusp tip to the lingual cusp tip. This marginal ridge is the *only* ridge that makes contact with the opposing tooth struc-

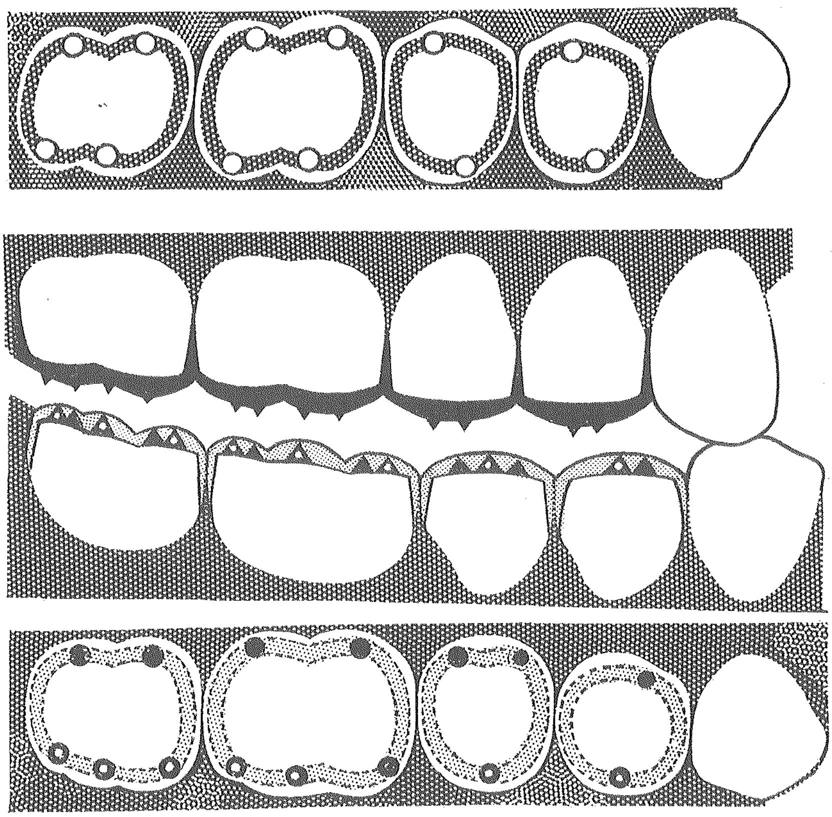


Fig. 449. The lower marginal ridges (broken lines) are placed from cusp cone to cusp cone and in definite relationship to the upper cusp cones and marginal ridges (see text).

ture—the distal part of the upper cuspid. There should be contact between the mesial portion of the buccal marginal ridge of the lower first bicuspid and the upper cuspid in the protrusive and lateral protrusive positions.

2. The distal marginal ridge of the lower first bicuspid is established from the lingual cusp tip distally and around to the buccal cusp tip. This marginal ridge should be distal to the tip of the lingual cusp of the upper first bicuspid in centric relation.

3. The mesial and distal marginal ridges of the lower second bicuspid are established in the same way as those of the lower first bicuspid, except that there is clearance in every relation. The buccal and lingual contours are filled in to the margins of the preparations on the cast.

4. From the mesiobuccal cusp tip of the lower first molar, a ridge is placed mesially around and back to the mesiolingual cusp point. It is checked for clearance in the various relations.

5. The mesiolingual cusp tip is joined to the distolingual cusp tip of the lower first molar with a marginal ridge. There must be no contact between the

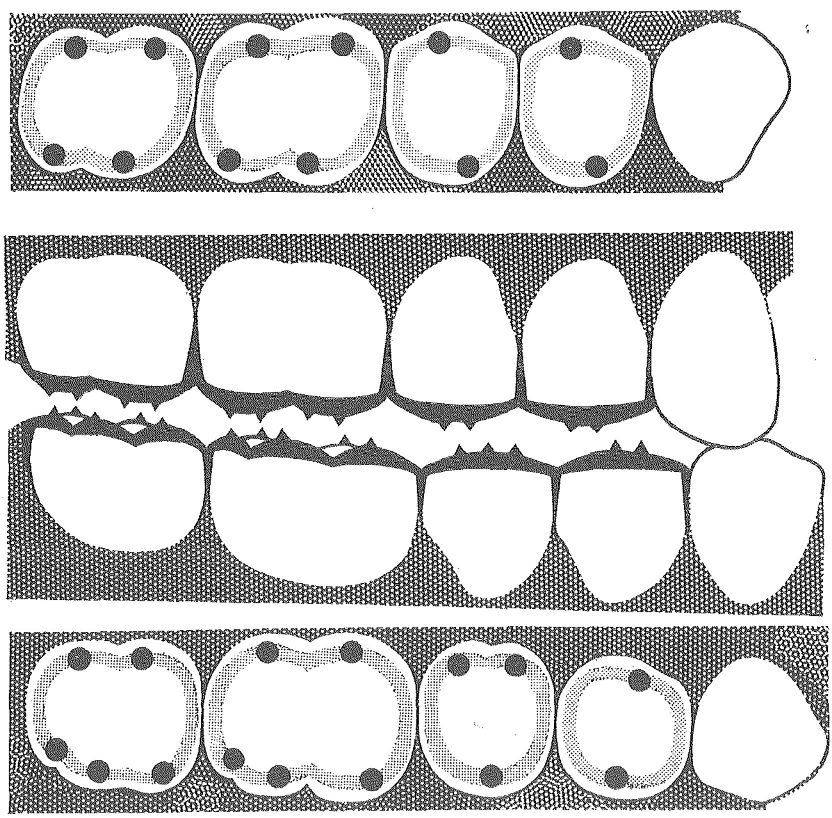


Fig. 450. The completed marginal ridges.

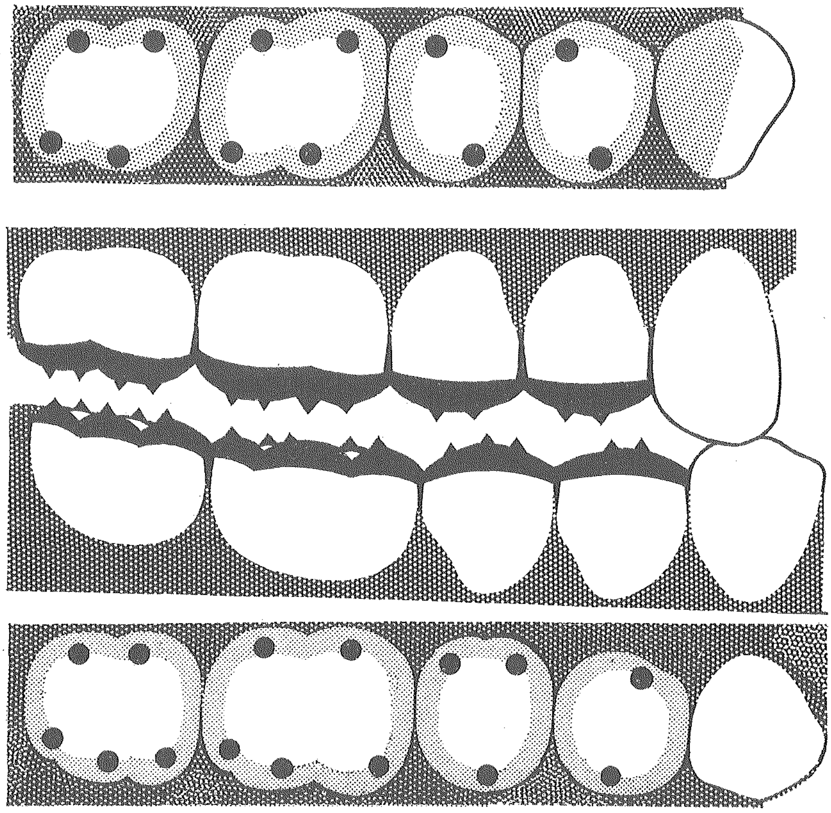


Fig. 451. The buccal and lingual contours are filled in to the margins of the preparations.

mesiolingual cusp tip of the upper first molar and this newly formed ridge in the working relation.

6. From the distolingual cusp tip of the lower first molar, the marginal ridge is continued distally to the distobuccal cusp tip. In centric relation, this marginal ridge should be distal to the distolingual cusp tip of the upper first molar. There should be clearance in the other positions.

7. The distobuccal cusp tip of the lower first molar is joined to the buccal cusp tip with a marginal ridge, which is tested for clearance. In the working relation, the distobuccal cusp tip of the upper first molar is between the distobuccal and buccal cusp tips of the lower first molar. In the balancing position, the mesiolingual cusp tip of the upper first molar is over the groove between the buccal and distobuccal cusp tips of the lower first molar.

8. The marginal ridges of the lower first molar are completed by joining the tips of the buccal and mesiobuccal cusps with a marginal ridge. In the working relation, the mesiobuccal cusp of the upper first molar is over this marginal ridge, which must have a groove in it for clearance. The buccal and lingual contours are filled in to the margins of the preparations on the casts.

9. The marginal ridges of the lower second molar are formed in the same manner. There must be clearance in every relation.

Fig. 450 Shows the completed marginal ridges. In Fig. 451, the buccal and lingual contours are filled in to the margins of the preparations.

Placement of triangular, transverse, and oblique ridges of upper teeth (Fig. 452)

1. A ridge of wax is placed from the buccal cusp tip of the upper first bicuspid down into the visualized central fossa. Another ridge is applied from the lingual cusp tip down into the visualized central fossa. In centric relation, the distal slope of the buccal marginal ridge of the lower first bicuspid crosses and contacts the buccal triangular ridge of the upper first bicuspid. There must be clearance in the other relations.

2. The triangular ridges of the upper second bicuspid are placed in the same way. There is contact between the buccal triangular ridge of the upper second bicuspid as it crosses the distal slope of the buccal marginal ridge of the lower second bicuspid.

3. On the upper first molar, a triangular ridge is placed from the mesiobuccal cusp tip to the visualized central pit. It runs backward somewhat diagonally. In centric relation, this ridge crosses the distal slope of the marginal ridge of the mesiobuccal cusp of the lower first molar. All other excursions must have clearance.

4. A ridge is placed from the mesiolingual cusp tip of the upper first molar extending to the pit of the visualized central fossa. It must be tested for clearance in all eccentric relations.

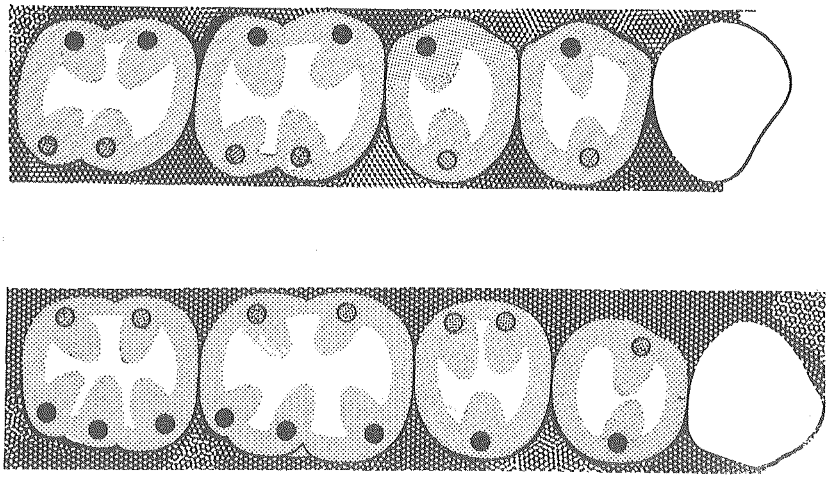


Fig. 452. The transverse and oblique ridges are placed from the cusp cones to their respective fossae (see text).

5. The oblique ridge of the upper first molar runs obliquely forward from the distobuccal cusp tip pointing to the upper first molar of the opposite side of the arch. As this ridge reaches the middle of the molar, it is divided by the mesiodistal central groove. The lingual portion is more prominent and turns in a more forward direction, pointing toward the upper cuspid on the opposite side of the arch. The buccal portion of the oblique ridge of the upper first molar contacts the groove of the marginal ridge between the buccal and distobuccal cusp tips of the lower first molar. There must be clearance in all eccentric relations.

6. A short ridge runs from the distolingual cusp tip of the upper first molar into the visualized distal pit. It must be tested for clearance in the excursions.

7. The triangular and oblique ridges of the upper second molar are formed in the same manner and have the same relationship to the lower second molar as those of the upper first molar have to the lower first molar.

Placement of triangular ridges of lower teeth (Fig. 452)

1. A ridge of wax is placed from the tip of the buccal cusp of the lower first bicuspid to the visualized central groove. It is then carried to the tip of the lingual cusp. In centric relation, the buccal portion of the triangular ridge of the lower first bicuspid contacts the inner aspect of the mesial portion of the lingual marginal ridge of the upper first bicuspid. The lingual portion of this triangular ridge (running from the tip of the lingual cusp of the lower first bicuspid to the central groove) should contact the lingual side of the mesial portion of the lingual marginal ridge of the upper first bicuspid. There should be clearance in the eccentric relations.

2. The triangular ridges of the lower second bicuspid are placed in a similar manner to those of the lower first bicuspid, with this exception. When two cusps are used on the lingual aspect of the lower second bicuspid, contact is made between the distolingual triangular ridge of the lower second bicuspid and the lingual side of the mesial portion of the lingual marginal ridge of the upper second bicuspid. There should be clearance in the eccentric relations.

3. The triangular ridges of the lower first molar run from each tip toward the visualized central pit. They radiate like the spokes of a wheel. The ridge from the mesiobuccal cusp tip of the lower first molar contacts the mesiolingual ridge of the upper first molar. The ridge from the buccal cusp tip of the lower first molar contacts the lingual portion of the oblique ridge of the upper first molar. The ridge of the distobuccal cusp tip of the lower first molar contacts the distolingual ridge of the upper first molar. The mesiolingual triangular ridge of the lower first molar contacts the mesial portion of the lingual surface of the marginal ridge of the mesiolingual cusp of the upper first molar. The distolingual triangular ridge of the lower first molar makes contact with the distal aspect of the lingual surface of the oblique ridge of the mesiolingual cusp of the upper first molar (actually with the dip in the lingual marginal ridge between the mesiolingual

cusp and the distolingual cusp). There must be clearance in all the eccentric relations.

4. The triangular ridges of the lower second molar are formed in the same way as those of the lower first molar.

Completion of fossae

Carving of developmental grooves. At this stage of the carving, there are openings between the ridges. Small amounts of wax are placed in these openings, and the articulator is carefully closed with each addition. Excess wax is removed. The developmental grooves are carved in these wax additions between the cusp lobes (Fig. 453). There is a developmental groove under each cusp tip. The tips, however, never touch the bottom of the grooves.

Carving of supplemental grooves. A supplemental groove is carved along the sides of each ridge (Fig. 453). This enhances the sharpness of the ridges. The grooves are patterned after those in good, unworn natural teeth.

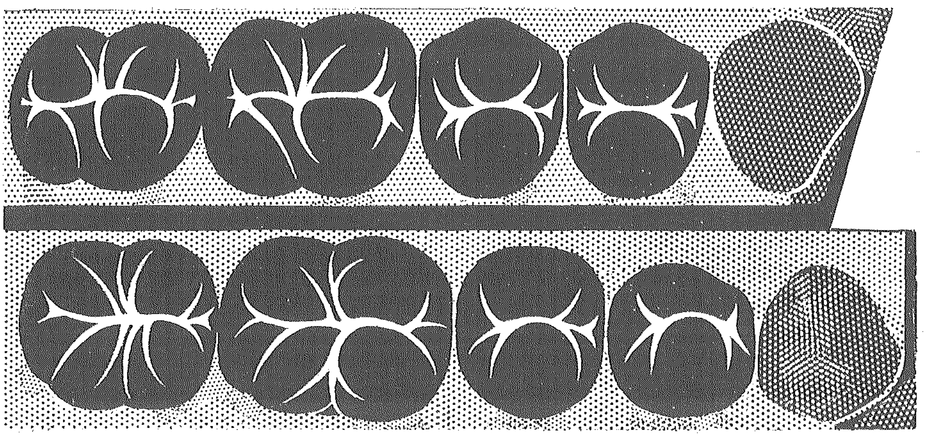


Fig. 453. The fossae are filled in, and the developmental grooves are carved between each cusp lobe. The sharpness of the ridge is enhanced by the supplemental grooves.

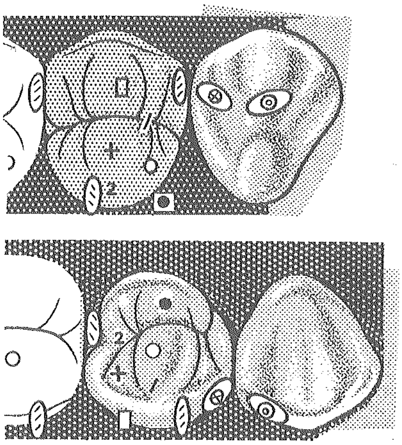
Final examination of contacts in centric relation

The waxed-up articulation is now re-examined for proper contacts.

The contacts of the upper and lower teeth are checked by the simple procedure of dusting talcum powder on the wax carvings and gently closing the articulator a few times. The points of contact will appear through the talcum dust.

As we view the *upper* carvings, the points of contact in centric relation should be as follows.

Upper cuspid (Fig. 454). (1) On the mesiolingual surface, a contact made by the distobuccal surface of the lower cuspid; (2) on the distolingual surface, a



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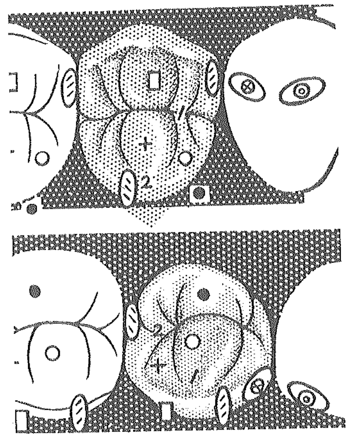

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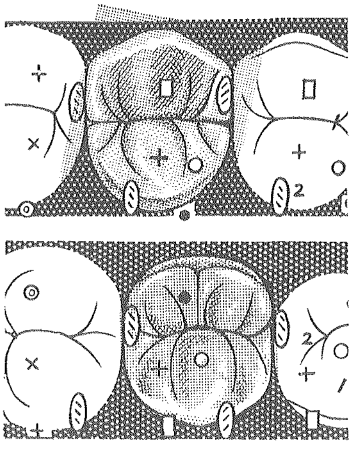
Fig. 454. Correlation of the contacting areas in centric relation of the upper and lower cuspids.
Fig. 455. Correlation of the contacting areas in centric relation of the upper and lower first bicuspids.

contact made by the outer surface of the mesiobuccal marginal ridge of the lower first bicuspid.

Upper first bicuspid (Fig. 455). (1) On the mesial marginal ridge, a contact made by the mesiobuccal marginal ridge of the lower first bicuspid; (2) on the buccal triangular ridge, a contact made by the buccal surface of the distal slope of the buccal marginal ridge of the lower first bicuspid; (3) on the distal portion of the lingual marginal ridge, a contact made by the distal marginal ridge of the lower first bicuspid; (4) on the lingual triangular ridge, a contact made by the inner aspect of the distobuccal marginal ridge of the lower first bicuspid; (5) on the inner aspect of the mesiolingual marginal ridge, a contact made by the buccal triangular ridge of the lower first bicuspid; (6) on the lingual side of the mesiolingual marginal ridge, a contact made by the lingual triangular ridge of the lower first bicuspid.

Upper second bicuspid (Fig. 456). (1) On the mesial marginal ridge, a contact made by the mesiobuccal marginal ridge of the lower second bicuspid; (2) on the buccal triangular ridge, a contact made by the buccal surface of the distal slope of the buccal marginal ridge of the lower second bicuspid; (3) on the distal portion of the lingual marginal ridge, a contact made by the distal marginal ridge of the lower second bicuspid; (4) on the lingual triangular ridge, a contact made by the inner aspect of the distobuccal marginal ridge of the lower second bicuspid; (5) on the inner aspect of the mesiolingual marginal ridge, a contact made by the buccal triangular ridge of the lower second bicuspid; (6) on the lingual side of the mesiolingual marginal ridge, a contact made by the distolingual triangular ridge of the lower second bicuspid.



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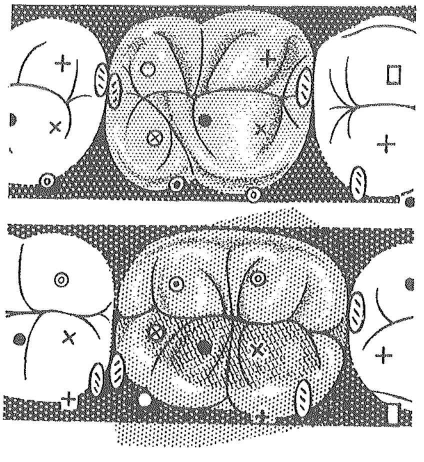

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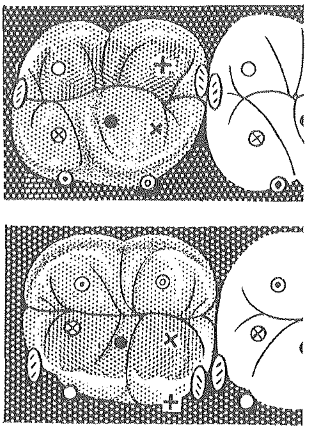

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Fig. 456. Correlation of the contacting areas in centric relation of the upper and lower second bicuspids.
Fig. 457. Correlation of the contacting areas in centric relation of the upper and lower first molars.
Fig. 458. Correlation of the contacting areas in centric relation of the upper and lower second molars.

Upper first molar (Fig. 457). (1) On the mesial marginal ridge, a contact made by the mesial slope of the marginal ridge of the mesiobuccal cusp of the lower first molar; (2) on the mesiobuccal triangular ridge, a contact made by the distal slope of the marginal ridge of the mesiobuccal cusp of the lower first molar; (3) on the oblique ridge of the distobuccal cusp, a contact made by the groove between the buccal and distobuccal cusps of the lower first molar; (4) on the distal marginal ridge, a contact made by the distal slope of the marginal ridge of the distobuccal cusp of the lower first molar; (5) on the distolingual triangular ridge, a contact made by the triangular ridge of the distobuccal cusp of the lower first molar; (6) on the lingual surface of the lingual marginal ridge as the marginal ridge dips from the mesiolingual cusp to the distolingual cusp, a contact made by the distolingual triangular ridge of the lower first molar; (7) on the mesial portion of the lingual surface of the lingual marginal ridge of the mesiolingual cusp, a contact made by the mesiolingual triangular ridge of the lower first molar; (8) on the lingual portion of the oblique ridge (on the mesiolingual cusp), a contact made by the buccal triangular ridge of the lower first molar; (9) on the mesiolingual triangular ridge, a contact made by the mesiobuccal triangular ridge of the lower first molar.

Upper second molar (Fig. 458). (1) On the mesial marginal ridge, a contact made by the mesial slope of the marginal ridge of the mesiobuccal cusp of the lower second molar; (2) on the mesiobuccal triangular ridge, a contact made by the distal slope of the marginal ridge of the mesiobuccal cusp of the lower second molar; (3) on the oblique ridge of the distobuccal cusp, a contact made by the groove between the buccal and distobuccal cusps of the lower second molar; (4) on the distal marginal ridge, a contact made by the distal slope of the marginal ridge of the distobuccal cusp of the lower second molar; (5) on the distolingual triangular ridge, a contact made by the triangular ridge of the distobuccal cusp of the lower second molar; (6) on the lingual surface of the lingual marginal ridge as the marginal ridge dips from the mesiolingual cusp to the distolingual cusp, a contact made by the distolingual triangular ridge of the lower second molar; (7) on the mesial portion of the lingual surface of the lingual marginal ridge of the mesiolingual cusp, a contact made by the mesiolingual triangular ridge of the lower second molar; (8) on the lingual portion of the oblique ridge (on the mesiolingual cusp), a contact made by the buccal triangular ridge of the lower second molar; (9) on the mesiolingual triangular ridge, a contact made by the mesiobuccal triangular ridge of the lower second molar.

As we view the *lower* wax carvings, the points of contact in centric relation should be as follows.

Lower cuspid (Fig. 454). On the distobuccal surface, a contact made by the mesiolingual surface of the upper cuspid.

Lower first bicuspid (Fig. 455). (1) On the outer surface of the mesiobuccal marginal ridge, a contact made by the distolingual surface of the upper cuspid; (2) on the mesiobuccal marginal ridge, a contact made by the mesial marginal ridge of the upper first bicuspid; (3) on the buccal triangular ridge, a contact made by the inner aspect of the mesiolingual marginal ridge of the upper first bicuspid; (4) on the buccal surface of the distal slope of the buccal marginal ridge, a contact made by the buccal triangular ridge of the upper first bicuspid; (5) on the inner aspect of the distobuccal marginal ridge, a contact made by the lingual triangular ridge of the upper first bicuspid; (6) on the distal marginal ridge, a contact made by the distal portion of the lingual marginal ridge of the upper first bicuspid; (7) on the lingual triangular ridge, a contact made by the lingual side of the mesiolingual marginal ridge of the upper first bicuspid.

Lower second bicuspid (Fig. 456). (1) On the mesiobuccal marginal ridge, a contact made by the mesial marginal ridge of the upper second bicuspid; (2) on the buccal triangular ridge, a contact made by the inner aspect of the mesiolingual marginal ridge of the upper second bicuspid; (3) on the buccal surface of the distal slope of the buccal marginal ridge, a contact made by the buccal triangular ridge of the upper second bicuspid; (4) on the inner aspect of the distobuccal marginal ridge, a contact made by the lingual triangular ridge of the upper second bicuspid; (5) on the distal marginal ridge, a contact made by the distal portion of the lingual marginal ridge of the upper first bicuspid; (6) on the distolingual triangular ridge, a contact made by the lingual side of the mesiolingual marginal ridge of the upper second bicuspid.

Lower first molar (Fig. 457). (1) On the mesial slope of the marginal ridge of the mesiobuccal cusp, a contact made by the mesial marginal ridge of the upper first molar; (2) on the mesiobuccal triangular ridge, a contact made by the mesiolingual triangular ridge of the upper first molar; (3) on the distal slope of the marginal ridge of the mesiobuccal cusp, a contact made by the mesiobuccal triangular ridge of the upper first molar; (4) on the buccal triangular ridge, a contact made by the lingual portion of the oblique ridge (on the mesiolingual cusp) of the upper first molar; (5) on the groove between the buccal and distobuccal cusps, a contact made by the oblique ridge of the distobuccal cusp of the upper first molar; (6) on the distal slope of the marginal ridge of the distobuccal cusp, a contact made by the distal marginal ridge of the upper first molar; (7) on the triangular ridge of the distobuccal cusp, a contact made by the distolingual triangular ridge of the upper first molar; (8) on the distolingual triangular ridge, a contact made by the lingual surface of the lingual marginal ridge as the marginal

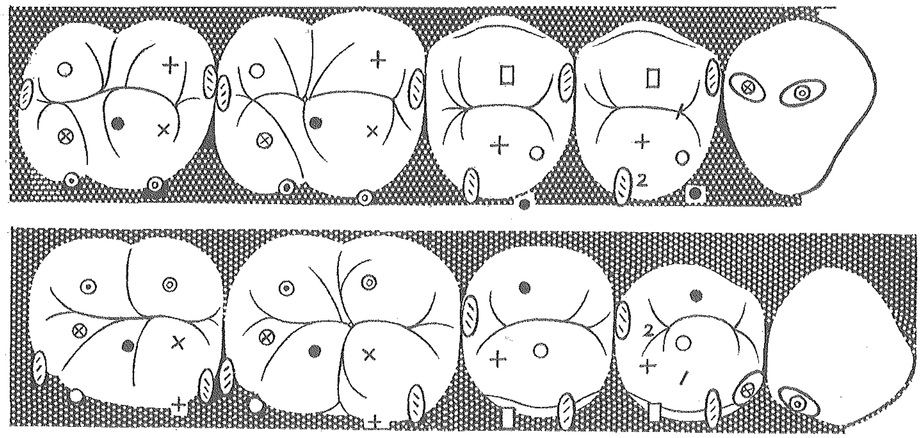

Fig. 459. Correlation of the contacting areas in centric relation of the upper and lower teeth.

ridge dips from the mesiolingual cusp to the distolingual cusp of the upper first molar; (9) on the mesiolingual triangular ridge, a contact made by the mesial portion of the lingual surface of the lingual marginal ridge of the mesiolingual cusp of the upper first molar.

Lower second molar (Fig. 458). (1) On the mesial slope of the marginal ridge of the mesiobuccal cusp, a contact made by the mesial marginal ridge of the upper second molar; (2) on the mesiobuccal triangular ridge, a contact made by the mesiolingual triangular ridge of the upper second molar; (3) on the distal slope of the marginal ridge of the mesiobuccal cusp, a contact made by the mesiobuccal triangular ridge of the upper second molar; (4) on the buccal triangular ridge, a contact made by the lingual portion of the oblique ridge (on the mesiolingual cusp) of the upper second molar; (5) on the groove between the buccal and distobuccal cusps, a contact made by the oblique ridge of the distobuccal cusp of the upper second molar; (6) on the distal slope of the marginal ridge of the distobuccal cusp, a contact made by the distal marginal ridge of the upper second molar; (7) on the triangular ridge of the distobuccal cusp, a contact made by the distolingual triangular ridge of the upper second molar; (8) on the distolingual triangular ridge, a contact made by the lingual surface of the lingual marginal ridge as the marginal ridge dips from the mesiolingual cusp to the distolingual cusp of the upper second molar; (9) on the mesiolingual triangular ridge, a contact made by the mesial portion of the lingual surface of the lingual marginal ridge of the mesiolingual cusp of the upper first molar.

Fig. 459 shows the correlation of the contacting areas in centric relation of the upper and lower teeth.

The next step is to separate the wax patterns and transfer them to the individual dies for marginal adaptation and contact adjustment. They are then sprued and cast in a hard gold.

CHAPTER 14

Diagnosis

It might appear appropriate to consider the subject of diagnosis rather early in a work of this nature, perhaps at the beginning. However, I disagree. Before it is possible to make a diagnosis, certain knowledge is necessary, and the preceding chapters were developed with the objective of laying the groundwork for intelligent diagnosis, as I understand it.

THE FIRST APPOINTMENT

At the first appointment, it is necessary to obtain a complete set of radiographs and to take accurate impressions for study casts. In addition, a conventional face-bow mounting and a centric relation record must be taken, which will enable us to mount the study casts in a fairly accurate relationship to each other.

The next step is to make a preliminary clinical examination, observing how the teeth come together. After adequate cheek retraction, the patient closes the jaws in the terminal hinge position, and the relationship of the mandibular teeth to the maxillary teeth as they approach each other in the centric relationship of the jaws is carefully noted. Prematurities in the centric relation closure are looked for, and a record of the tooth or teeth causing the eccentric slip is made. Examine the articulation in the various excursions—protrusive, right lateral, and left lateral—noting its general character. Obviously, the complete picture cannot be seen until the casts are properly mounted on an adjustable articulator.

Next, test the mobility of the teeth and note the presence and location of any periodontal pockets. The general condition of the periodontium is evaluated.

Since it is helpful to have some pictures of the mouth, the anterior tooth arrangement should be photographed for future reference and comparison.

Before the first appointment is over, it is advisable to have a discussion with the patient about his dental history and problems. Are there any habits that might affect his dental condition? It is also important to know something of his general health. When did he have the last physical checkup? What treatment, if any, is he undergoing? What medication is he taking at the present time? It is good, too, to learn something about his business and social life. No details—just general information.

As a result of the efforts during this initial appointment, certain valuable data have been gathered which will enable us, after some consideration, to present an intelligent diagnosis to the patient.

For example, some idea of the particular problems of the patient has been obtained. His reactions to the procedures of taking impressions, radiographs, and face-bow and centric relation records have been observed. This is important! Some patients who need full-mouth rehabilitation cannot possibly endure the procedures involved, and it is best to find this out at the very beginning. From the evaluation of the patient's general health, one may conclude that some systemic conditions contraindicate extensive treatment. A patient who has suffered several coronary attacks is hardly a candidate for extensive treatment. A patient with uncontrolled diabetes is a poor risk by virtue of the condition of his periodontium.

From the general discussion during the first appointment, it may be possible to get some clue to the patient's emotional status. Frequently this is difficult to do, and it is wise to proceed with caution. Emotional instability, however, is a hazard with which the best dental practitioner may be unable to cope.

Before the examination is finished, one will be able to decide whether treatment is indicated. It is now practical to determine whether treatment is likely to be undertaken. If the diagnosis is to be completed, considerable work will have to be done. Clutches will have to be made, registrations taken, the articulator adjusted, and study casts mounted. It is ridiculous to carry out all these procedures if there are strong doubts about the patient's desire to undergo treatment.

How does one decide whether to proceed with the diagnosis?

When one first begins to practice this type of dentistry, it is rather difficult to judge whether a patient is willing or able to undergo such a procedure. Therefore, he may have to gamble the investment of his time and efforts. Occasionally he may lose. After doing this work for some time, however, one will find that most of the patients who come to him are aware of what is involved and are more likely to submit to treatment. Of course, there are always the shoppers. These can be eliminated by quoting a reasonable diagnostic fee. If they will not pay for a good diagnosis, they surely would not be interested in extensive dental treatment.

If we are reasonably sure that the patient will be guided by our recommendations, an appointment should be made for the registrations.

COMPLETION OF DIAGNOSIS

At the second appointment, in addition to registrations, a face-bow transfer and a centric relation record will be taken.

Between the second and third appointments, the articulator will be set from

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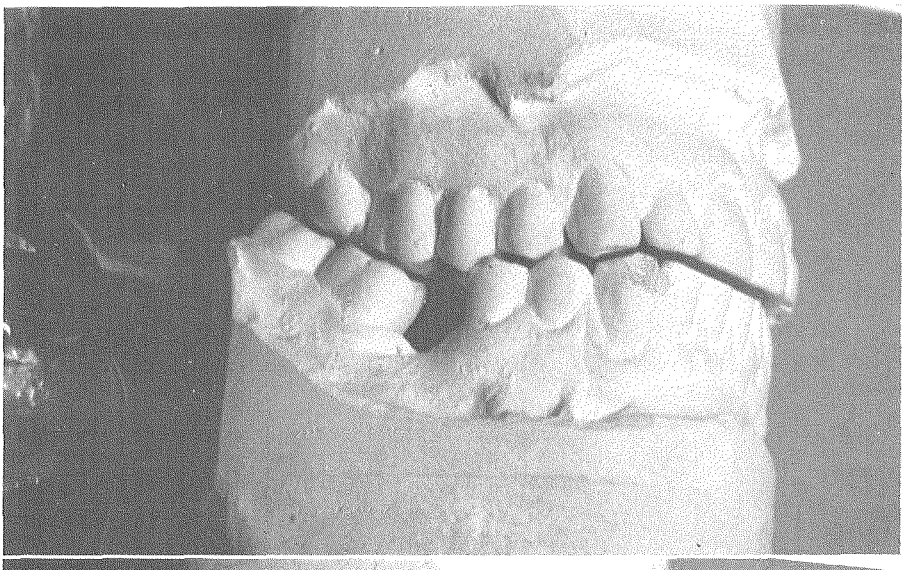

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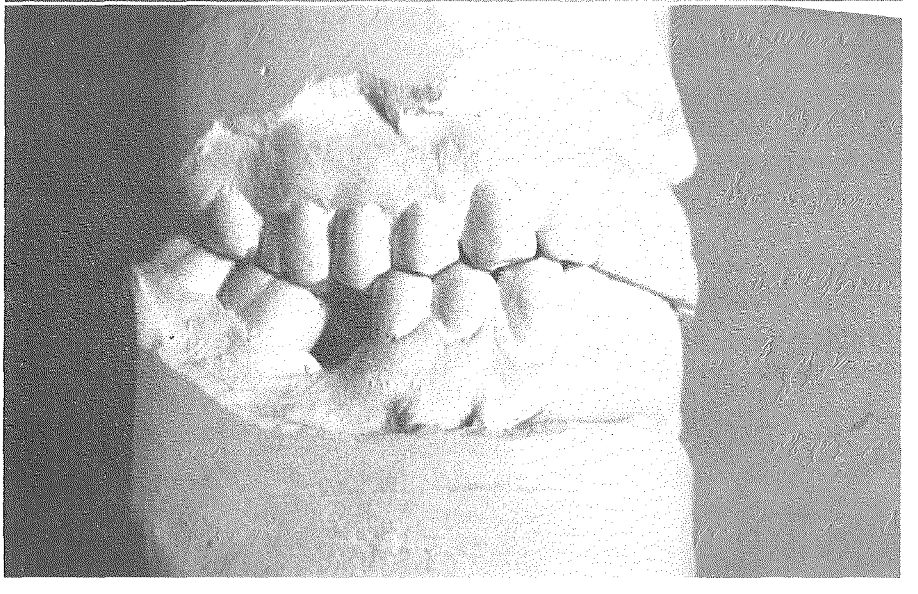
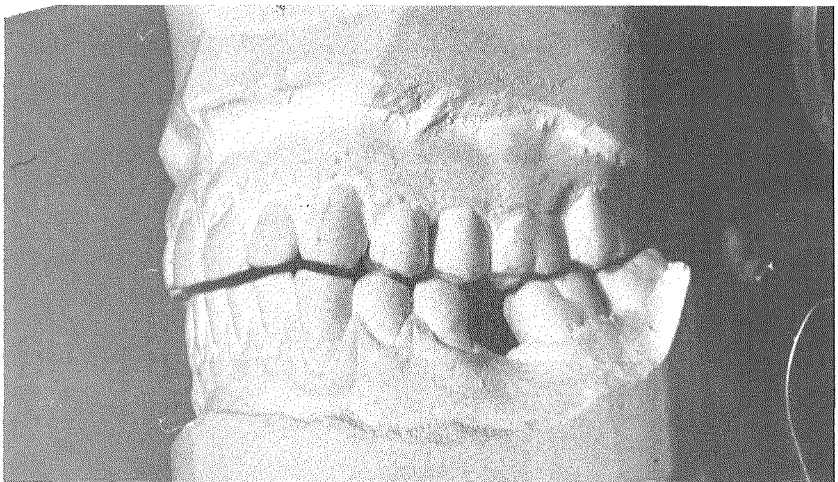


Fig. 460. Diagnostic casts properly mounted on an articulator reveal the initial occlussal contact (right side).
Fig. 461. The diagnostic casts are forced into maximum occlusal contact (centric occlusion) by displacing the condyle forward (right side).

the registrations, and the study casts are remounted to the correct axis. The information obtained from the correctly mounted study casts on the adjusted articulator will not only help in making the diagnosis, but will be valuable in treatment planning and prognosis.

From the articulated study casts, we will be able to correlate our findings with the radiographs. Both the mounted casts and the radiographs should be studied in the light of the recorded clinical findings—the tooth mobility and the condition of the periodontium. It is thus possible to explain the spacing anterior teeth, the mobile bicuspid, the abscessed molar, the deep pocket, etc. The radiograms will indicate the presence of residual infection, a retained root, or the general condition of the alveolar process.

The articulated casts clearly show whether centric occlusion occurs in centric relation and, if not, how great the discrepancy may be (Figs. 460 to 463). Because the adjusted articulator will reproduce all the patient's movements, the ec-



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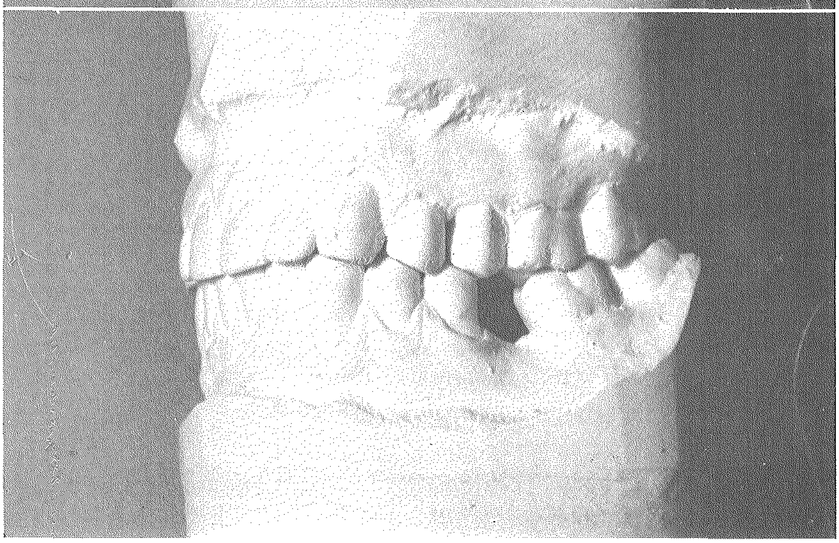

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Fig. 462. Diagnostic casts show premature contact on the left side. Note the space between the anterior teeth due to the premature contact.
Fig. 463. The left side forced into centric occlusion. Now the anterior teeth make contact. To accomplish this, the condyle has to be pulled forward (see Fig. 467).

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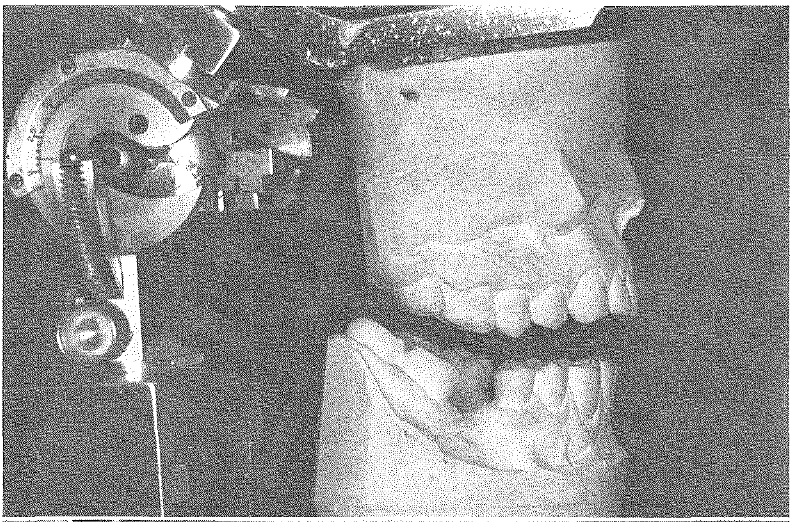

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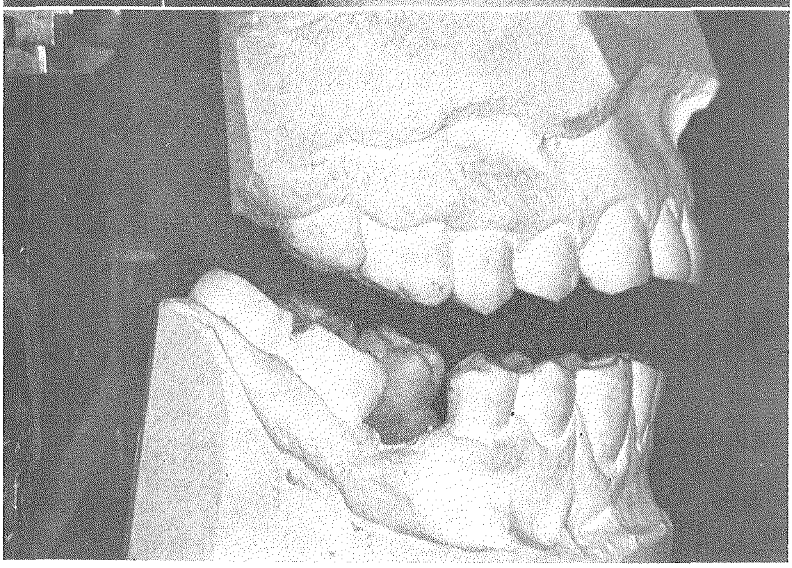

Fig. 464. The plane of occlusion is examined in relation to the condyle path.
Fig. 465. The curve of Spee is studied as a guide to tooth preparations.

centric relations can be carefully studied. The anterior guidance and function can be evaluated. The relation of the cuspid can be analyzed, and its restoration can be intelligently planned.

The relation in size and position of the opposing arches can be carefully surveyed. Crossbite relations will become evident, whether bilateral or unilateral.

The relation of the plane of occlusion to the condyle path will be apparent (Fig. 464). Knowledge of the effect of this relationship on the cusp heights will indicate whether any change is required. The occlusal plane can be altered to some degree by preparation planning.

The curve of Spee can be studied (Fig. 465). Its effect on the restorations can be visualized, and any necessary changes can be considered.

The curve of Wilson will also be easy to observe. It will have an influence on the restorations that are planned.

Careful analysis of all these factors will give some indication of the vertical dimension involved—whether there is to be a decrease or an increase. Very often, because of deflective occlusal contacts or prematurities that are uncovered and the new position of the condyle on the condylar path (by reason of the correct centric relation), we will find that the vertical dimension must be decreased posteriorly and increased anteriorly. This is not contradictory nor capricious. If the jaw is examined from centric *occlusion,* we will be opening it. If the jaw is examined from centric *relation,* we will be closing it, at least in the posterior region. This is so because the condyle is being allowed to go up on its path to the terminal hinge position. This means that there is a closing of the vertical dimension in this region after the prematurities are removed by way of tooth preparation.

From all the information thus gathered, we will be able to determine the type of preparations required to properly restore the mouth to good function. From the knowledge of articulation and developing the articulation in wax, we will be able to tell whether the patient can be treated by onlays or whether full crowns are required.

The articulated casts will give some idea of the esthetic possibilities of the restoration—whether the teeth can be moved orthodontically or whether they have to be jacketed. The casts will also indicate the type of practical compromise that may be required.

Such information can be obtained only from casts that are properly mounted on an adjusted articulator. Any attempt to make these decisions from unmounted casts, improperly mounted casts, or from the mouth itself will be self-defeating. It will result in needless destruction of tooth structure and perhaps necessitate a remaking of the restoration.

Only on casts that are properly mounted on an adjusted articulator will it be possible to observe so vividly the malfunction of a temporomandibular joint. With the casts from a patient with a painful joint, one can actually see what the condyle has to do in order to accommodate itself to the whims of malrelated teeth (Figs. 466 and 467). We can actually see how the muscles, ligaments, and joint tissues would have to be abused to permit malrelated teeth to enmesh.

When all the information has been thoroughly studied, the patient's mouth should be re-examined, and any doubtful points should be clarified. With the radiographs and mounted study casts before us, we should carefully correlate the details as they are observed in the mouth. The bone destruction in the radiographs may appear excessive, whereas, clinically, there may be only slight mobility. The reverse may likewise be true—hardly any bone loss according to the radiographs, but extreme mobility clinically. *Usually the clinical evaluation*

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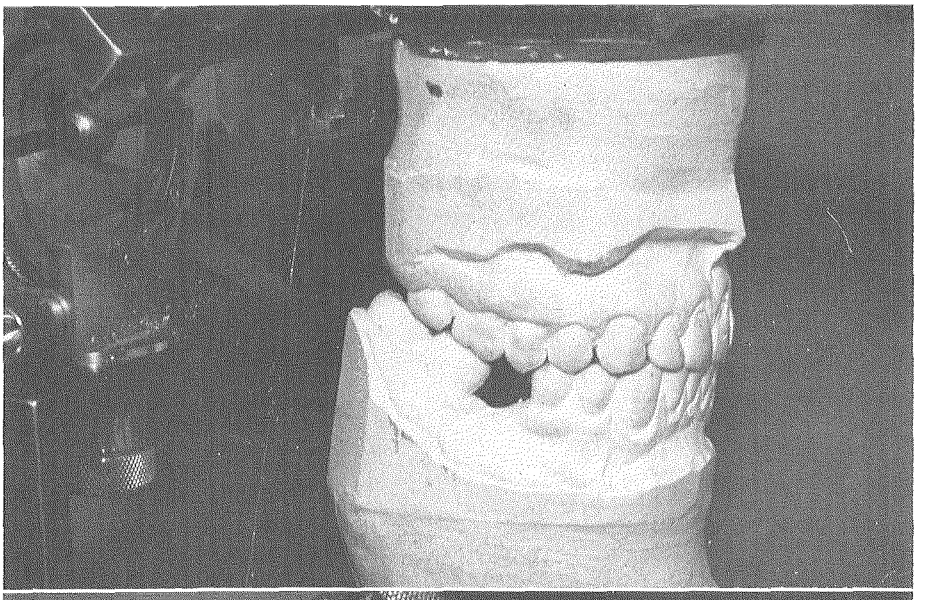

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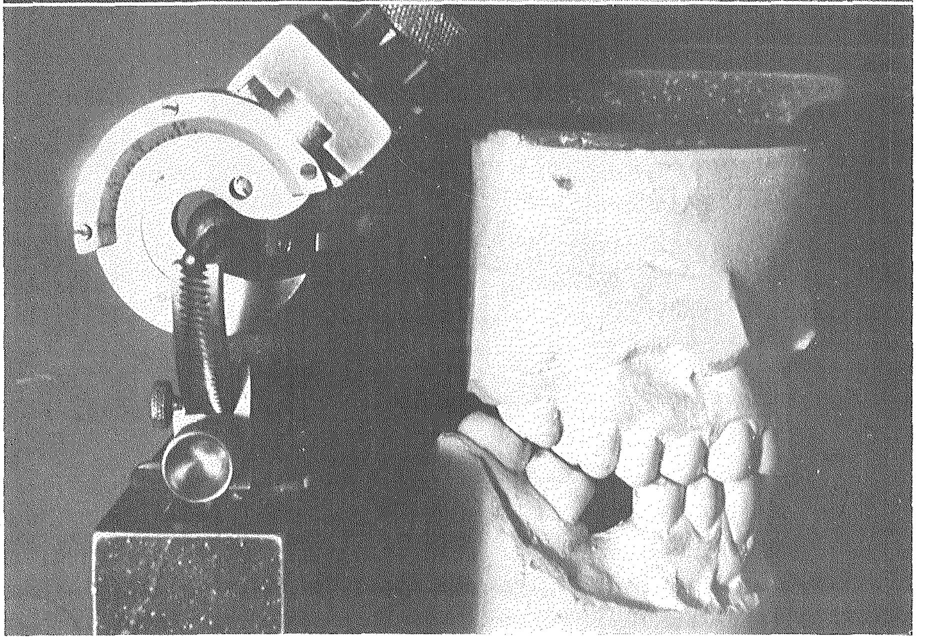

Fig. 466. The teeth occluded in centric occlusion.
Fig. 467. The condyle (ball) pulled forward to allow meshing of occlusal surfaces out of centric relation.

is more valid than the radiographic interpretation. The shape of the roots is a significant factor. The most difficult teeth to treat are the ones with tapered roots with bone loss and considerable mobility.

The diagnostic findings are now explained to the patient, the treatment is described briefly, and the time involved and the possible contingencies anticipated are indicated. (The sequence is important.) The patient is entitled to the probable prognosis. He should know about how long the treatment will take and approximately what investment is required. Because the exact course of treatment nor the exact tissue response cannot be foretold, the cost cannot be estimated exactly. Nevertheless, most patients must be given an idea of the approximate cost.

The adjusted articulator will be used to relate the master casts on which the actual restoration will be constructed. After the restoration is completed, it will be returned to the adjusted articulator for minute adjustments. These could never be made so accurately nor so easily in the mouth.

The appliance is worn temporarily and then again returned to the adjusted articulator for the correction of any changes that may have occurred because of tooth movement or the settling of a tooth or appliance.

Casts of the finished work may be mounted on the adjusted articulator and kept as a record for reference years later. Until this step is reached, the diagnosis is not complete.

Reference

1. McCollum, B. B.: Considering the Mouth as a Functioning Unit as the Basis of a Dental Diagnosis, J. South. California D. A. 5:268-276, 1938.

CHAPTER 15

Treatment planning

Before treatment is begun, it is important to have a complete plan of operation. Usually the patient wants to know just what is going to be done. So that he may plan his life accordingly, he should be told the probable length of time involved in the treatment, the length and frequency of the appointments, and the possible indisposition. A person in business may not want to return to his office after a two-hour session feeling numbness or discomfort. He may therefore prefer to have appointments in the afternoon in order that he may return home directly. Other patients would rather have the work done early in the morning to get it out of the way. For the best dentist-patient relationship, all these things should be considered.

Some patients have great distances to travel. Their treatment and appointments should be planned with a view to keeping the number of trips to a minimum. When patients come from out of town, the laboratory schedule should be so arranged that the necessary work can be finished in a reasonable time.

Usually it is advisable to give the patient a general outline—not the particulars—of the planned procedure. The details will serve no purpose except possibly to confuse, scare, or impress him. He will be more impressed, however, by the results. Occasionally a patient is interested and intelligent enough to want to know more about the projected work. In such instances a more detailed exposition of what is involved may help the general cause of patient education since these patients may discuss this type of treatment with their family and friends. In any event, it is extremely important that exactly what is planned is outlined in the mind.

PERIODONTAL TREATMENT

From the examination and diagnosis, it will have been decided whether the first course of action is to be periodontal treatment. Depending upon the patient, this may be extensive or conservative. Depending upon personal judgment, periodontal therapy may be postponed until the more important phases of correct function are established.

A sensible procedure is to combine the periodontal treatment (if not too extensive) with the appointment for the preparations. At this session usually one quadrant of the mouth is anesthetized. By the time the preparations are finished, we have ample access to all the gingival tissues, and the interproximal areas are as accessible as they are ever going to be. Deep scaling and curetting is easily accomplished, and if any pockets are to be removed, they can be quickly attended to. How often has one taken an impression that went beyond the margin and found an area covered with calculus? Now is the best time to remove it. Furthermore, periodontal treatment (or curetting) will allow better gingival retraction at this time than could otherwise be obtained without additional tissue trauma. Moreover, since temporary coverage must be placed on the teeth anyway and cemented to place, this can be just as well accomplished with a surgical dressing such as Ward's WondrPak.* All that is done is to extend the dressing over the gingival tissues.

In any case, whether these procedures are combined, the first part of treatment planning should encompass the soft tissues. All residual infections, abscessed teeth that cannot be salvaged, and acute periodontal pockets should be eliminated.

MANDIBULAR REGISTRATIONS

The next step to plan is the obtaining of the mandibular registrations. They are usually taken on the first treatment appointment. This step must precede the decision as to the type of restorations and preparations that will be necessary.

Clutches are to be constructed on the casts previously mounted for the purpose of diagnosis. By means of these clutches and the pantograph, the patient's individual mandibular movements will be recorded, and the pantograph registrations will then be transferred to a suitable articulator. After adjustment of the articulator to the pantograph registrations, the study casts will be remounted to the correct axis by means of a face-bow transfer and a centric relation record.

It is advisable to have a duplicate set of study casts accurately mounted on the articulator. Usually it is possible to pour a second set when alginate material is used for the impressions. One face-bow transfer and one centric relation record are sufficient to mount both sets of casts.

One set is preserved as a permanent record of the pretreatment condition (Fig. 468). The second set is utilized for making temporary restorations if they are to be used. In addition, the second set is used in making the diagnostic preparations (Fig. 469) and wax-up (Fig. 470) to determine the type of preparations required and the amount of tooth structure to be removed in each area.

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*Westward Dental Mfg. Co., San Francisco, Calif.

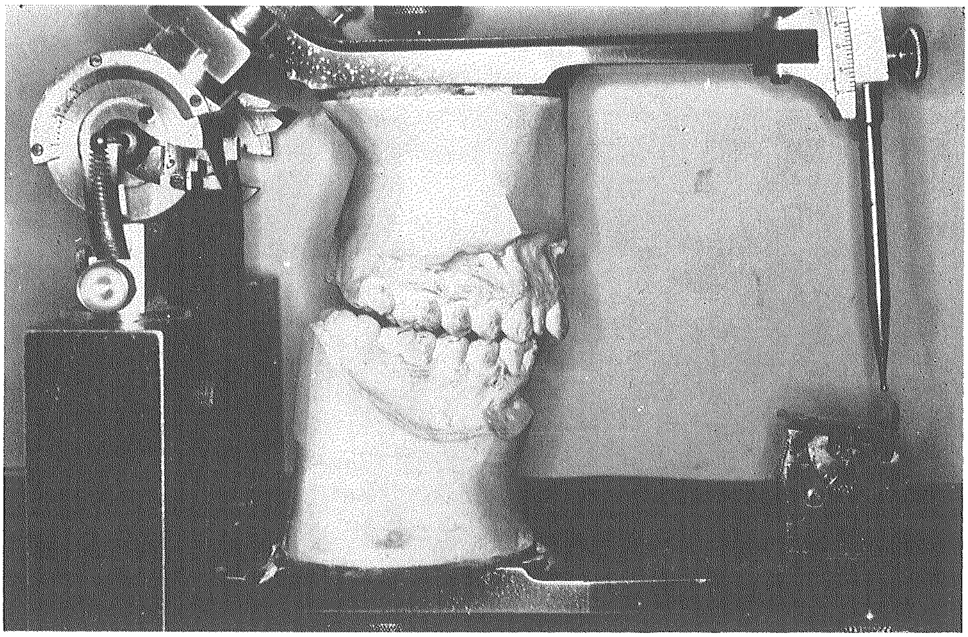

Fig. 468. One set of diagnostic casts is preserved as a permanent pretreatment record.

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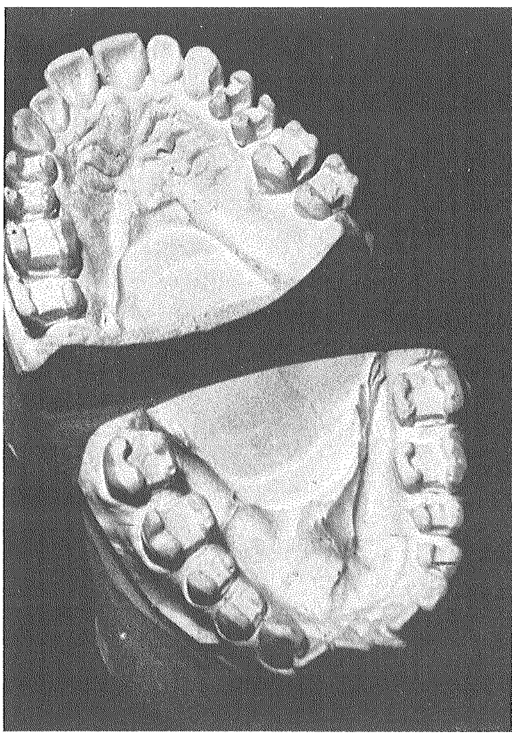

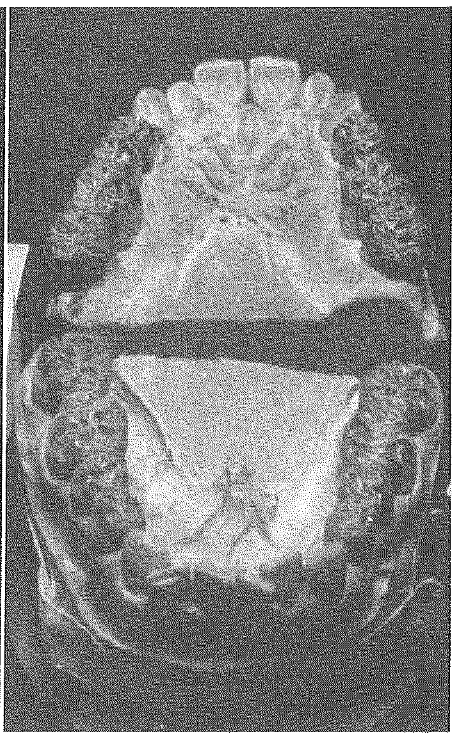

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Fig. 469. Diagnostic preparations are cut on the casts in the laboratory.
Fig. 470. A diagnostic wax-up has been completed. This will reveal the need for any changes in the preparations made in Fig. 469.

RESTORATIONS

At this point the restorations are planned.

With the knowledge of the principles of articulation and the development of an articulation in wax, the problem before us can be surveyed. The study casts will now duplicate the patient's relationship in every detail. The long axis of each tooth can be examined as it is related to the others in the various excursions. The anterior overlap and overjet can be studied, and any changes are planned. Some orthodontic procedures may be indicated. The buccolingual relationship of the posterior teeth is evident and will be helpful in determining the type of restoration to be employed. The curve of Spee and the plane of occlusion are now observable in their true relationship to the oral mechanism. Any changes in these conditions are planned before tooth preparation begins.

The necessary cusps can be visualized or actually carved on the study casts. This will dictate the amount and location of any tooth reduction necessary to establish proper articulation. Edentulous areas are outlined, and their restoration is planned. Abutment teeth are examined in the light of the replacements they are to support. If precision attachments are contemplated, the preparation of the abutment teeth is planned to enhance the results of the restoration. The cuspid relationship is carefully examined, and the type of restoration is projected. This is an important decision which cannot be made until accurate mandibular recordings are available because the path of travel of the lower cuspid is determined by the Bennett movement of the jaw.

By considering all the foregoing factors and conditions, it will be possible to plan the treatment and decide which type of restoration will best accomplish the desired objective. The first preference would be for restorations of the onlay type, but these are not always practical nor possible. We may have to resort to veneer crowns in some or all areas, in which case a decision will have to be made as to the type of veneer material to be used. The preparations will depend upon the material selected.

The order in which the teeth are to be prepared may require some planning. If the patient is wearing a removable appliance, the work should be plotted to enable him to wear it as long as possible, or its replacement should be arranged to prevent any embarrassment to the patient. This is especially true if an anterior tooth is involved. Usually it is preferable to prepare the anterior teeth after all the posterior restorations are in place, but sometimes this is not possible, and they may have to be prepared and temporarily covered before anything else is done. Good judgment should dictate the course of action in each patient.

When the treatment is planned, the edentulous areas must be considered. If a removable appliance is to be made, the impression can be taken even before the preparations are started. In this way, the base can be constructed and ready by the time the mouth is fully prepared. Dovetailing these procedures will expedite the completion of the entire restoration.

If any teeth are to be removed, this should precede all other treatment to allow maximum time for healing. It might be advisable to plan the work so that the preparations are not started until a reasonable time has elapsed for healing. In this way, we will not have to wait so long after the teeth are prepared before proceeding with the construction of the restoration.

PROGNOSIS

When the plan of treatment is completed, a prognosis for the restorations should be decided and explained to the patient. Often teeth are involved that are quite questionable. There is no sure-fire method of determining just how certain teeth will respond to treatment. Sometimes, happily, the results are amazing. Although one should try to save as many teeth as possible, occasionally enthusiasm may cause one to overstep the bounds of reason. This is all right as long as one is prepared to change the treatment plan as the case may warrant. It is good practice to plan the restorations so that, if a questionable tooth does not respond to treatment, we have an alternative solution.

Sometimes a restoration has to be completed with a precision attachment in a healthy tooth next to a questionable one. For instance, if the upper right first bicuspid has a good periodontium, the second bicuspid and second molar are doubtful, and the first molar is missing, a fixed bridge would be constructed from the second molar to the second bicuspid, and an attachment would be placed in the first bicuspid. The male attachment, which is part of the fixed bridge, helps to stabilize the bridge by virtue of its insertion in the first bicuspid. If the bridge abutments have to be removed at a later date, the attachment is already in place. Usually there is a similar condition on the other side, and another attachment has been placed and paralleled to the first one.

This, then, is what is meant by "treatment planning" and is why it is so important to make a careful study of all the factors involved before treatment is begun.

CHAPTER 16

Preparation of the mouth for rehabilitation

After completion of the necessary diagnostic procedures, decision that complete oral rehabilitation is indicated, and setting up of the treatment plan, the mouth is prepared for the restoration.

Depending upon the findings, remove or have removed any infective processes such as retained roots, impactions, unimportant devitalized teeth, and the like. Today, with proper endodontic treatment, the retention of strategic teeth is possible. However, since these teeth are potential liabilities from the standpoint of the complete treatment, often it is wise to plan the restoration for their possible loss at a subsequent time. In other words, one should be prepared for such contingencies as fractures, undetected decay, and recurrent infection. Wherever feasible, insurance against fracture is provided by the use of a metal post and/or a collar of metal.

As with most general rules, exceptions are sometimes in order, e.g., the retention of an impacted third molar if its removal would jeopardize a second molar needed for a bridge abutment or the removal of a devitalized strategic root in a patient suspected of having a focus of infection. Occasionally a perfectly good tooth may have to be sacrificed because of its relation to the other teeth. It is not wise to compromise the result of the entire effort just to save a single tooth.

TREATMENT OF SOFT TISSUE

Most of the patients whom one is called upon to treat have some periodontal involvement. It may vary from slight to very severe. The time of treatment will depend upon the type and severity of the condition. If it is mild, routine therapy (scaling and curettage) is sufficient. If the condition is severe, however, certain considerations must be taken into account. Extensive periodontal surgery may be necessary, and this frequently leaves a nonesthetic result. Although the removal of infected tissue is very definitely part of the treatment and, in fact, one of the criteria of successful treatment, still the esthetic considerations are also important.

Conservative approach

What is recommended here is a conservative approach—in other words, only the very necessary minimum of periodontal surgery until the restoration has been functioning for a while. It is amazing how much tissue improvement can take place as a result of proper function. In many patients the necessary surgery is minimized remarkably.

There is a possible disadvantage to this approach. Because it cannot be determined beforehand exactly how much change will take place, it sometimes becomes necessary to reprepare several teeth in order to obtain a more esthetic effect. This may be the price of conservatism. However, after one observes the improvement of several patients following the establishment of proper function, it is natural to conclude that this is the better approach. It becomes a matter of personal judgment. From my experience in this type of work, I can testify that indeed very little extensive periodontal surgery has been required. My own inclination is to adopt the conservative approach almost routinely.

Posterior region

The location of the severely involved tissue is important. The posterior segments are more difficult to keep clean and stimulated by home care. From an esthetic standpoint, they are not so essential as the anterior segments. Consequently, it seems more logical to strive to remove all periodontal pockets posteriorly even if this entails extensive surgery. The abnormally long crowns that result from these procedures are less conspicuous in the posterior region. The restorations, if they are full crowns, should be made to cover all exposed tooth structure to prevent the possibility of secondary decay. Just as the soft tissues posteriorly are difficult to care for properly by home care, so is it difficult to keep the tooth surfaces clean to prevent decay.

Anterior region

In the anterior region, where esthetics is so important, it may be necessary to accept a compromise. Shallow pockets, which can easily be kept under control by home care and frequent visits to the dentist, may be the lesser of two evils. My experience indicates that when a mouth is restored to proper function, such pockets as remain either improve or stay the same. They seldom become worse. All that is required is proper function, frequent curettage, and good home care. From an esthetic point of view, this is better than denuded root surfaces or excessively long crowns.

PREPARATION OF THE TEETH

The type of preparation to be used in the treatment of the function of an entire dentition is dependent on several conditions. The problem is to attach or place restorations that will function properly. How these restorations are to be placed in or on the teeth will depend primarily upon the relationship of the teeth to each other and to their opposing members. In order to be able to plan this procedure correctly, it is obvious that carefully made study casts are needed, properly mounted on an adjustable articulator that duplicates the patient's jaw movements. This presupposes that accurate registrations have already been taken and a proper mounting of the casts made with a face-bow transfer and a good centric relation record. If such is the case, we are now in a position to observe the relationship of the teeth to each other.

It should begin to be apparent that the decision on how the teeth are to be prepared will rest on a determination of the cuspal relationship necessary to make the mouth function properly. In other words, the finished articulation will have to be visualized before tooth surfaces are ground away. It is usually a wise procedure to prepare the teeth of the mounted casts and to wax up the restoration sufficiently well to arrive at an accurate picture of where the cusps are going to fall.

Once there is a substantial idea of the articulation to be established, one is in a position to decide how the teeth are to be prepared. Certain areas will have to be removed to allow space for an opposing cusp. Certain areas will have to be built up to make the proper contact. Certain teeth will have to be warped in order that they may interdigitate properly with the opposing members. The forces of articulation will have to be visualized, and their dissipation must be planned.

Method of treatment

Factors determining treatment. There are a number of factors which will determine whether onlays or full coverage will be used.

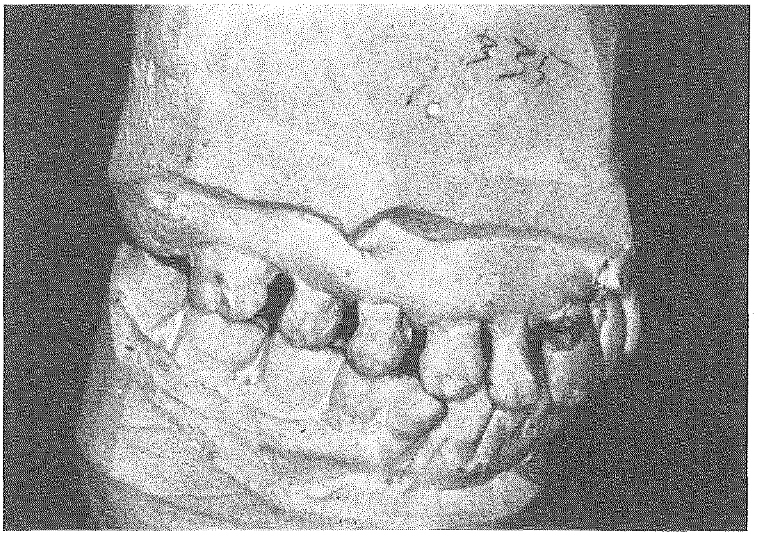

Fig. 471. The adverse relationship of the teeth to each other dictates full coverage.

Adverse relationship of long axes of teeth. Frequently, when the properly mounted study casts are examined, it will become evident that the long axes of the upper and lower teeth are not ideally related. The long axis of an upper tooth may be directly over the long axis of the opposing lower tooth. Such an arrangement precludes the use of onlays in the reconstruction procedures, for it would not be possible to interdigitate the upper and lower cusps properly without producing a monstrous result. This situation of necessity requires the use of full coverage (Fig. 471).

In some patients in whom the long axes of the upper and lower posterior teeth are not ideal, it may be possible by warping onlay preparations to achieve a suitable articulation. For example, by overbuilding the mesial aspect of a lower onlay and the distal aspect of the opposing upper onlay, it may be possible to effect a functioning articulation without too great a display of gold on the mesial proximal surfaces of the upper teeth. On the other hand, it may be necessary to overbuild the mesial aspect of the upper posterior teeth while overbuilding the distal aspect of the opposing lower teeth. This is less desirable from an esthetic standpoint because of the excessive display of metal. It is possible, of course, to overcome this condition by using full veneer coverage. Still, after observing the change that has taken place in some veneers after a number of years, I am inclined to wonder whether it would not have been better in these restorations to have had a display of metal rather than discolored veneer material.

Insufficient overjet of posterior teeth. In the discussion of articulation, it was demonstrated that properly articulated occlusal surfaces require an overjet of the upper posterior teeth over the lower posterior teeth. If there is an insufficient buccal overjet, then onlays again are precluded. A condition such as this would necessitate the construction of onlays having a ledge from the gold to the tooth surface, and this would not be satisfactory. Therefore, to establish proper buccal overjet and have restorations that blend with the tooth structure, full coverage is here indicated.

Crossbite relationships. Very seldom can natural teeth in a crossbite relationship be restored to proper function by means of onlays. Occasionally this is possible if the teeth happen to be properly tipped and ideally interdigitated. Usually, however, a crossbite relationship must be treated by full coverage. This is not to imply that the teeth can be restored to a normal relationship by full coverage, for that would require too much tilting of the long axis. Rather, we mean that full coverage is the only method by which a proper crossbite relationship can be established when it is indicated (Fig. 472).

Caries-susceptible mouths. Mouths which have required a good many fillings over the years are usually candidates for full coverage. When we find MOD restorations as well as Class V restorations, both buccal and lingual, it hardly seems wise to labor merely to have a few islands of enamel. Full coverage, of course, does not rule out the possibility of future decay. As a matter of fact, a

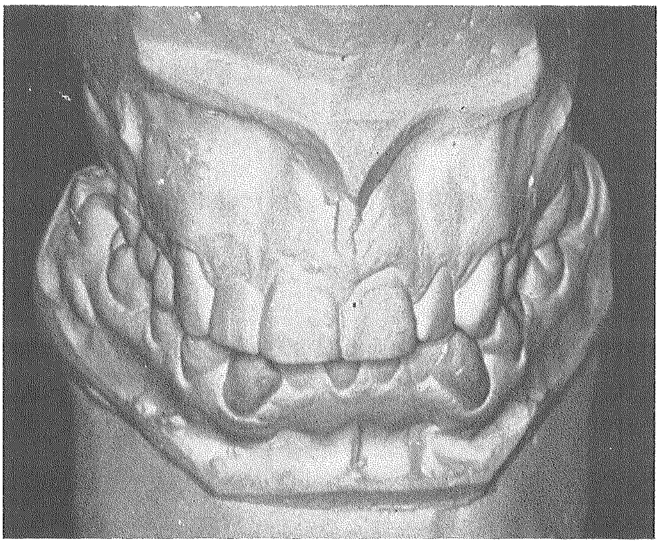

Fig. 472. A crossbite relationship usually calls for full-coverage treatment.

caries-susceptible mouth must be watched very closely after full coverage because the margins of the restorations are for the most part hidden under the free margin of the gingiva.

Thus far, it might appear that the obvious way to treat all patients is by full coverage. Although it is true that it is much easier and quicker to prepare a full crown or a series of full crowns than to prepare satisfactory onlays, it is also true that considerably more tooth structure has to be sacrificed in a full-crown preparation. To date, there is no satisfactory substitute for natural tooth structure. From many standpoints, plastic veneers are far from desirable, and porcelain has its drawbacks.

Wherever possible, the restoration of choice is the onlay and for these reasons: (1) there is less destruction of tooth structure, (2) there are no veneers to construct or maintain, (3) there are fewer margins in areas susceptible to decay, and (4) there are more guides left for proper contouring.

Use of full coverage. For patients in whom it is not practical to use onlays, a

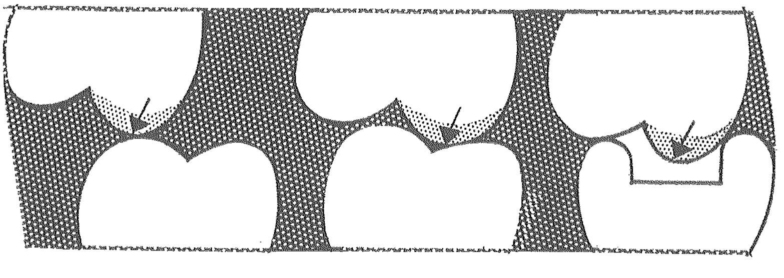

Fig. 473. Drawing showing the need for sufficient room for the projected cusps of opposing teeth.

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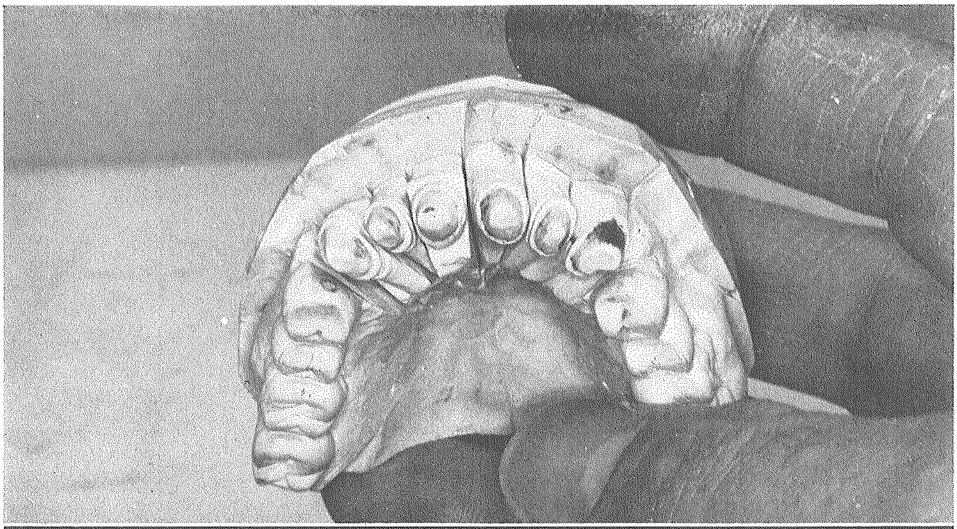

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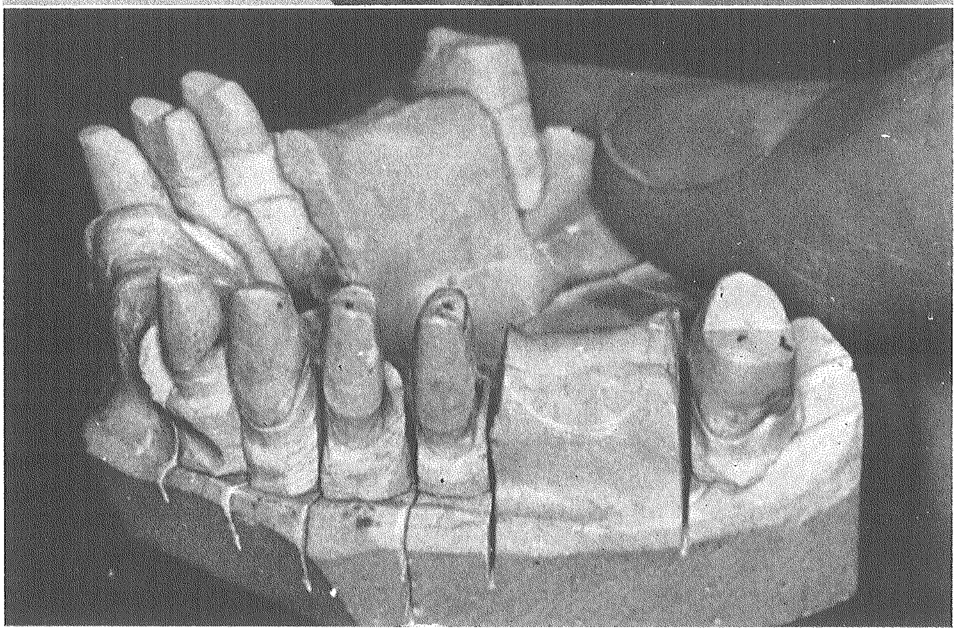


Fig. 474. Porcelain jacket preparations.
Fig. 475. Chamfer type of preparation.

definite compromise is indicated, and full coverage. If the result is to be satisfactory, we must be guided by certain considerations.

The reduction of the occlusal surface must be executed so as to allow sufficient depth for the opposing cusp (Fig. 473). In other words, it is usually not enough to cut straight across the occlusal surface; rather, it has to be reduced more mesially and distally, depending upon the relationship of the tooth to its antagonist. Here is another advantage of the onlay preparation: in most cases it provides ample space in its proximal box form.

The reduction of the buccal surface must be made with the requirements of a veneer in mind, when one is indicated. Sufficient tooth structure must be removed to allow for an adequate thickness of veneer material. Furthermore, the reduction must be carried below the gingiva when esthetics is a prime factor (Fig. 474).

Chamfer preparation. The most satisfactory type of full-coverage preparation is the chamfer (Fig. 475). This conclusion is based on a long and careful observation of both chamfer and full-shoulder preparations. For patients in whom reconstruction is being done, restorations are temporarily cemented for rather lengthy periods, and it has been found that washouts occur less frequently under chamfer-type preparations than under full shoulders.

Full-shoulder preparation. It is almost impossible to cast accurately to a complete shoulder preparation. It is also considerably more difficult to adequately seat a restoration that has a full shoulder. Moreover, when the full shoulder is used as a fixed bridge abutment, the problem of perfectly seating the restoration is increased.

The strongest advocates of this type of preparation still place an apron beyond the shoulder. Why? To ensure and protect its fit or lack thereof. Under the circumstances, we ask, is it not wiser to use a chamfer and preserve all that tooth structure?

Use of onlays. Onlays (Fig. 476), too, must be intelligently prepared, and the following principles and procedures should be observed:

1. The cavity outline should permit the restoration to blend naturally into the remaining contours of the tooth structure.

2. The cavity margins should be carried to immune areas—in other words, extension for prevention.

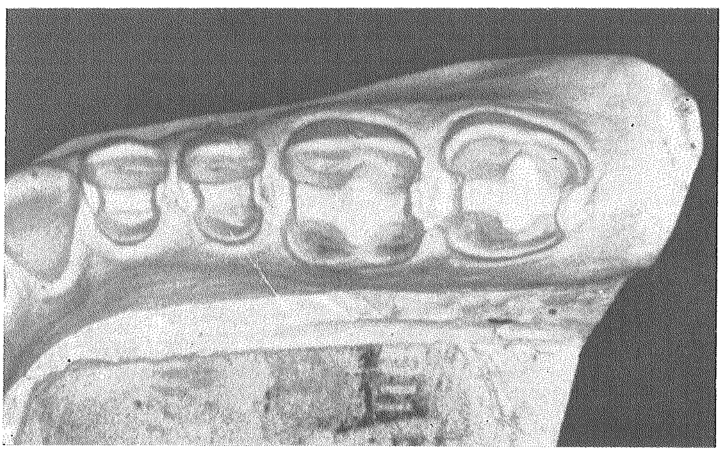


Fig. 476. MOD onlay preparations.

The margins must be carried beyond the occluding surfaces so that function will not tend to open them.

3. All functioning surfaces should be covered or "shoed" to minimize the possibility of a sheared cusp.

4. Flat gingival seats, square walls, and reasonable depth for a sufficient thickness of filling material are required to ensure retention and adequate strength against swaging and opening of the margins. Slice preparations are not suitable.

5. Cavity margins should end in sound tooth structure.

6. So long as sufficient retention is obtained, it is not necessary to carry the proximal margins below the free margin of the gum.

7. Cavity outlines must include sufficient areas to permit articulation to be established without an undue display of filling material. This is especially important for the cuspids and the anterior teeth.

8. Proper bevels should be employed to enhance the life of the restorations. Short, thick bevels are preferable to thin ones.

9. Accessory anchorage in the form of pits or grooves may occasionally be required for adequate retention.

10. All ground surfaces should be polished with fine stones, diamond points, or cutile fish discs.

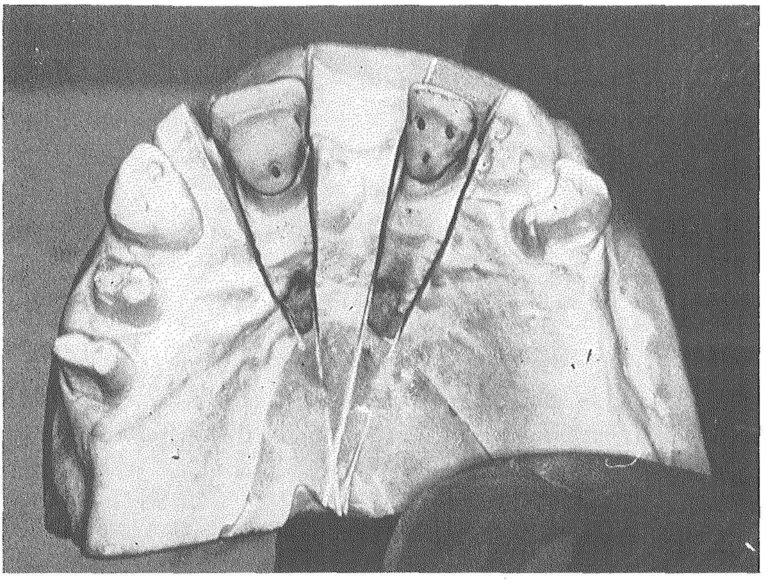
Pin-ledge restorations. Extremely valuable in full-mouth rehabilitation is the pin-ledge type of preparation. Until recently, it was a rather difficult restoration to construct and therefore not used by many men. Now, however, because of the technique developed by Dr. E. David Shooshan[1] of Pasadena, California, the pin-ledge has again assumed its rightful place in dentistry. New burs and drills, coupled with nylon bristles for making the indirect impressions and the wax patterns, have simplified the construction of this type of restoration.

In many instances in which the lingual area of an anterior tooth has to be built up for contact, it is easy to make a pin-ledge preparation. Often the enamel does not have to be removed at all. The pin holes are located clear of the pulp and started with a half-round bur. A 24 or 27 thousandth twist drill is then used to make the pin holes. If desired, a slight ledge may be added for gold bulk.

It is obvious that the pin holes must be parallel. This is an easy procedure, provided one does not move his finger rest after starting to drill the holes. The hand and arm must be kept rigid to maintain parallelism of the handpiece and bur. If one is not experienced in this procedure, it is wise to practice on extracted teeth on a manikin.

Depending upon the particular conditions present, many variations are possible. Frequently a Class III cavity is encountered on one side of the preparation, and here an old-fashioned groove and a proximal slice may be made.

If the pin-ledges are to be used as a periodontal splint, then the proximal contact areas may be slightly prepared with a flame stone or disc to permit soldering to the adjacent pin-ledge.



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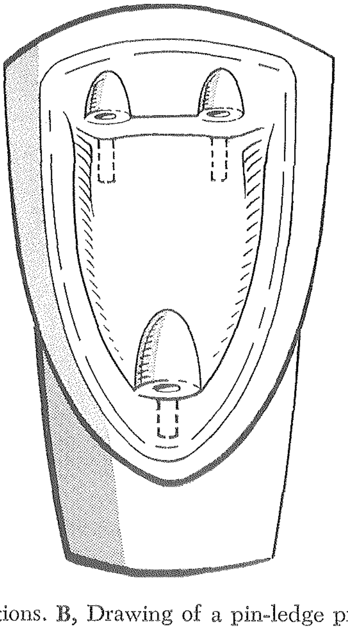

B

Fig. 477. A, Pin-ledge preparations. B, Drawing of a pin-ledge preparation.

Pin-ledge preparations are adequate to carry anterior pontics without destruction of all the abutment tooth structure (Fig. 477).

High speed

Methods of preparing the teeth are changing so rapidly today that it is impossible to cover all of their ramifications. Some generalizations, however, can be made.

High speed in dentistry is here to stay. Preparations are easier to make, and the procedure is less fatiguing to the patient. Whereas in the past, tooth preparation in full-mouth rehabilitation was a real task, now, thanks to improved anesthetics, diamond points, carbide burs, and high-speed equipment, this phase of the treatment is the easiest.

Many precautions, of course, have to be observed with the rapidly cutting instrument. Since good vision is obviously necessary, the lighting facilities should be better than average. Only good carbide burs and diamond points should be used, and careful control is mandatory. To avoid possible trauma, the oral tissue must be retracted (preferably by an assistant).

So that there are no "fried pulps," adequate cooling is essential. The use of air and water with an automatic attachment is recommended. Adequate aspiration is also necessary with fluid coolants, and care should be taken to prevent the propulsion of tooth and restoration material into the patient's throat.

Helpful hints

Because they have proved of value in my own practice, the following work habits and procedures are recommended:

1. Whenever possible, work in a sitting position. Apart from the fact that this is less tiring to the operator, a more relaxed feeling is transmitted to the patient.
2. Prepare the teeth in quadrants. With one injection of anesthetic it is usually possible to prepare four teeth as readily as one or two.
3. Make the same cuts on all the teeth before discarding the cutting point, thereby getting the maximum work out of an instrument before changing to another.
4. Frequently examine the progress made, using air to clear the field.
5. At the preparation stage, remove only enough decay necessary to prepare the tooth. Complete removal at this time may sometimes create problems in impression-taking. The only exception is when there would be danger of pulpal involvement unless complete removal were resorted to. In this case, the decay should be removed and replaced with cement. This cement, in turn, should be removed prior to final cementation so that there will be just one mix of cement between the restoration and the tooth.
6. Carefully examine all margins and the tooth structure adjacent to the margins, especially in the gingival areas. There may be calculus present which must be removed. Restorations, after all, are to be made against sound tooth structure, not against a layer of calculus.
7. Carefully examine all preparations for undercuts, for definite, smooth finish lines, and to determine whether the tooth structure has been adequately removed in the proper places.

When the preparations are finally completed to our satisfaction, the impressions are taken (see Chapter 17).

TEMPORARY COVERAGE OF PREPARED TEETH

After the teeth are prepared and the impressions taken it becomes necessary to give some temporary protection to the preparations.

Usually the "temporaries" are made before taking the impressions. Those made of gutta-percha will help retraction. Those made of acrylic can be trimmed and polished by the technician while the operator takes the impressions.

Onlay type

If the preparations are of the onlay type, hard gutta-percha is used to form a continuous bridge from one preparation to the next (usually there are four in a row). The gutta-percha bridge is trimmed and adjusted to the opposing teeth and then cemented in place with a temporary cement, such as Moyco* or Pulprotex,† to prevent sensitivity. A temporary gutta-percha filling should never be placed without some type of temporary cement to keep saliva from seeping between it and the preparation. This type of temporary coverage is adequate for a week or ten days, during which time a temporary splint is made of good scrap gold.

Occasionally, an aluminum shell is used for temporary protection of a preparation. The shell should be carefully fitted and lined with *soft* gutta-percha and then cemented to place with a temporary cement.

Full-coverage type

For most patients, when full coverage is indicated, the best temporary coverage can be quickly made with self-curing plastic.

Prior to preparation of the teeth, but after diagnosis and treatment planning, the study casts are marked according to the quadrants to be prepared. Any edentulous areas between the teeth are filled in with wax and carved into suitable pontics. A thin layer of wax is applied with a spatula to the buccal and lingual areas of the remaining teeth and over the gingival tissues adjacent to the teeth (Fig. 478). This thin layer of wax permits us to make a slightly oversized eggshell. The oversizing will allow for the shrinking of the self-curing plastic; it will provide sufficient thickness in the eggshell; and it will enable the shell to clear the preparations when it is seated to place in the relining procedure that follows. The gingival relief will prevent impingement of the soft tissues by the eggshell.

After the study cast has been prepared as described (both sides can be done at the same time and the anterior teeth, too, if involved), a hydrocolloid impression is taken of the cast (Fig. 479). The impression is chilled and separated from the cast, and a thin layer of self-curing plastic is then applied with a camel's-hair brush. Small amounts of the powder and liquid should be picked up with the

*The J. Bird Moyer Co., Inc., Philadelphia, Pa.
†The L. D. Caulk Co., Milford, Del.

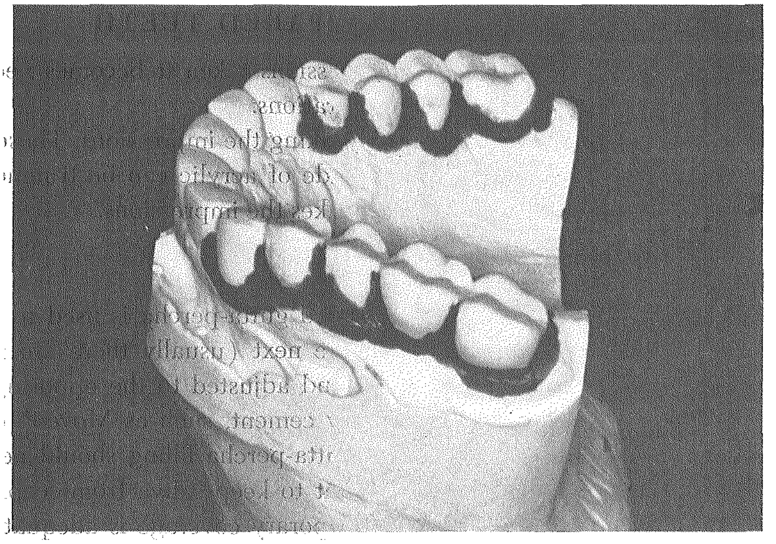

Fig. 478. Wax applied to study casts preparatory to the construction of temporary restorations.

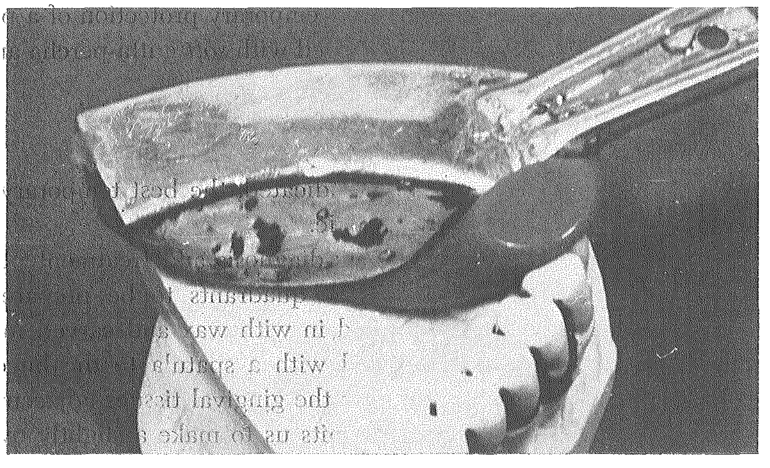

Fig. 479. Hydrocolloid impression of prepared cast.

brush in this application. The liquid causes the powder to spread evenly in the impression (Fig. 480). The impression is tilted to permit the material to flow where it is needed. Since the desired result is to have an eggshell of equal thickness in every area, one should avoid overbuilding the material in any section. When the surface of the impression of the teeth is evenly lined, some material should be allowed to build up on the gingival tissue areas about 2 or 3 mm. beyond the preparation.

After the plastic has cured, the eggshell can be removed in quadrants (Fig. 481) and stored until the preparations are made. So that they will remain moist, the shells should be kept in a proper storage container.

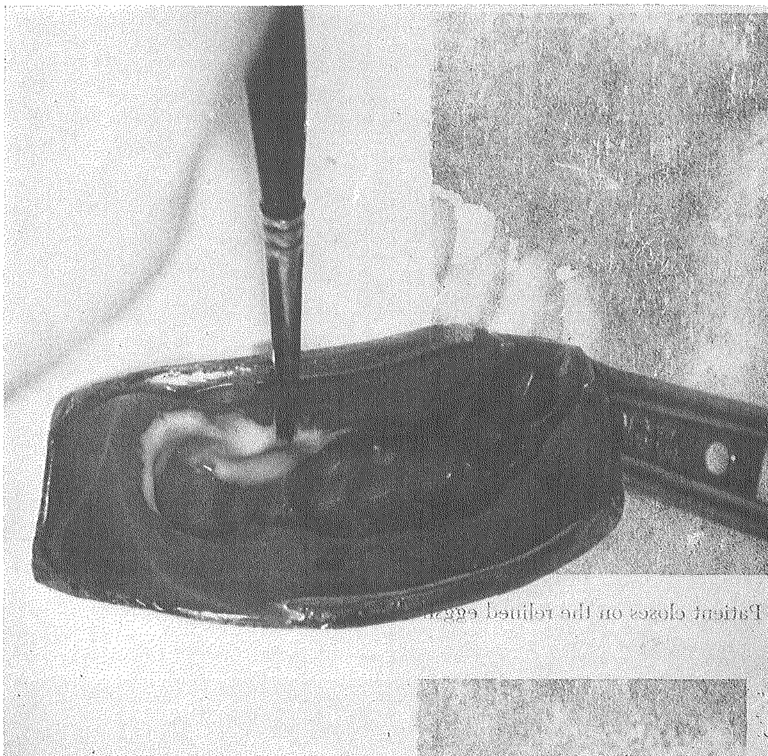

Fig. 480. Applying Replica* powder and liquid to make temporary eggshell restoration.

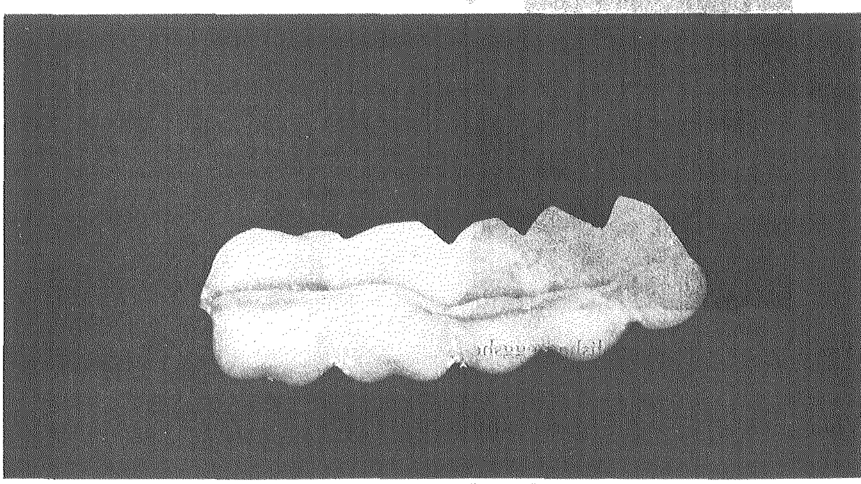

Fig. 481. A quadrant eggshell.

*Cosmos Dental Products, Inc., New York, N. Y.

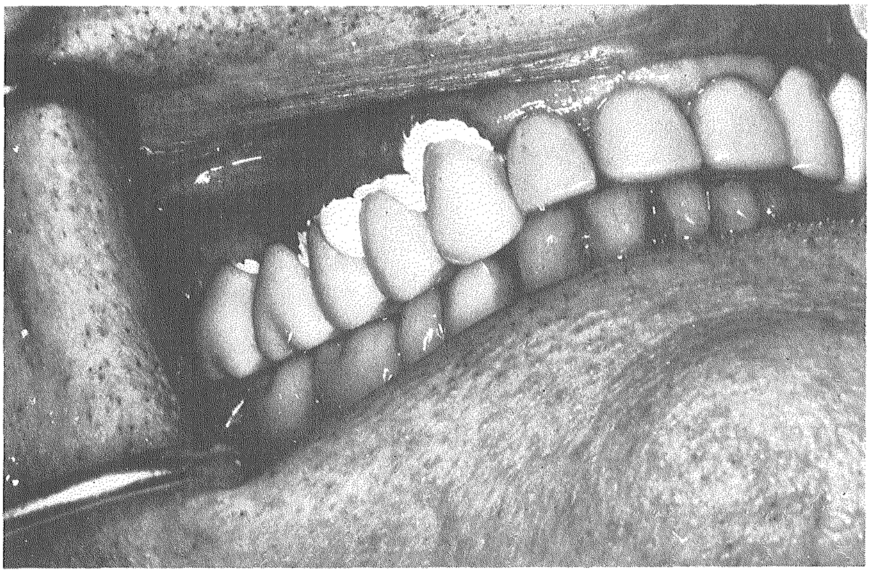

Fig. 482. Patient closes on the relined eggshell to establish occlusion.

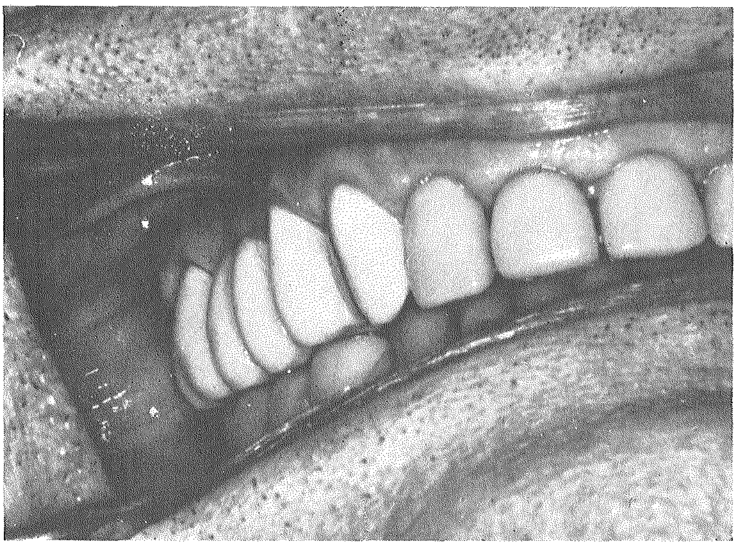

Fig. 483. The trimmed and polished eggshell is cemented to place.

When a quadrant is prepared and before the impression is taken, the eggshell is tried on the preparations to make sure that it seats perfectly. It is then relined on the prepared teeth. The teeth and *gingival* tissues are lubricated with mineral oil, petrolatum, or a material called Nu-Life Nu-Lube*, and the eggshell is filled

*Niagara Scientific Products, Buffalo, N. Y.

with a mix of self-curing plastic. The shell is placed on the preparations, and the patient is instructed to close the teeth slowly (Fig. 482). Any gross excess is removed with a plastic instrument, and the patient is again instructed to close the teeth. After a minute or so, the relined shell is gently lifted to ensure its removal, but not removed completely. It is then reseated; the patient is told to close the teeth once more; and the shell is cooled with water to prevent overheating.

When the self-curing plastic has hardened, the eggshell is removed and trimmed, and the impression procedures are carried out. After the impressions are obtained, the relined and trimmed shell is ready to be cemented to place with temporary cement (Fig. 483). It seldom requires any occlusal adjustment. When it does, this can be accomplished very easily with a rubber wheel.

Another method of making a more durable temporary plastic splint has been developed by Dr. Morton Amsterdam of Philadelphia, who uses soft gold shells for marginal adaptation.[2]

References

1. Shooshan, E. David: A. Pin-Ledge Casting Technique—Its Application in Periodontal Splinting, D. Clin. N. America, pp. 189-206, Mar. 1960.
2. Amsterdam, Morton and Fox, Lewis: Provisional Splinting—Principles and Techniques, D. Clin. N. America, pp. 73-99, Mar. 1959.

CHAPTER 17

Taking impressions

In the process of full-mouth rehabilitation, several types of impressions are involved. Here we shall deal with those for dentulous patients. Edentulous impressions, both full and partial, will be discussed in a separate chapter.

ALGINATE IMPRESSIONS FOR STUDY CASTS

Advantages

Some men perfer alginate impressions for study casts, and the material has certain advantages. It does not have to be previously prepared. Since it is not a thermal material, it causes no heat discomfort to the patient. Furthermore, with alginate material, it is possible to pour an extra set of casts.

Technique

For satisfactory results, careful attention must be paid to the details of handling the material. The powder-water ratio must be observed. The tempera-

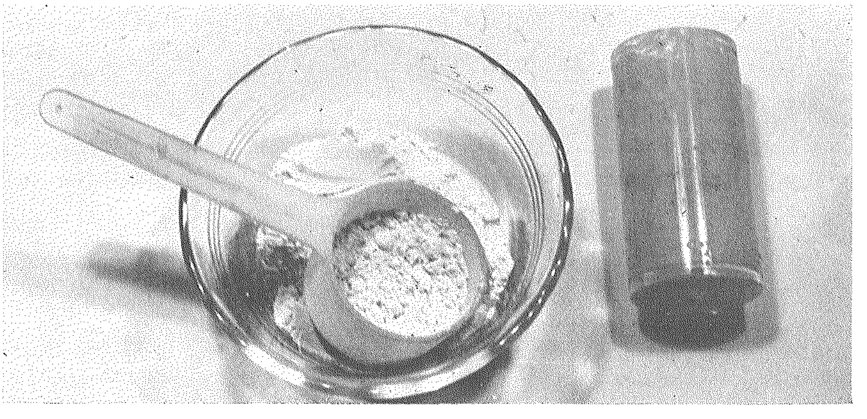

Fig. 484. Alginate material is measured out in a container in advance so that it can be incorporated into the mix at one time.

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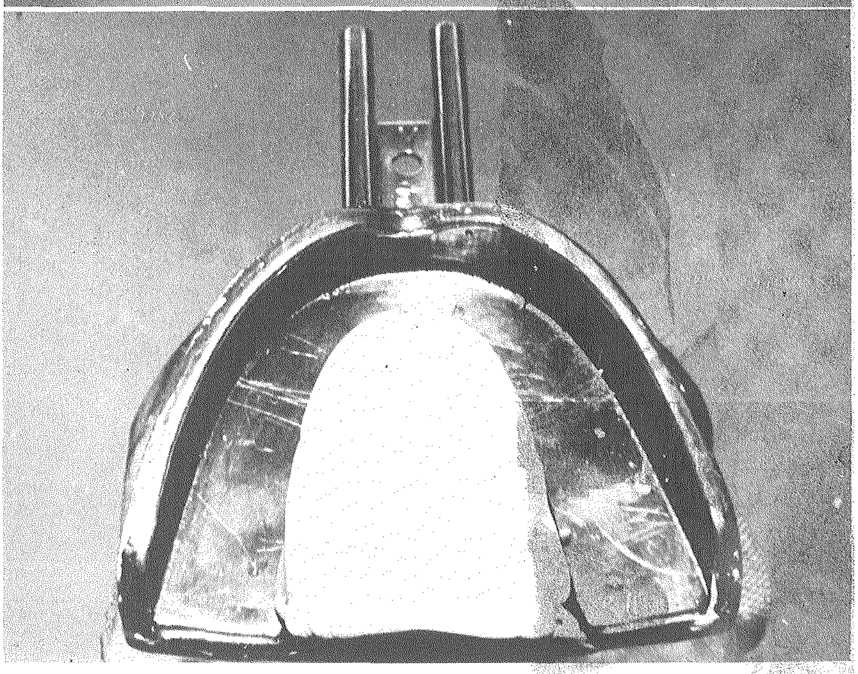

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Fig. 485. Packaged alginate material is ready for use.
Fig. 486. Compound palate stop on the upper tray prevents overseating of the tray.

ture of the water is important. Since the powder must be incorporated into the mix at one time, the desired amount should be measured out in another container prior to starting the mix (Fig. 484). Some manufacturers provide for this by packaging the material in the correct amount for each use (Fig. 485).

It is important to prevent the tray from showing through the material. Although this can happen with any impression, it seems to occur more easily with alginate material. A compound palate stop in the vault of the upper tray (Fig. 486) and a compound periphery one on the lower tray (Fig. 487) will forestall this.

After the alginate material is well mixed, the tray is loaded. A small amount of the material is smeared over the occlusal surfaces of the teeth to prevent air from being trapped in the sulci and the grooves (Fig. 488). The tray is then placed in position and held steadily (usually for 3 minutes) until the material is

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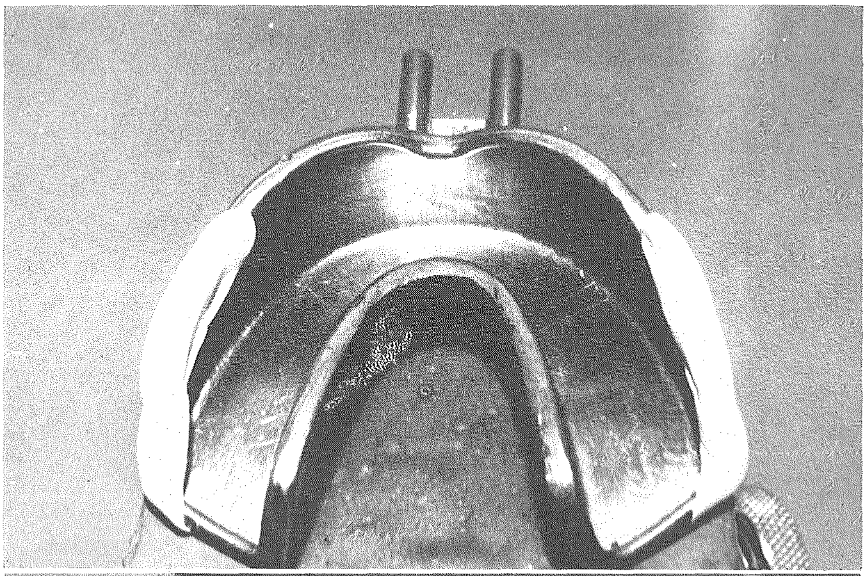

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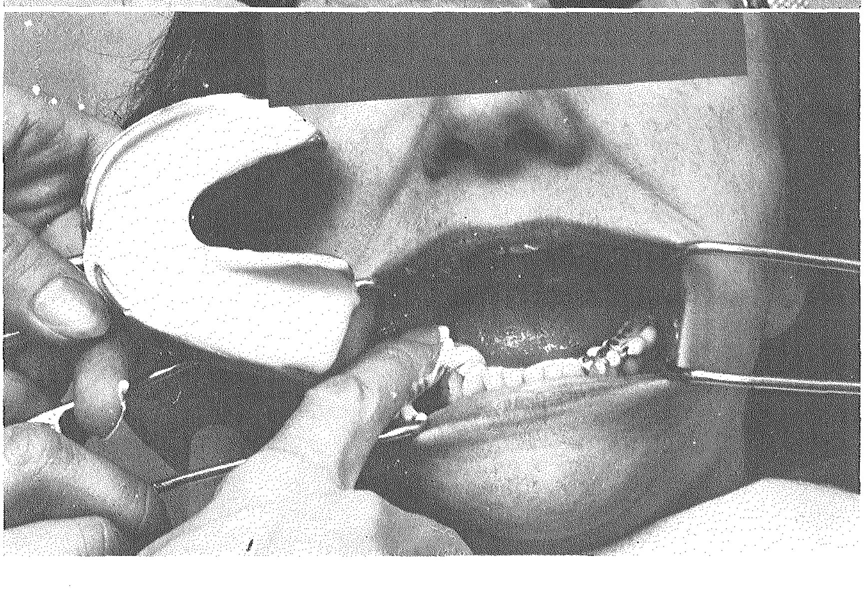

Fig. 487. Buccal compound periphery prevents overseating of the lower tray.
Fig. 488. Alginate material is wiped on the occlusal surfaces to prevent trapping of air.

completely set. The impression is removed by a quick pull on the peripheries (not the handle) of the tray to prevent undue distortion.

For best results, the impression must be poured immediately. A small amount of powdered stone (the same as will be used for the cast) is placed in the impression, and the inside is gently scrubbed with a soft, wet brush to produce a better cast. The impression is then washed out carefully. After the free moisture is removed with a gentle blast of air, the mixed stone is poured into the impression and vibrated to eliminate air bubbles. The impression should never be inverted because the weight of the stone will pull it away from the impression. After 45 minutes, the impression may be separated from the cast.

If the gross undercuts in the impression were removed before the first pour, it is possible to pour a second cast with fairly accurate results.

HYDROCOLLOID IMPRESSIONS

When properly handled, hydrocolloid material seems to produce accurate results with a minimum of effort.

Impressions for study casts

To obtain satisfactory casts with hydrocolloid material, certain requisites are involved. These include (1) selection of a suitable tray—one large enough to carry a sufficient bulk of material to resist permanent deformation at the time of removal; (2) proper softening, tempering, and cooling of the material; and (3) careful handling of the impression when the casts are being made.

Selection and adaptation of tray. A water-jacketed tray which has no holes in the impression area should be selected. It must be large enough to hold an adequate amount of material, particularly in the areas where deformation is necessary to remove the impression. These are usually the molar areas. If the last molars flare buccally, creating an undercut in the gingival regions, it is necessary to use a tray sufficiently large in this section to carry an adequate bulk of material. Hydrocolloid will withstand a 20 per cent deformation by volume without permanent distortion. The limitation as to the size of the tray depends, of course, on the mouth opening compared to the ridge size. If the patient has a very large dental arch but a narrow slit for a mouth opening, the problem is a serious one.

There is usually a rim lock on the tray to retain the material. It is necessary to increase this by adding softened impression compound to the periphery of the warmed tray (Fig. 489). The tray is tried in the mouth while the compound is still soft, after which it is removed from the mouth, and the inner edge of the rim lock is trimmed so that it presents a right angle to the side of the tray (Fig. 490). If the anterior teeth flare out, it is wise not to have compound on the anterior rim because, if it softens with the hydrocolloid, it may lock in this undercut with disastrous results. What would invariably happen is that, in removing the complete impression, one would tear the tissue covering the alveolar ridge, and these tears are very painful and slow to heal.

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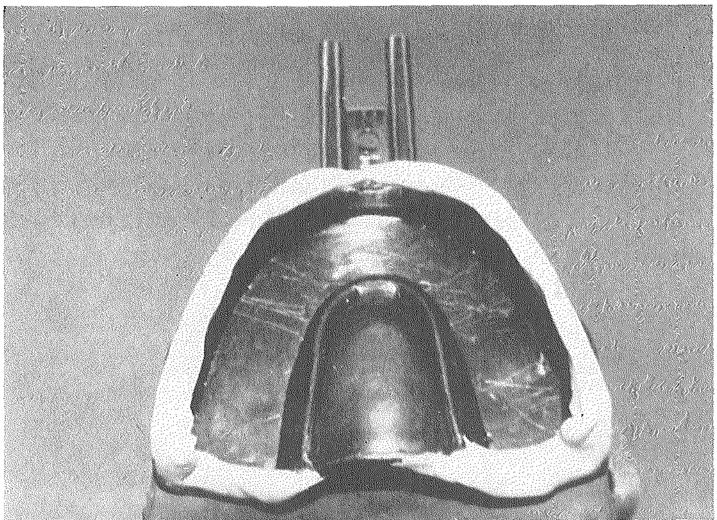

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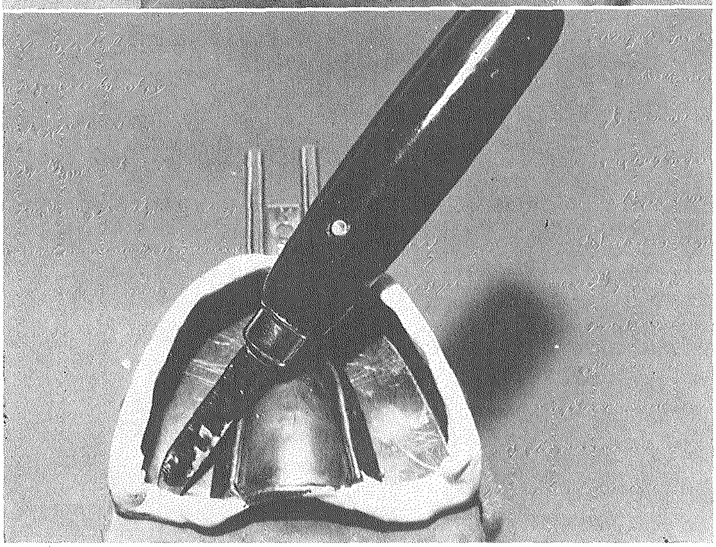
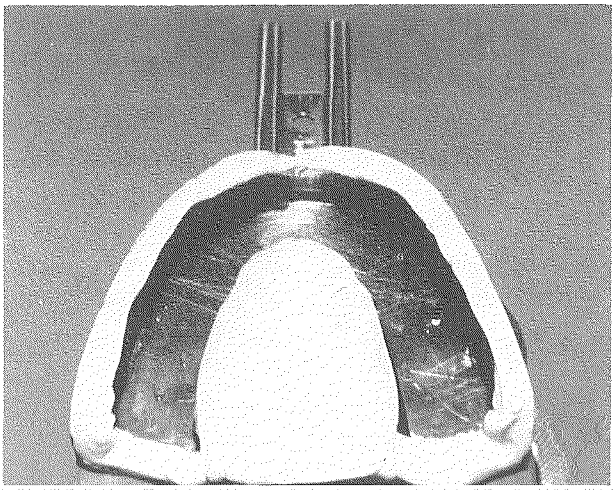


Fig. 489. Compound rim lock on upper tray.
Fig. 490. Compound rim lock trimmed to a right angle on the inside surface.

On an upper tray, it is advisable to place some compound across the back to prevent the softened hydrocolloid from running down the throat. A small amount of compound is usually placed in the vault of the tray so that there will be less bulk of hydrocolloid in this area (Fig. 491). It also serves as a stop to prevent overseating of the tray. If the tray shows through the impression material, the impression cannot be accepted as accurate.

The lower tray is prepared in the same way. Again, the compound rim should not be placed in any area where there is a possibility that it may become locked in an undercut.



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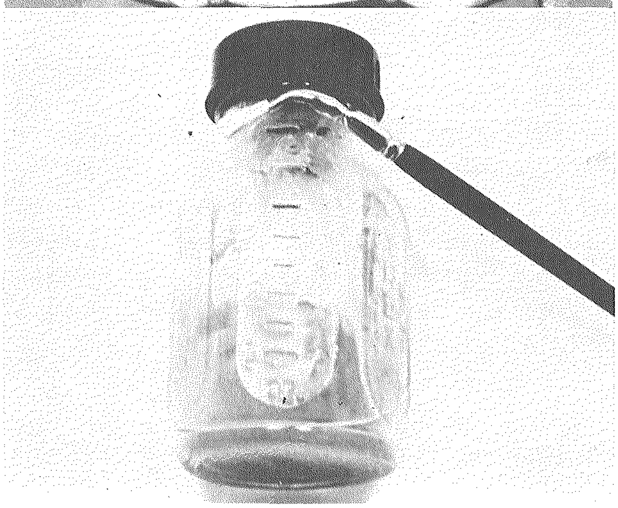

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Fig. 491. In addition to a compound rim lock, a compound palate stop is used for hydrocolloid impressions.
Fig. 492. Bent show-card brush for application of the diluted hydrocolloid in the Pyrex bottle.

At this point, the softened hydrocolloid is placed in the tray.

Handling of material. The material is prepared each morning by boiling it for 10 minutes. The tubes are then transferred to a thermostatically controlled water bath and stored at a temperature of about 160° F., depending upon the particular material used.

In addition to the hydrocolloid in the tubes, a diluted mixture of hydrocolloid is also boiled, which will be painted on the teeth to prevent the trapping of air in the impression procedure. The diluted material is prepared fresh about twice a week. One ounce of boiling water is placed in a 4-ounce wide-mouthed Pyrex nursing bottle. To this is added approximately 1 ounce of boiled hydrocolloid (Fig. 492). The mixture is stirred until smooth and then stored in the water bath at 160° F. Next day, the unused diluted material is boiled with the tube material and again placed in the storage bath.

The longer the boiled material is stored (within a limit of 6 or 8 hours), the better it handles. The minimum time for storage should be about one-half hour.

Ten minutes before an impression is to be taken, a tube of hydrocolloid is transferred to a tempering bath of about 140° F. The tempered material is then placed in a prepared tray, and tray and material are immersed in another tempering bath of about 110° F. for 1 minute (Fig. 493). During this 1-minute tempering period, retract the mouth, dry the teeth, and apply the diluted material with a white ¼-inch show-card brush (Fig. 494). The brush may be bent to a convenient angle for easy access to all areas. By the time these details are attended to, the hydrocolloid in the tray has tempered for the required minute. Now remove the tray from the tempering bath, shake off the excess water, and seat it to place.

For an accurate impression, the chilling of the hydrocolloid is critical. The material must be chilled for 5 full minutes with water running through the jacket. The temperature of the cooling water should be about 70° F. Too cold or too rapid a chilling will produce distortion. Inadequate chilling will leave the material in a softened condition, and it will not register the desired areas.

After proper and adequate cooling, the impression must be removed with a quick pull to avoid deformation. Wiggling and prying will cause distortion.

Hydrocolloid impressions should be washed in cool water to remove any debris or saliva. After drying the impression superficially with a blast of air to rid it of water bubbles, pour immediately with an accurate stone. When 45 minutes have elapsed for setting, the impression can be separated from the cast, and the cast is trimmed to the desired shape.

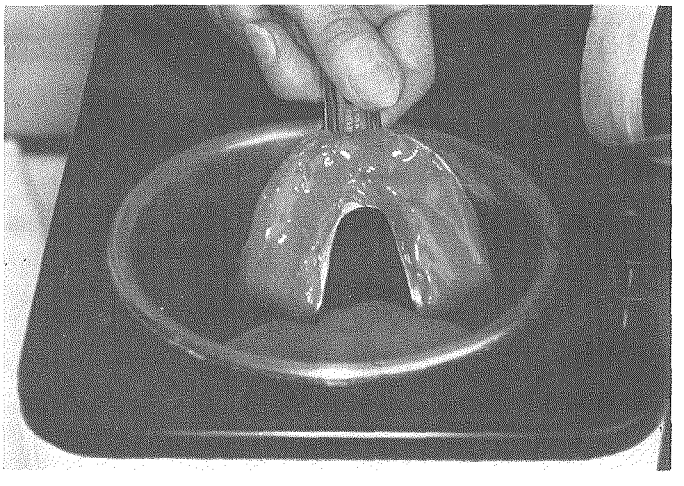
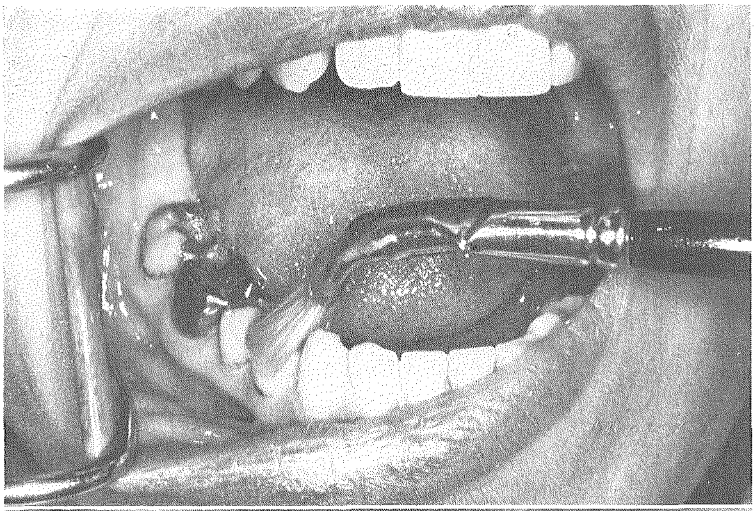


Fig. 493. The loaded tray is immersed in a water bath at 110° F.



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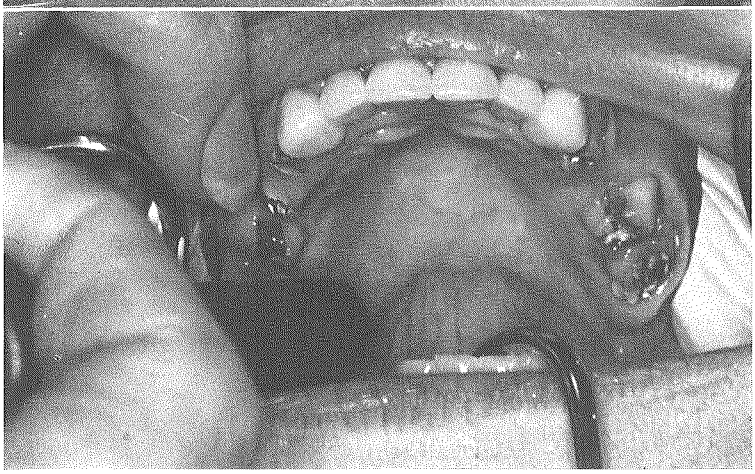

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Fig. 494. Applying thin hydrocolloid with a bent brush.
Fig. 495. Applying the thin material with a syringe.

This very same procedure is followed when the working master impressions are taken to produce working casts of the prepared teeth. The only deviations might be in the use of local anesthesia when extremely sensitive preparations are involved and in the use of a syringe for applying the diluted hydrocolloid.

The syringe application seems to produce more accurate marginal detail (Fig. 495). This is probably because the fine needle of the syringe can be placed between the tooth preparation and the gingival tissue, as well as because the syringe material can be a little thicker than the painted material. The only drawback is the difficulty of getting around all the prepared teeth before the material first applied begins to gel. After trying both methods, the operator must decide which works better for him.

Quadrant impressions for individual dies

As each quadrant of teeth is prepared, a quadrant impression, which is used for individual dies, is also taken. On these dies are adapted the margins of the wax patterns before casting. The reason for the quadrant impression lies in the fact that we are able to get better gingival retraction (under anesthesia) immediately after preparation than we could possibly get later in the master impression. (Even if it were possible to do so, it would be an unnecessary procedure and uncomfortable for the patient.) Moreover, the removal of a master impression is likely to produce distortion some place. There is less chance of distortion with a quadrant impression because it does not have to be drawn over so many teeth.

Sectional trays are rimmed with compound. An anterior compound stop is extended to the unprepared teeth. A posterior compound stop is extended to the tissue in back of the last prepared tooth. These stops help to hold the tray steadily while the hydrocolloid is chilled (Fig. 496).

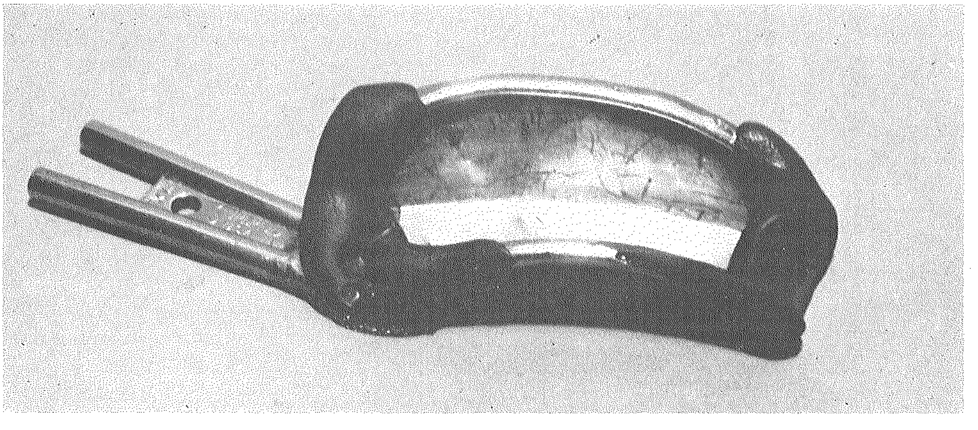
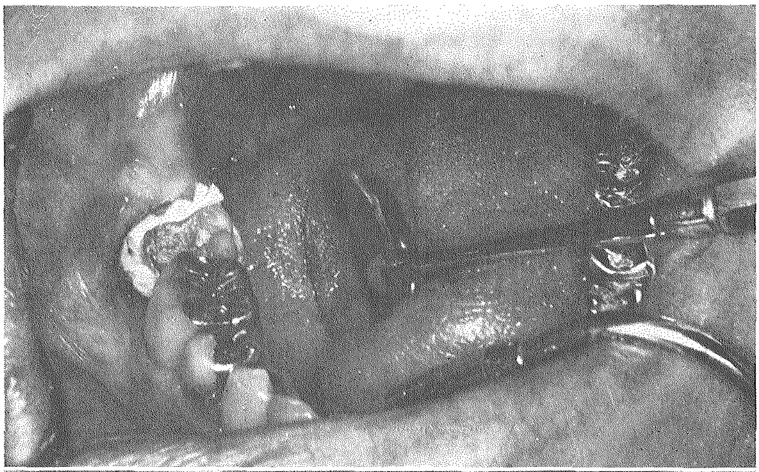


Fig. 496. Anterior and posterior compound stops to maintain the stability of the tray while the hydrocolloid sets.

Gingival retraction prior to impression-taking. When hydrocolloid is used, gingival retraction must be done prior to taking the impressions.

Use of Gingi-Pak. In order to secure adequate gingival retraction, it is necessary to use a material like Gingi-Pak,* a cotton thread impregnated with 8 per cent Adrenalin chloride, or Racord,† which is impregnated with 8 per cent racemic epinephrine chloride and 2 per cent zinc chloride. The Gingi-Pak is cut into short strands and gently packed between the tooth and the gingival tissues. A plastic instrument and a large spoon excavator work very nicely in placing the Gingi-Pak in the gingival sulcus (Fig. 497). Should there be considerable seepage of blood,

*Surgident, Ltd., Los Angeles, Calif.
†Pascal Co., Inc., Seattle, Wash.



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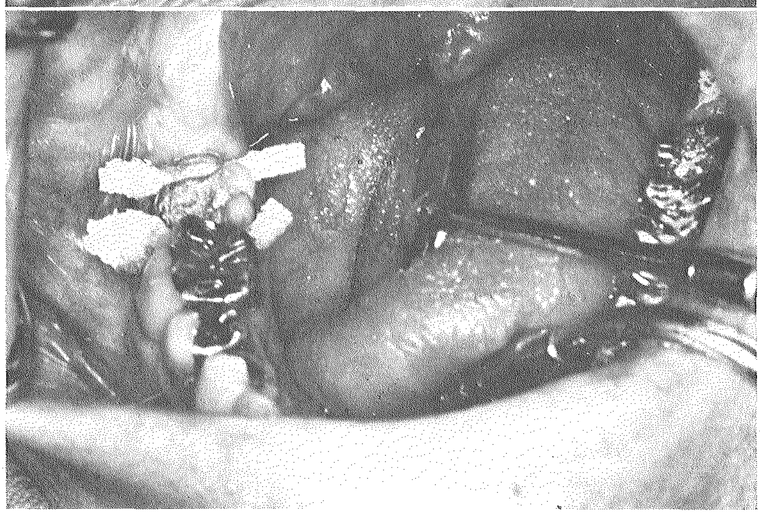

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Fig. 497. Gingi-Pak placed interproximally for tissue retraction.
Fig. 498. Spongical strips placed interproximally will cause mechanical retraction of the gingiva.

it may be advisable to add a *small* amount of Orostat* (8 per cent Adrenalin chloride). This should be used sparingly, however, and only when absolutely necessary because in some patients it produces quite a circulatory reaction. If we are dealing with inlay and onlay preparations, it may be helpful, in addition to Gingi-Pak, to use some Spongicals† (Fig. 498). This cellulose material, if placed dry, will expand on becoming moistened and produce good mechanical gingival retraction.

Use of radioknife. The least desirable way of attaining access to the margins of

*Surgident, Ltd., Los Angeles, Calif.
†Nordenta Products of America, Elmira, N. Y.

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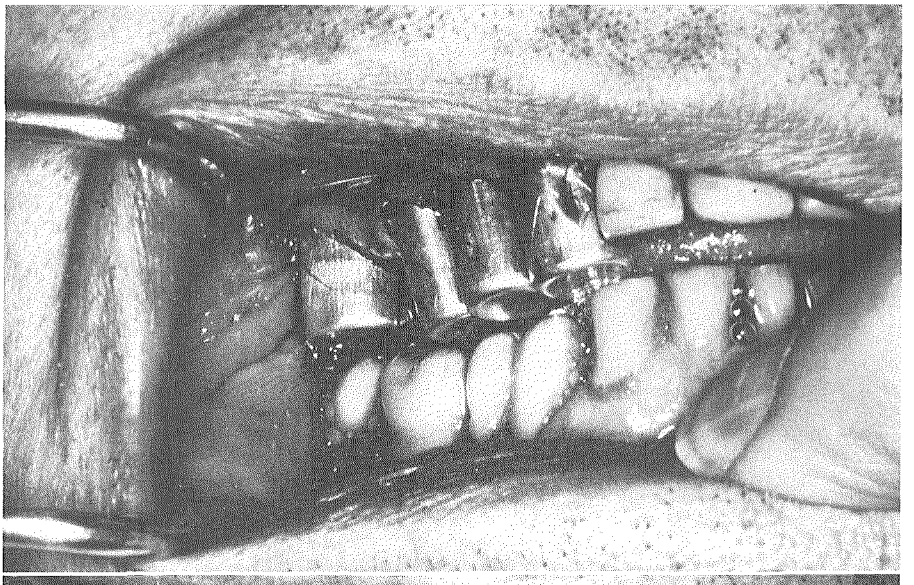

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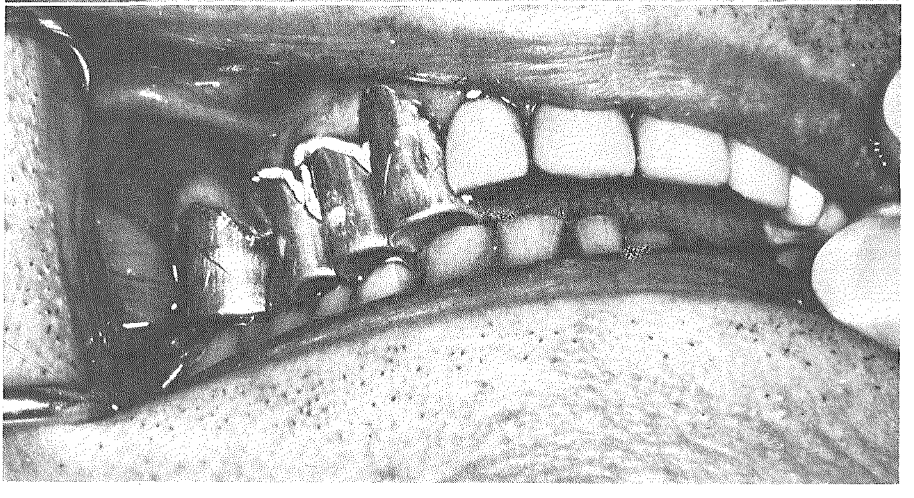

Fig. 499. Aluminum shells contoured to the preparations are longer and slightly oversized.
Fig. 500. Aluminum shells lined with gutta-percha are pressed to place.

the preparations is with the radioknife. In stubborn conditions it may be indicated, but if it is used carelessly and touches the interproximal septa of bone, sequestrum can easily result. One satisfactory way to remove tissue is to cut it off with a small pair of scissors, after which the Hyfrecator* can be used to stop the seepage of blood.

Use of an aluminum crown. In order to achieve adequate tissue retraction in most full crown preparations, it may be necessary to resort to the use of an aluminum crown.

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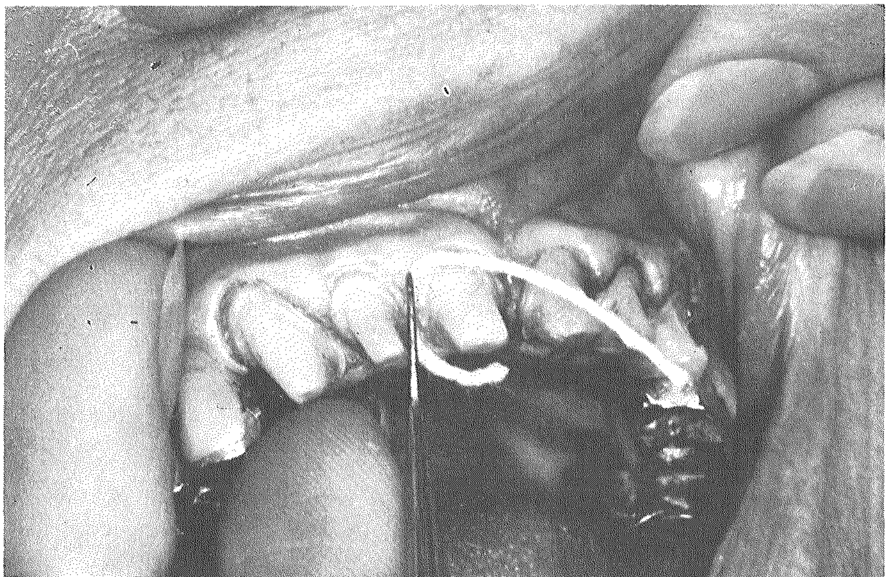
*The Birtcher Corp., Los Angeles, Calif.

An oversized aluminum crown is used for this purpose, about two sizes larger than the proper band for taking an impression, and it is trimmed until it is several millimeters longer than the preparation (Fig. 499). Line the crown with soft gutta-percha and place it on the tooth, pushing it while the gutta-percha is still soft so that it presses against the gingival tissue (Fig. 500). It must do this if it



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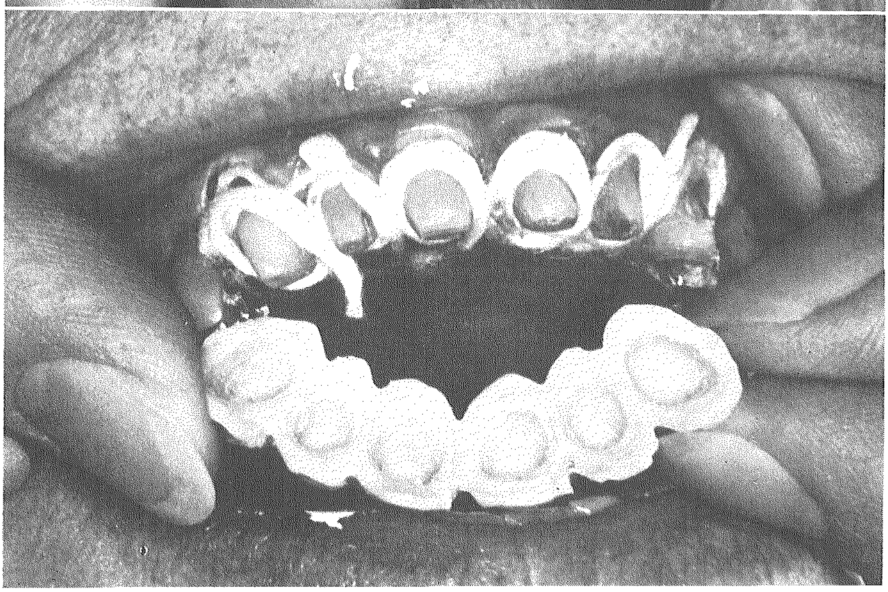

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Fig. 501. Racord being carefully tucked into the gingival sulcus for retraction.
Fig. 502. Gingi-Pak loosely wrapped around the preparation. Roughly trimmed temporary appliance ready to be placed to force the Gingi-Pak against the tissue for further retraction.

is going to retract the tissue sufficiently. Then remove the crown and trim only the gross excess of gutta-percha, leaving most of it to push against the tissue.

Taking a single strand of Racord, wrap it around the tooth several times and carefully tuck it into the gingival sulcus (Fig. 501). Next, loosely wrap a double strand of Gingi-Pak around the crown preparation, but do not tuck it into the sulcus (Fig. 502). Now replace the gutta-percha-lined aluminum crown on

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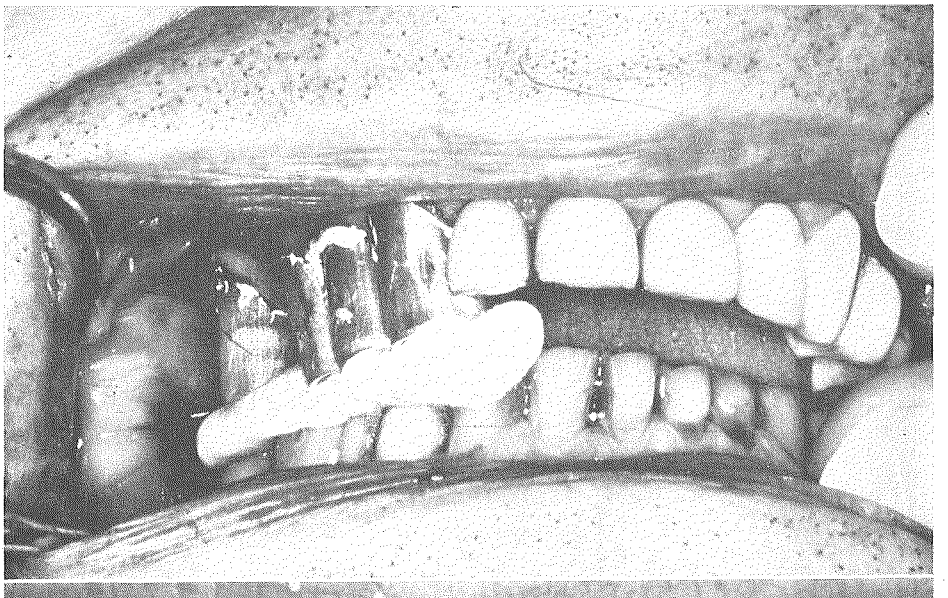

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Fig. 503. Gutta-percha-lined aluminum crowns are bitten to place to force the Gingi-Pak against the tissue to retract it.
Fig. 504. Margins of jacket crown preparations adequately retracted prior to impression-taking.

the tooth, press it to place against the Gingi-Pak, and have the patient bite on a cotton roll on the aluminum crown (Fig. 503). After 5 or 6 minutes, the tissue should be well retracted to permit easy access to the margin of the preparation (Fig. 504).

By one means or another, the gingival margins must be exposed at least 1 mm. below the margins of the preparations if an accurate impression of them is to be obtained.

The gingival packing is left in place for 5 minutes. Occasionally, a second piece of packing is placed over the first; then after 5 minutes, the second piece is removed, and the first is left in place. This helps to hold the tissue away from the margin and prevents seepage.

Be sure to remove any gingival packing before dismissing the patient!

The rimmed sectional tray is now filled with hydrocolloid and placed in a tempering bath. During this tempering period, the gingival packing is *gently* removed so as not to start further blood seepage, and the preparations are carefully bathed with water and dried. A piece of Fiber-Lint* (an excellent blotting paper for keeping the mouth dry) is positioned over the opening of Stensen's

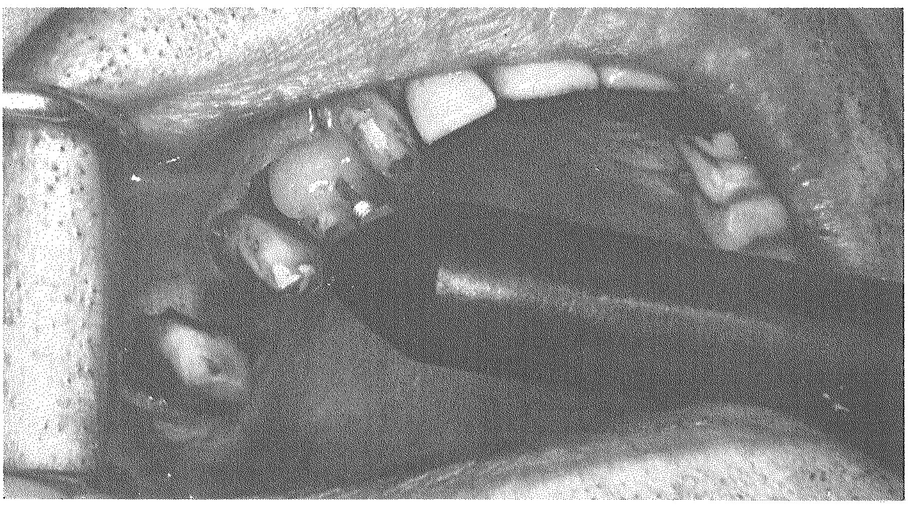

Fig. 505. Thin hydrocolloid being applied to the preparations with a syringe.

duct (the parotid duct) and held in place by a cheek retractor. After again carefully drying the preparations (not dehydrating them, but removing any free moisture), apply the diluted hydrocolloid to the gingival margins and the deep portions of the preparations (Fig. 505). The syringe seems to produce better results here, and since there are usually only four preparations to handle, it is no problem to apply the material adequately.

*S. S. White Dental Mfg. Co., Philadelphia, Pa.

The syringe material comes prepared in ampules,* each containing enough material of the proper dilution for the syringe. An ampule of the material is placed in the syringe, which is then boiled for 10 minutes. After that, it is stored in the water bath at 160° F. until ready for use.

The tray with the tempered hydrocolloid is now removed from the water bath. After shaking off the surface water, place it in position, and the cooling process is begun.

When the impression has been adequately chilled, it is removed with a quick snap. It is a good procedure at this point to take a second quadrant impression in view of the fact that we have anesthesia and retraction. The investment of an additional 10 minutes may prove very advantageous should one of the dies be broken or imperfect in some respect.

The temporary coverage is now cemented to place with temporary cement.

Pouring the impression. For best results, the impression should be poured immediately (Fig. 506).

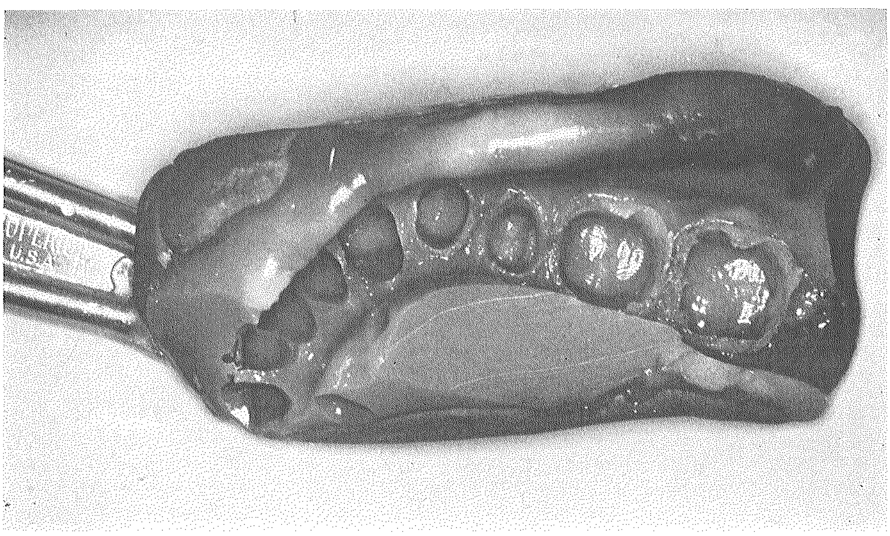

Fig. 506. Completed hydrocolloid impression of a quadrant of preparations.

In pouring the quadrant impression, it is advisable to utilize dowel pins. With the master impression, dowel pins may be placed in position, but it is not necessary to do so. Master impressions are routinely poured in one pour, whereas the quadrant impressions are poured in two sections. Dowel pins are placed over the prepared teeth in order that the individual dies will have an accurate seat in a base (Fig. 507). The dowel pins may be suspended in position by means of straight (banker's) pins and sticky wax, or they may be placed in position in

*Surgident, Ltd., Los Angeles, Calif.

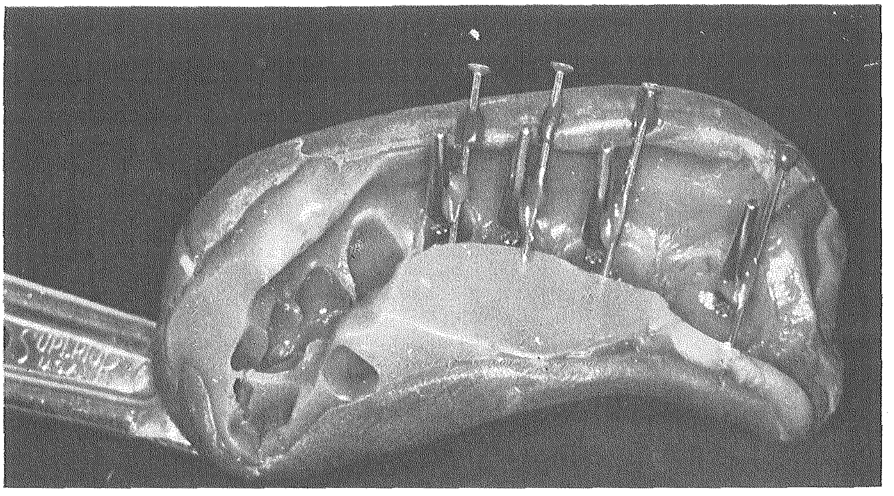

Fig. 507. Dowel pins suspended in place by means of banker's pins prior to pouring the quadrant hydrocolloid impression.

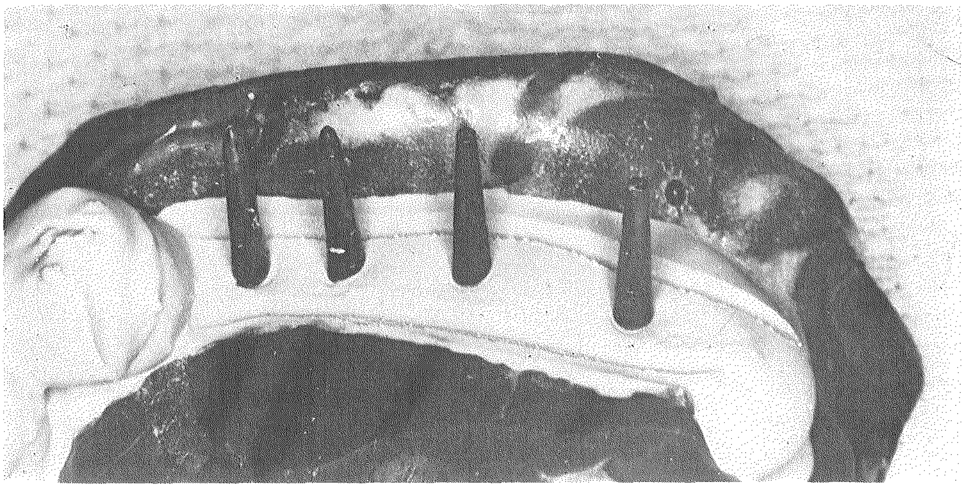

Fig. 508. Quadrant impression poured, banker's pins removed, and longitudinal grooves cut alongside the pins to furnish a better seat for the individual dies when the cast is separated.

previously marked areas after the initial pour is made. This is a matter of personal preference.

The initial pour is made to cover the entire tooth and a little more, and the dowel pins are engaged in this pour with their stems parallel. Little nobs of stone are built up in edentulous areas and on either side of the last prepared tooth to prevent the cast from coming apart when it is cut into individual dies. While the first pour is setting, two small grooves are scraped on either side of the row of pins (Fig. 508) to ensure additional accuracy in reseating the individ-

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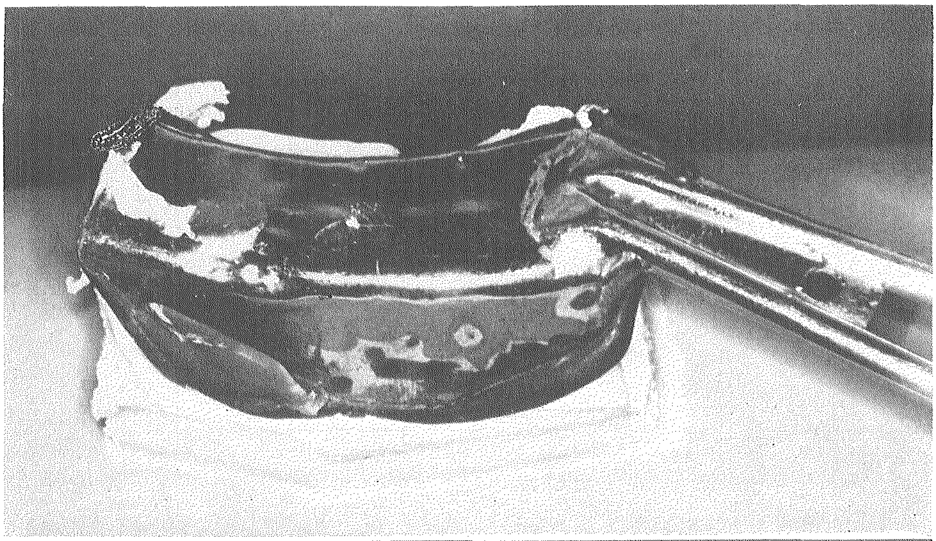

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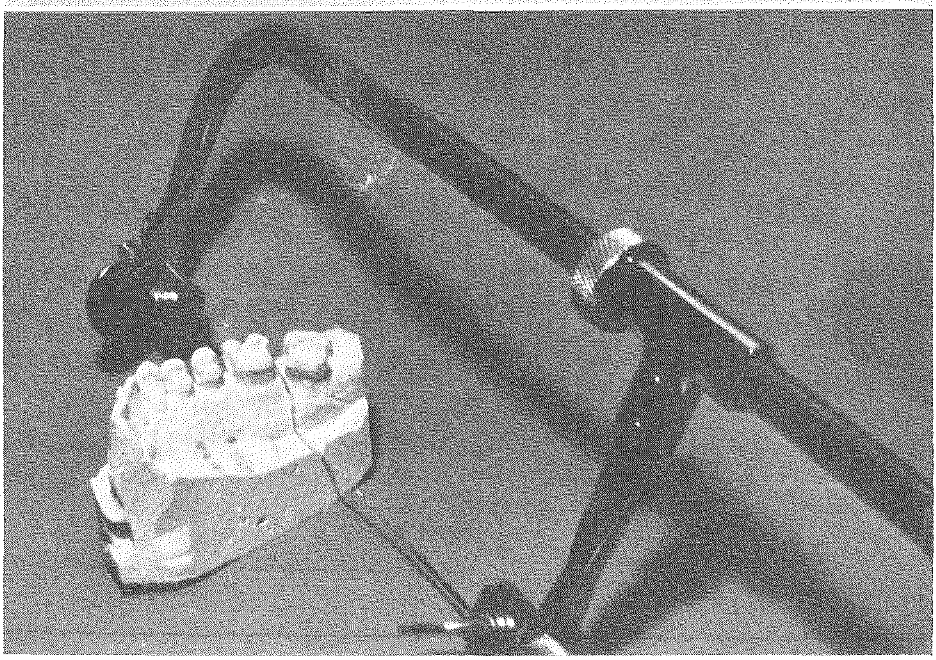

Fig. 509. The second pour of the quadrant impression is made after the pins and the base of the first pour have been lubricated with soapy water.
Fig. 510. Saw blade cut through the first pour of the cast.

ual dies. The base of the first pour and the pins are lubricated with soapy water, and the rest of the impression is poured with a suitable base (Fig. 509). If desired, the second pour may be of a stone of a different color to guide us where to end the saw cut when the cast is separated into individual dies. Both pours, however, must be of a good quality die stone.

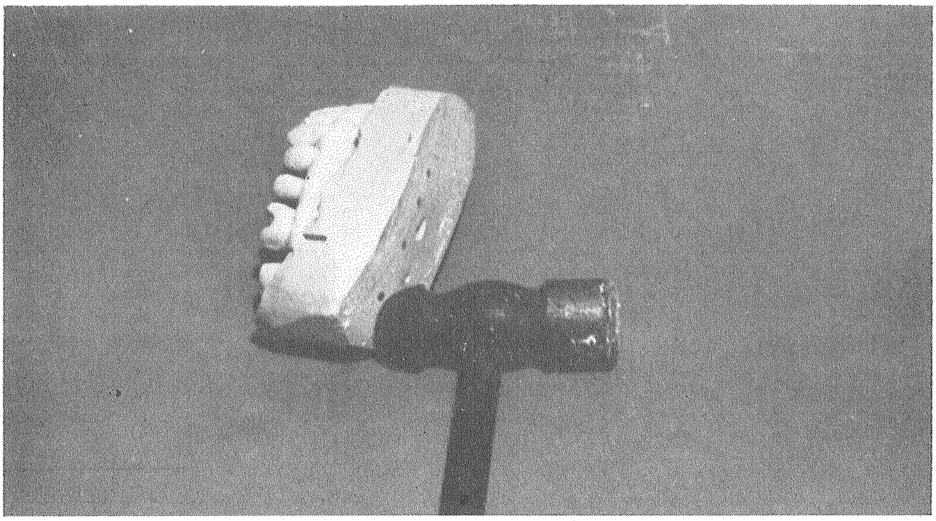

Fig. 511. Dies tapped out after locating the dowel pins.

After about 30 minutes, when the second pour has sufficiently set, the impression is removed from the cast, which can now be separated into the individual dies. It is a trifle more difficult to saw through stone when it is still wet, but the marginal areas can be trimmed with greater facility. Using a thin jigsaw blade with large tooth separations (which will not clog too easily), cut through the interproximal areas until reaching the second pour or the base of the cast (Fig. 510). Now locate the dowel pins from the base side of the cast and gently tap them with a jeweler's peening hammer (Fig. 511). The individual dies will readily separate from the base, and the marginal gingival areas can be cleaned up.

These casts are set aside until needed for the final adaptation of the margins and contact points.

RUBBER BASE IMPRESSIONS

In recent years, I have used rubber base material for both master and quadrant impressions. Compared with hydrocolloid, the material has some advantages and disadvantages. Its use becomes a matter of personal choice, governed somewhat, perhaps, by the facilities at hand. As far as accuracy is concerned, both materials, properly handled, produce equally good results.

Advantages of rubber base material

Rubber base material has the following advantages:

1. There is no temperature shock to the patient. When anesthesia is not present, the patient is more comfortable with the rubber material than with hydrocolloid.

2. The material seems to offer a little more resistance to the tissue and thus does some of its own tissue retraction.

3. It is less likely to tear in thin areas, such as delicate slices and pin holes.

4. It does not have to be poured immediately.

5. It is possible to pour several casts from the one impression—although the second may lack some of the fine details because the delicate surfaces may have been torn in the separation of the first cast.

Disadvantages of rubber base material

The following are the main disadvantages of rubber base material:

1. For best results, an individual tray is required.
2. Compared with hydrocolloid, the material is messy to handle.
3. Two persons are required to manipulate the material.
4. The teeth must be thoroughly dry—which is sometimes a problem without anesthesia.

To obtain satisfactory results with rubber base material requires a little practice.

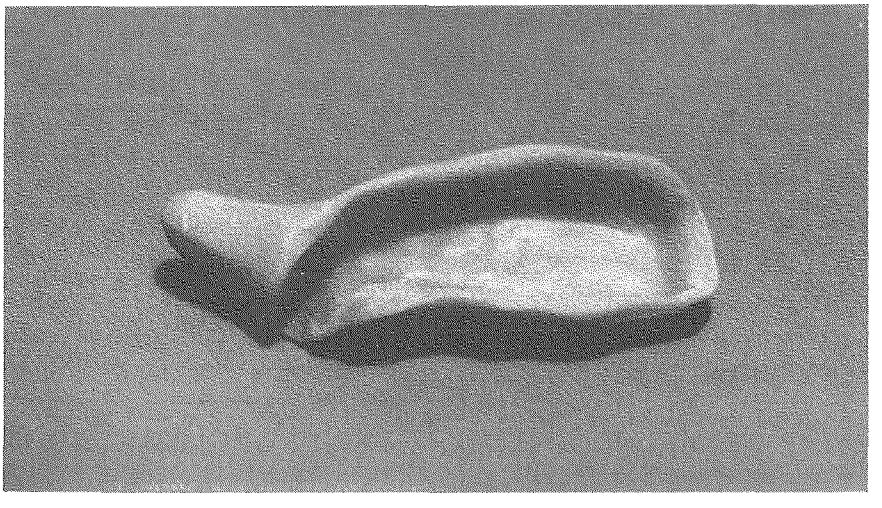

Fig. 512. Section tray custom-made for a rubber base impression.

Construction of tray

Although it is possible to use stock trays altered with compound, better results are achieved more readily with custom-made trays. In the construction of such a tray, a study cast is used. For a quadrant tray, two layers of Tenax* baseplate wax are adapted to the study cast over the teeth, extending at least a tooth beyond the ones to be included in the impression (Fig. 512). The unprepared tooth

*S. S. White Dental Mfg. Co., Philadelphia, Pa.

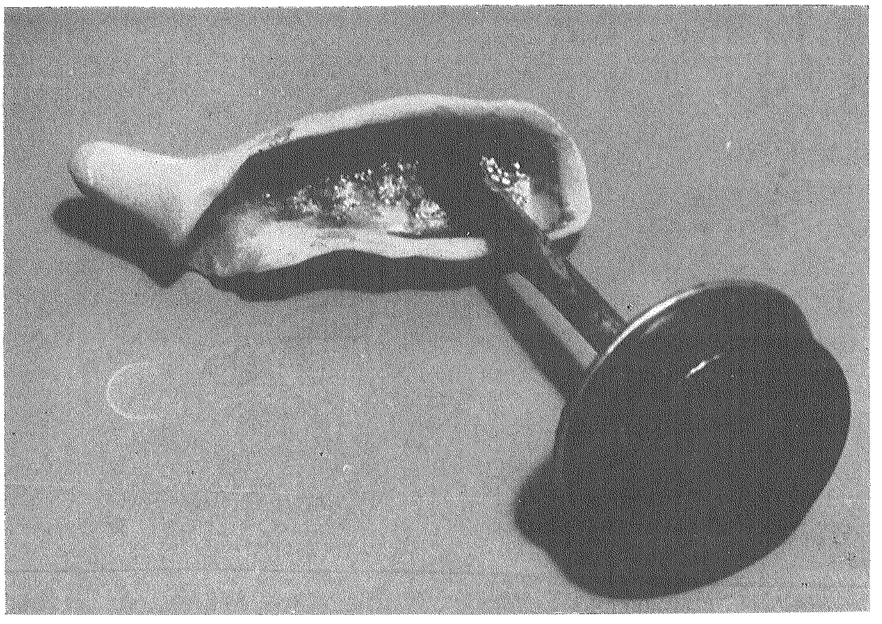

Fig. 513. Custom-made tray painted with adhesive.

acts as a stop in properly positioning the tray while the impression is being taken. For a full impression, the tray is extended beyond the last teeth onto the soft tissue. A quick-setting acrylic material such as Ontray* is used to construct the tray, which is then painted with an adhesive (Fig. 513).

There are two ways of taking a rubber base impression.

Reline technique

One method is the reline technique, in which a preliminary impression is taken in a heavy-bodied material (Fig. 514). When this has set and is removed, careful trimming of the interproximal areas and the areas adjacent to the preparations is essential. This is best accomplished with a pair of curved surgical shears (Fig. 515). Unless an escape is created for the reline material, inaccuracies will develop in the impression. When the trimming is completed, make a mix of thinner material and, after drying the preparations, apply this to the teeth with a plastic carrier or other convenient instrument (Fig. 516). Seat the prepared impression over this material, taking care not to allow any moisture to accumulate on the thin mix. When the impression is gently seated to place, release the pressure and allow the impression to set completely.

With this method there is the inherent possibility of displacing the set material by hydraulic pressure, with a probable rebound and an inaccuracy. This is the

*William Getz Corp., Chicago, Ill.

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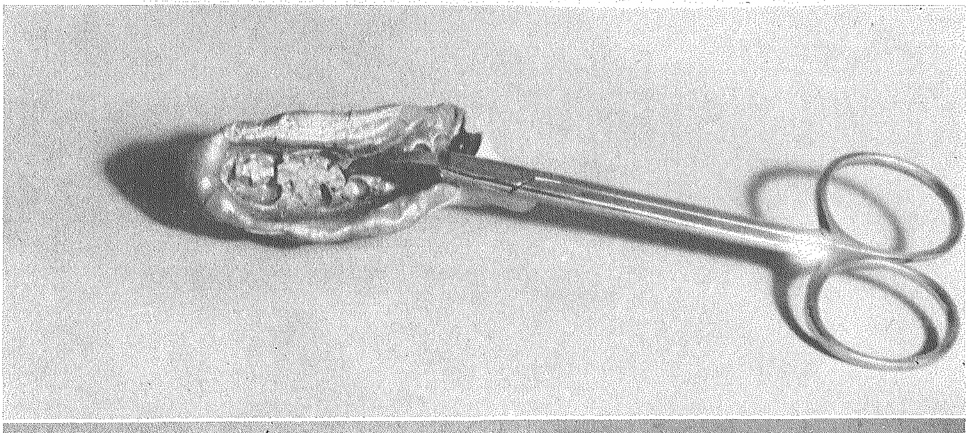

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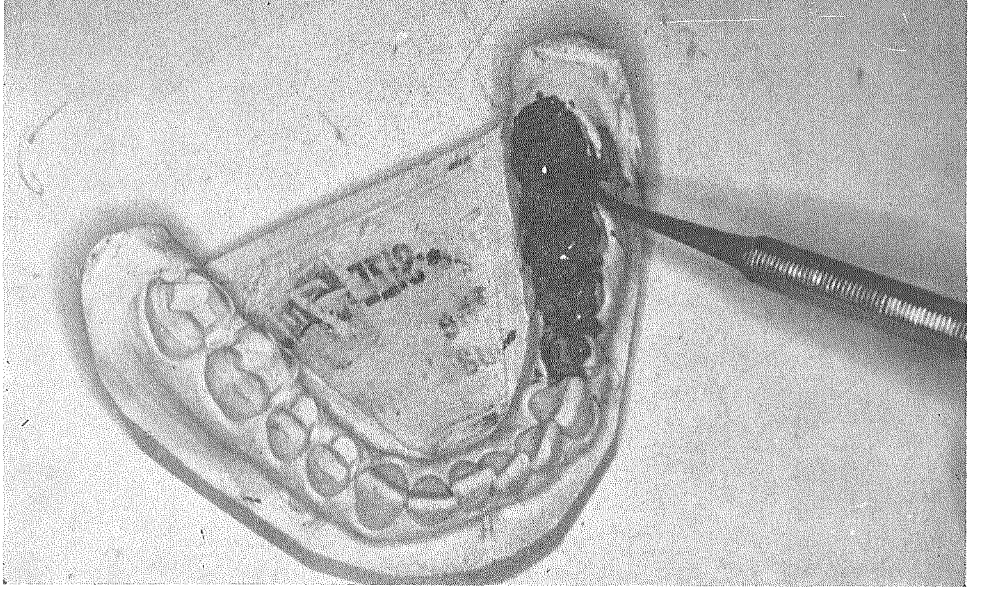


Fig. 514. Impression made with heavy-bodied rubber material.
Fig. 515. Curved scissors used to trim the interproximal areas of the rubber impression.
Fig. 516. Soft rubber material being applied to tooth preparations.

reason why an escape is provided for the relining material by adequate relief in the necessary areas.

Two-mix technique

A safer method of taking a rubber base impression is the two-mix technique, in which the syringe is used to apply the thinner material. This procedure requires the aid of an assistant.

The gingival tissue is retracted as in the other techniques. A piece of Fiber-Lint is positioned over Stensen's duct and held in place by a retractor, which the patient is asked to hold. Heavy-bodied material is dispensed on a mixing pad and thin material on another. While the operator mixes the heavy material, the assistant mixes the other. While she loads the syringe from a dappen dish into which the thin mix has been placed (Fig. 517), the operator loads the tray with the heavy mix. The teeth and gingival crevices are thoroughly dried, and the thin material is carefully applied to the gingival margins and the rest of the preparation to prevent air from being trapped between the preparation and the material (Fig. 518). The tray, loaded with the heavy-bodied material, is seated to place before any moisture can get at the thin mix over the teeth. It is held firmly in place for 6 minutes and then removed.

It is possible to obtain a very satisfactory impression by this technique, with accurate marginal detail.

These impressions do not have to be poured immediately although it is wiser to do so whenever possible. The procedure for making the master casts and individual dies is the same as that followed in the hydrocolloid technique.

The use of rubber base or hydrocolloid material in a single tube impression

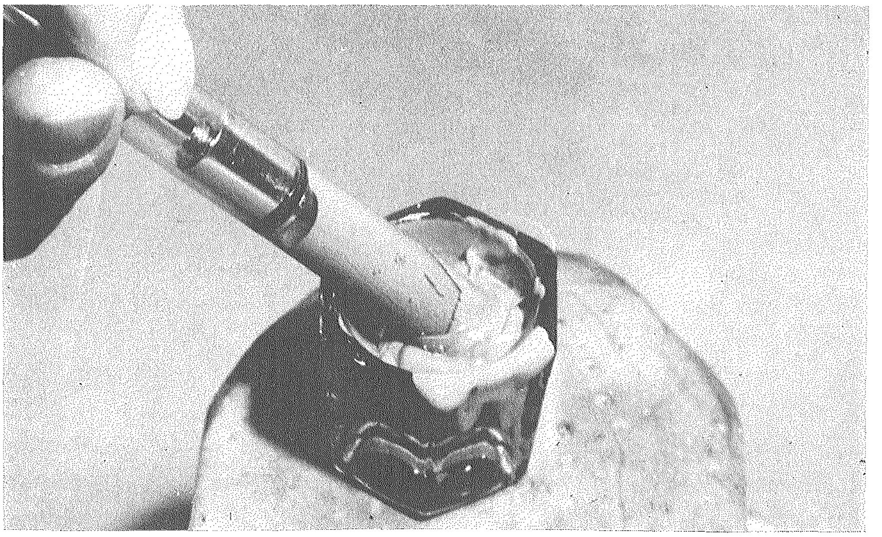


Fig. 517. Loading the syringe with soft rubber material from a dappen dish.

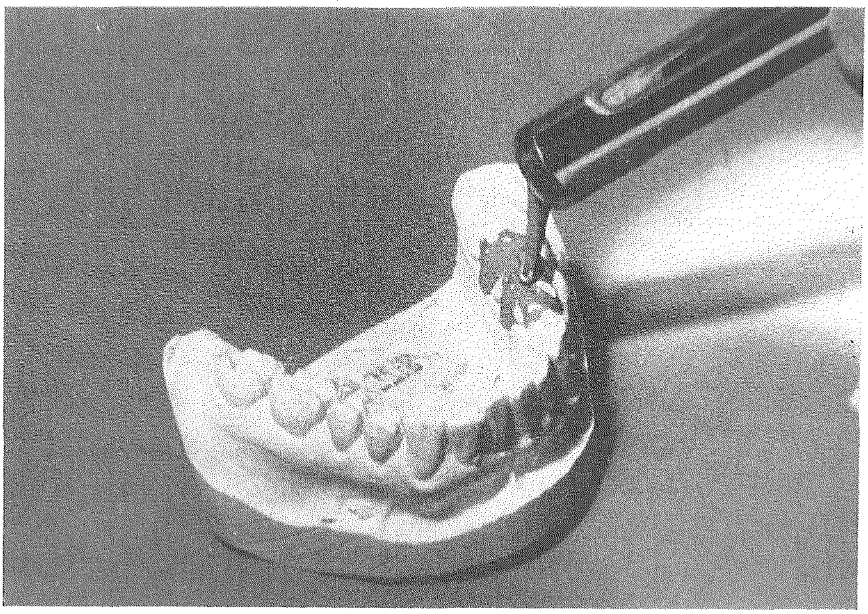


Fig. 518. Applying the syringe material to the preparations.

has never appealed to me. It requires just as much time as a quadrant impression and does not furnish the adjacent teeth for contact areas or for articulation with the opposing teeth. If an individual die is required, I would rather use the old copper band method, employing Kerr's red stick compound.*

COPPER TUBE IMPRESSIONS

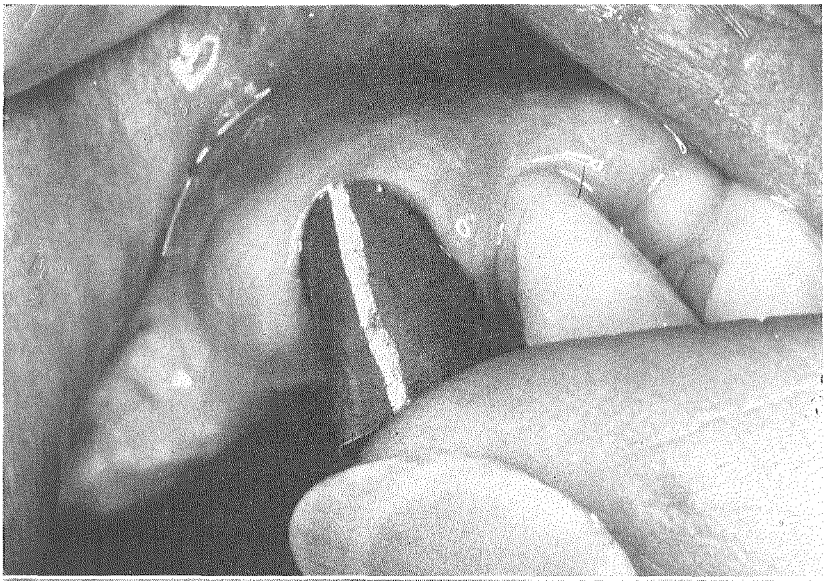
For one reason or another, one may occasionally prefer to use individual copper tube impressions for an entire restoration. Sometimes the teeth have been previously prepared, and their finishing lines are too far below the gingiva to conveniently retract this tissue for other types of impressions. Abutment teeth that are to carry attachment cases are also more conveniently treated by means of copper dies.

Gold cast copings or Dura-Lay† copings on copper dies provide an accurate working cast when the remount type of impression is used to make the master cast. The individual copings are fitted to the prepared teeth, and the impression accurately positions the dies in the cast (see Chapter 19).

Technique

A 36-gauge copper band is selected, trimmed, and festooned to the prepared tooth. A properly festooned band will stay firmly in place when tested for rock-

*Kerr Manufacturing Co., Detroit, Mich.
†Reliance Dental Mfg. Co., Chicago, Ill.



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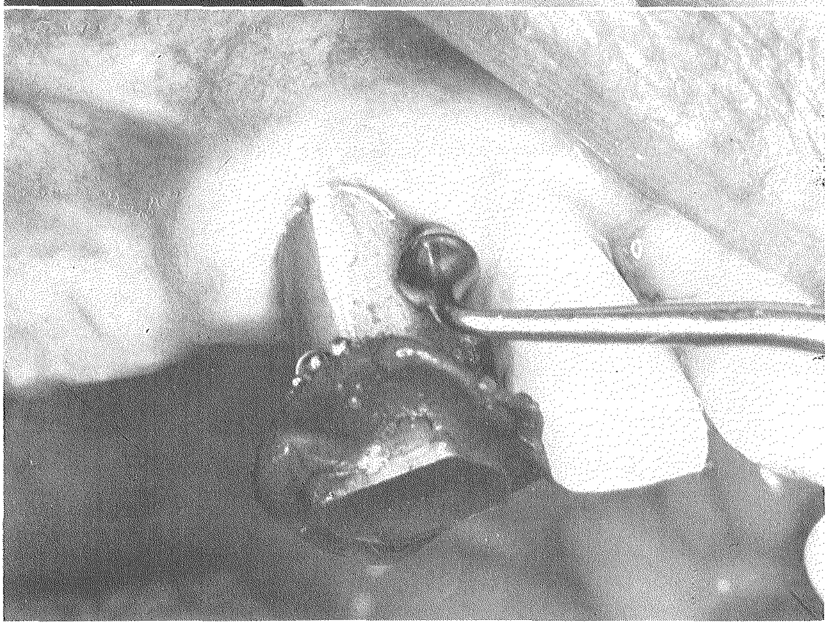

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Fig. 519. Testing the festooned copper band for rocking after fitting it to the preparation.
Fig. 520. Burnishing the margin of the band before chilling the softened compound in the band.

ing with finger pressure (Fig. 519). Care must be taken not to damage the tissue during the procedure. The trimmed band is annealed and filled with compound and then placed in position and firmly held while the margins are burnished with a suitable instrument (Fig. 520). Following this, the band is chilled with cold water.

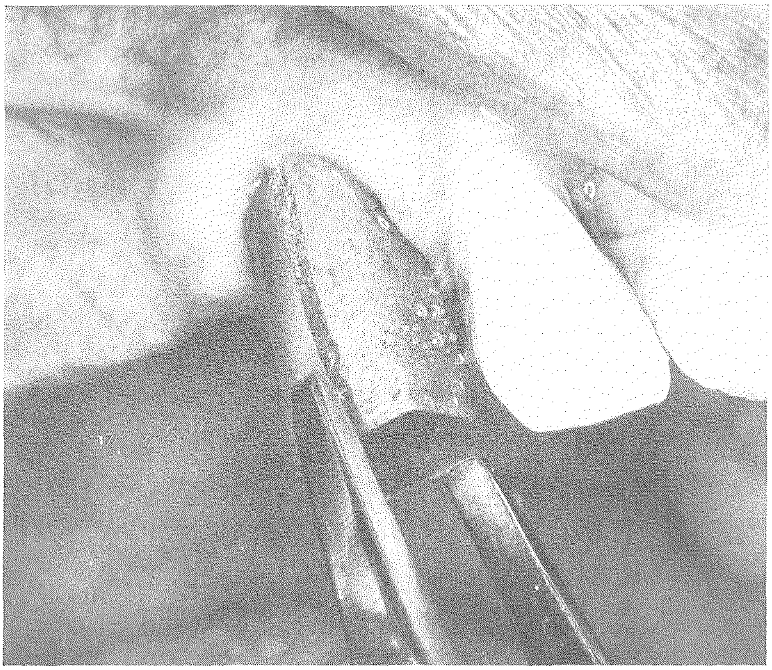

Fig. 521. Beebe pliers used to remove the chilled copper band and compound impression of the preparation.

A pair of Beebe pliers will facilitate the removal of a copper band impression (Fig. 521). These pliers have two triangular points which will adequately grasp the band and an adjustable stop screw which will prevent the impression from being crushed as it is removed. To avoid distortion, we should not rock the band during removal.

Sometimes it is desirable to line a copper band impression with graphite wax. When this is done, extreme care should be exercised when the band is removed. This material does not harden completely when it sets and is easily distorted without one's knowing it.

Copperplating the band

The plain compound band or the graphite-lined compound copper band can be copperplated by a simple process. The band is attached to a plating holder, with contact established by the copper band and the plate of the holder. The inside of the compound impression is carefully painted with Aqua Dag,* a graphite metalizing material (Fig. 522), and a collar of green casting wax is placed around the band (Fig. 523). This wax will not crack and allow the current to escape. The holder with the copper band attached is placed in a copper-

*Acheson Colloid Corp., Port Huron, Mich.

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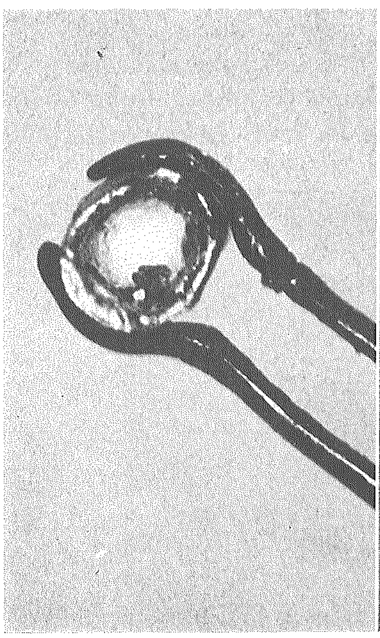
Fig. 522. Application of Aqua Dag to furnish electrical conduction for plating.
Fig. 523. Soft green casting wax wrapped around the copper band and holder in preparation for plating.



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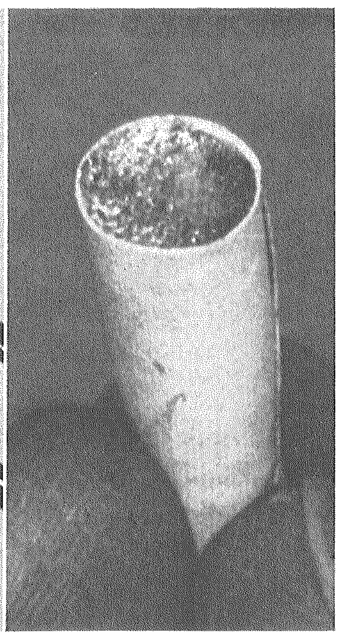

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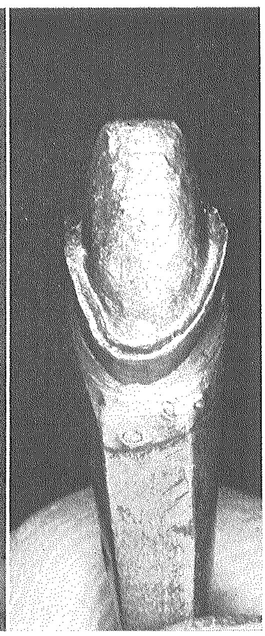

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Fig. 524. Soft solder applied to the plated surface for re-enforcement against crushing forces.
Fig. 525. Tape to form the tail of the finished die.
Fig. 526. The trimmed die.

plating machine and slowly plated overnight. The plated band is reinforced with soft solder (Fig. 524), and a metal stem is attached to the solder, thus ensuring a crush-proof die (Fig. 525). The copper band is now removed, and the copper-plated die is trimmed and ready for use (Fig. 526).

IMPRESSIONS OF PIN-LEDGE PREPARATIONS

A special technique is required to obtain impressions of pin-ledge preparations. These preparations are very necessary to the practice of dentistry, but until recently, the impression procedure was extremely difficult, and many men had to resort to waxing directly in the mouth, with all its inherent drawbacks.

A technique has now been developed by Dr. E. David Shooshan of Pasadena, California, which makes it a simple procedure to obtain good impressions of these preparations. The technique requires the use of nylon bristles and hydrocolloid.

The pin holes in the preparations are made with special drills of various sizes. If a .025 drill is employed, then a .024 bristle is used in the impression procedure. The nylon bristle is cut into ½-inch lengths with a sharp razor blade. If the edge of the cut bristle becomes flattened, it can be trued with a carborundum disc so that it will fit into the pin hole without binding.

When all the bristles are in the pin holes, select a suitable waxing instrument and heat it. Then, with this heated instrument, gently touch the projecting end of each bristle and just as gently wipe it away after having mushroomed it to the desired length. Both the temperature and the wiping motion are important. This may require a little practice; otherwise one may wind up pulling the bristle out of the hole or making a long, thin nylon thread for which he has no use.

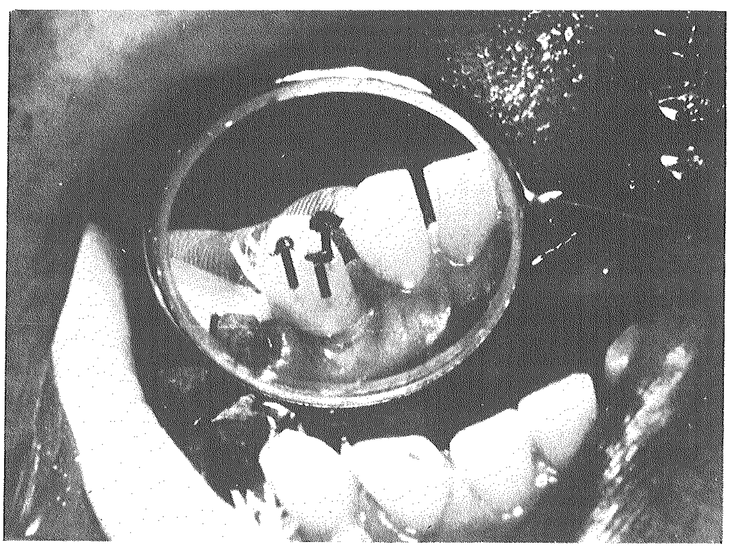

Fig. 527. Nylon bristles headed prior to taking the hydrocolloid impression.

When all the bristles have been headed, we are ready to proceed with the hydrocolloid impression (Fig. 527).

The material is placed in the tray, which has been previously prepared with stops and a periphery as for the other hydrocolloid impressions. While the tray with the material is being tempered, syringe material is placed around the pin holes and bristle heads. The hydrocolloid-filled tray is then placed in position and cooled for 5 minutes with 70° F. water, after which it is removed with a quick snap, and the impression poured in a suitable stone.

When the impression has been separated and the dies trimmed, we begin the waxing of the pin-ledge patterns. The bristles used for the impression are removed and replaced with bristles 1/1,000 smaller in size. The ends are mushroomed as before but closer to the surface of the preparation so that they will be engaged in the wax. Now the wax pattern is completed.

TREATMENT OF MASTER CASTS

Stone master casts, after being properly related to the articulator and mounted, are treated by oil immersion. Prior to this, the casts and mounting blocks are allowed to dry thoroughly for several days. The quadrant casts can be treated in the same manner although ordinary separators may be used here since the wax patterns are not likely to be left on for any length of time.

The dry master casts and mountings are immersed in a fine mineral oil in a jar which can be subjected to a vacuum atmosphere. When the jar is sealed, a vacuum is created over the oil covering the casts, and the air is thus removed from the casts and mountings. This may take an hour or longer. When the bubbling has completely ceased, the vacuum is released, and the atmospheric pressure allowed to drive the mineral oil through the casts and mountings. This is usually an overnight procedure. The reason for doing this after the master casts are mounted is to avoid the possibility of having the fresh stone rob the casts of their impregnated oil.

The casts and mountings are removed from the oil bath and dried with paper towels. It is now possible to blot all the free oil off the casts and yet, when wax is applied for the carving of the articulation, to remove the wax patterns with ease—even after several weeks. It sometimes takes that long before an articulation is completed in wax, and it would be most discouraging, after all the work, to find that the patterns could not be removed without breaking. Properly treated casts, however, can actually be waxed several years later, and the wax patterns can be easily removed. Moreover, there is never any free lubricant on the casts to contaminate the wax patterns.

Well-adapted wax patterns now require an accurate investing and casting technique to ensure well-fitting restorations.

Because the remount type of impression has several variations and uses, it is dealt with in a separate chapter.

Max Kornfeld, D.D.S., F.A.C.D., F.I.C.D.

CHAPTER 18

The clinical application of dental materials to the casting and soldering processes

A better understanding of the materials which have been used and proved reliable over a period of years, as well as the new materials now available, will enable us to employ techniques which will produce restorations that have a high degree of accuracy. An understanding of these restorative materials must be related to clinical applications. As Phillips points out "this relationship is practical, dynamic and fundamental to successful dentistry."[1]

Crown and bridge prosthesis probably requires more training and technical skill than most things we do. It is highly scientific and deserves a careful diagnostic approach, along with considerable conscientious ability. We find that many bridges fail not only from a structural and mechanical inadequacy, but also because certain biological factors were not properly evaluated in the diagnosis of the case.

PRINCIPLES OF CAVITY PREPARATION

Proper cavity preparation is of prime importance, along with proper tooth form and function. Excellent cavity preparation is a must, along with definitive retentive form and marginal outline.

One of the commonest causes of small type casting failures is haphazard cavity preparation. It is not necessary to cut the cavities very deeply, especially since experience has taught that parallel walls, judicious use of pits, wells, or pin anchorage, and proper selection of the gold alloy will give adequate retention and maintain as much frictional adaptation as possible with less probability of degenerating pulps.

Abutment preparations employing unnecessarily complicated designs which increase the cavo-surface length, which in turn increases the hazard of poor margins, should be avoided. The amount of retention and strength required in a retainer varies with and under different conditions. The degree of torque and strain to which a retainer will be subjected depends upon the length of the span, the occlusion, the mobility of abutment teeth, the musculature of the individual, etc. Retainers should be self-retentive since the function of cement is to hermetically seal it to the prepared tooth. Whenever possible, it is advantageous to lay the peripheral margins on sound enamel with a definite abrupt bevel and slightly above the gingival margin, as it not only facilitates accurate marginal adaptation of the gold but also prevents tissue irritation.

We should not permit restorative dentistry to become a field of one preparation for all teeth. The use of other types of retainers that do not encroach upon the terrain of the marginal gingiva is urged when at all possible.

Fox[2] has made the following pertinent statements:

"Clinical evidence clearly demonstrates that subgingival extensions of full coverage margins produce an environment unfavorable to the health of the marginal gingiva. In the area adjacent to full coverage, it is difficult to maintain marginal gingiva which are thin and acceptably contoured for physiologic function and food flow.

"In contrast to the maintenance of healthy gingiva around enamel and cementum of natural tooth substance, the gingival tissues around full coverage seem to be more thickened, more rolled, and generally more inflammatory in character.

"Even with the most careful techniques of tooth preparation and tissue handling during preparation of tooth, impression taking, temporization, and final cementation, the full coverage extended subgingivally limits the opportunity for the marginal gingiva to achieve maximum patterns of health.

"This is not an indictment of full coverage. There has, however, been a tendency to utilize this procedure without definitive indication. Where indicated and demanded in the therapeutics of restorative dentistry, it can be utilized to advantage. Where full coverage is therapeutically utilized with finesse and understanding and precision technique, it offers much in many clinical circumstances."*

Many dentists have assumed mistakenly that research investigation of casting techniques has been concluded long ago, and that the materials involved have been developed to such perfection that they can be manipulated with considerable latitude of technique. Unfortunately this isn't so because much work is still being done, and much more still has to be done before the various procedures necessary to evolve the perfect casting have been developed. There are still too many unsolved variables.

Keys[3] has shown with photomicrographs and diagrams from well-known texts on metallography and physical metallurgy that sharp corners and acute angles in castings tend to produce planes of weakness and areas of porosity because of their influence on the rate of cooling of the cast metal as it freezes. From this he concluded that in inlay work results can be improved by modifying the cavity

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*From Fox, Lewis: Letters to the Editor, Dental Times 3:6, 1961.

preparation to eliminate all sharp and abrupt angles and by the formation of a cove effect at all lines and points within the cavity.

Myers[4] has also pointed out that modifications in cavity preparation that reduce the detrimental effect of failure to balance the variables in casting include beveling of margins, maintaining as nearly as possible uniformity in thickness of the various parts of the casting, and avoiding irregular angles and sharp curves.

The object of a dental casting technique is to produce from a wax pattern a casting which will fit snugly on the preparation but at the same time slip completely to place with finger pressure or with only very light tapping with a mallet and orangewood stick. The casting when completed should be smooth and free from bubbles and internal or surface porosity.

The problem of casting dimensionally accurate gold inlays, pin-ledges, crowns, etc., can be solved only when the physical properties of the materials entering into the casting process are thoroughly understood and intelligently applied.

TISSUE RETRACTION AND IMPRESSIONS

That the indirect technique has been accepted by the profession as a whole in the reconstructive phases of dentistry is due primarily to the development of materials which can accurately reproduce all areas and types of preparations and retain their dimensional accuracy upon removal from the mouth.

"Microscopically accurate dies can routinely be secured with proper use of the hydrocolloid technique. When a standardized and sound procedure is followed, reversible hydrocolloid is unexcelled as an impression material."*

Because all margins of a prepared tooth must be completely exposed and the cavity dry, varying gum conditions must be recognized and a suitable method for the retraction of the tissues must be decided upon.

Impression materials such as Dietrich's or modeling compound, when properly manipulated, are physically capable of pressing away the gingiva and creeping into the crevice, thus reproducing the margin. The hydrocolloid gels, however, do not possess this ability to adequately displace soft tissue; therefore, the margins must be exposed before the impression is attempted. Failure to retract or remove interfering gingival tissue prior to impression taking has led to more failures with hydrocolloid than all other causes combined. It is imperative that the margin of the preparation and about ½ mm. beyond it must be visible, or the hydrocolloid cannot accurately reproduce the margin. Tissue retraction should be done very carefully so as not to detach the membrane from the tooth.

Tissue retraction

The retraction technique that I use is to first isolate the area from the cheek with cotton rolls and then apply Orostat to the cervical tissue. This effectively

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*From Phillips, R. W., and Ito, B. Y.: Factors Influencing the Accuracy of Reversible Hydrocolloid Impressions, J.A.D.A. 43:1-17, 1951.

controls any seepage or bleeding that can creep back into the retraction on removal of the pack.

For posterior interproximal inlays a piece of Gingi-Pak or a Gingi-Pak pellet is tucked into the gingival crevice with the aid of a gingival retraction instrument which has serrated ends and is designed for this purpose. The tissue is forced away from the tooth and not depressed. The pressure is directed obliquely against the long axis of the tooth, rather than toward the apex of the root. Pack tightly with cotton pellets to hold the cord or pellet in place and leave in place for 2 to 3 minutes. "Rapid retraction occurs while bleeding is simultaneously controlled. The pack is removed and the area is flushed, isolated, and dried with a gentle stream of warm air."[6] A final inspection of the margins should show a dry, open field, and the impression can now be taken.[6]

When the tissue for full and three-quarter crowns is being retracted, a good procedure utilizes aluminum shells.

"The shells are selected slightly larger than the prepared teeth and are contoured gingivally with crown and bridge shears and left long enough to allow the edge of the shell to enter the gingival crevice. The shells are then checked for length under biting stress. They are now filled with soft warm temporary stopping and forced to place, first with finger pressure and then under biting stress, to clear the occlusion. The filled shells are now removed with a curved serrated hemostatic forceps, and the excess stopping is trimmed away."*

Two lengths of Gingi-Pak, long enough to loop around the tooth, are cut. One length is looped around the tooth, twisted tight with curved serrated forceps, and then the gingival retraction instrument is used to gently tuck it down into the gingival crevice. The second length of cord is next looped over the crevice created by the first length and packed into position. The prepared aluminum shell or shells are now placed on the teeth and forced to place under biting stress for 4 or 5 minutes. Thus, the cord is held snugly in the crevice while the medicament is at work relaxing the tissue. Retraction occurs while bleeding is simultaneously controlled. When ready to take the impression, remove the aluminum shell, carefully remove the cord or pack, and flush, isolate, and dry the area with a gentle stream of warm air.[7]

"In a certain percentage of cases the tissue retraction problem cannot be handled by the methods already discussed. These are usually the cases where a large bulk of inflammatory edematous tissue interferes with making a good preparation and/or taking a good hydrocolloid impression. When confronted with this problem, it will be found expeditious to resort to surgical removal of the tissue. This can be accomplished by the use of surgical knives or by means of the electro-dental scalpel or the so-called 'radioknife,' which employs an extremely high frequency induction current."*

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*From Garvey, F. Raymond: Retraction of the Gingival Tissue for Hydrocolloid Impressions. In Hydrocolloid Handbook, Minneapolis, Minn., 1954, General Refineries, Inc., pp. 9, 13.

Impressions

After the retraction of the gingival tissue has been accomplished, the next procedure is the taking of the impression. The material of choice is a reversible dental hydrocolloid. "The base for reversible dental hydrocolloids is agar-agar, which is derived from sea plants; it can be liquefied by boiling and cooled to temperatures which can be tolerated by the tissues of the mouth."[8]

Reversible hydrocolloids

The armamentarium (Figs. 528 and 529) necessary for the reversible hydrocolloid method of impression taking is a conditioner which is thermostatically controlled and contains water baths for the liquefaction, storage, and tempering of the impression material, small and large syringes, individual jacketed hydrocolloid, rim-locked water-cooled trays, and tubing for cooling water supply. With such equipment, it is possible to liquefy the hydrocolloid impression material to the proper temperatures and place it in the mouth without injuring the tissues.

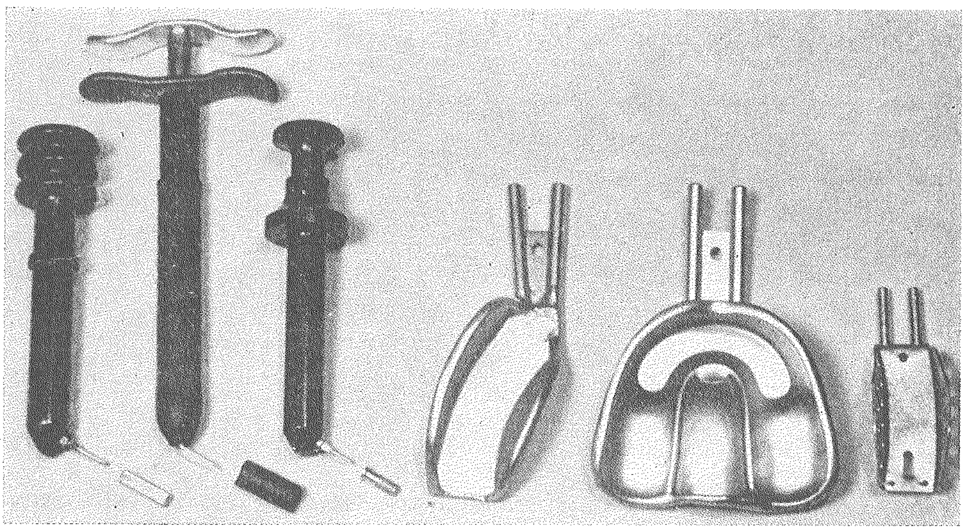

Fig. 528. Armamentarium for use in obtaining impressions with reversible hydrocolloid material. Three types of syringes for injection of the material into prepared cavities are shown at the left. On the right are various types of water-cooled trays. (From Skinner, E. W., and Phillips, R. W.: The Science of Dental Materials, Philadelphia, 1960, W. B. Saunders Co.)

Technique. The impression is taken in a tray of sufficient size to provide a bulk of material so that if undercuts are present there will be sufficient bulk of impression material to allow for passing these areas without permanent distortion. The hydrocolloid should be able to be stretched or compressed without crushing or fracturing the material. Stops, either of wax or modeling compound, should be placed at each end of the tray beyond the prepared teeth to allow for sufficient thickness of the impression material over the occlusal area of the prepared teeth

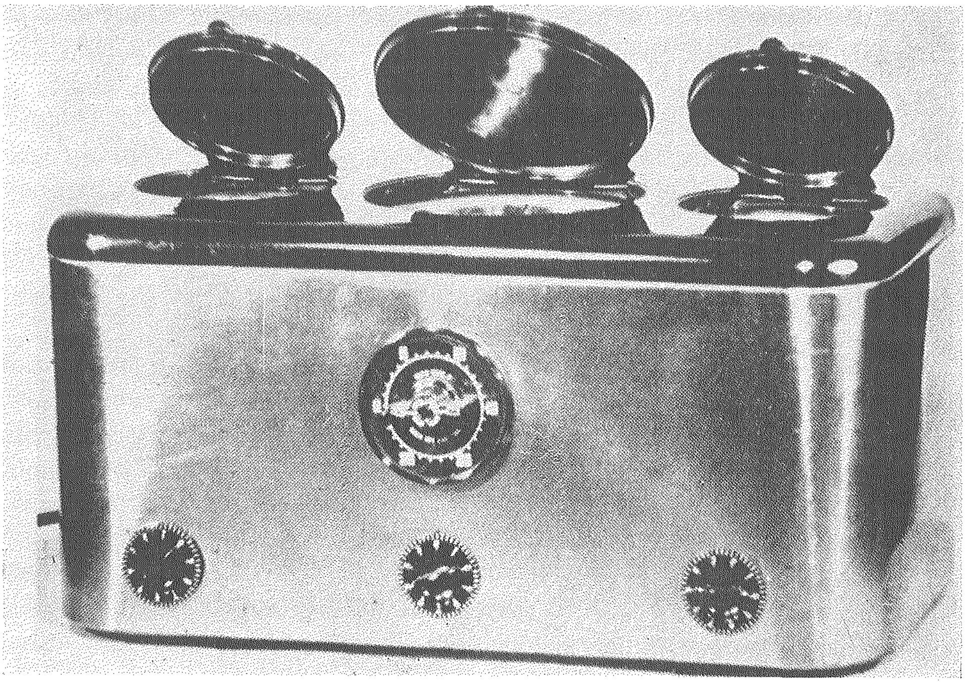

Fig. 529. A conditioner for impressions made with reversible hydrocolloid. Compartment at the left is a bath for boiling, the center bath is for storage, and the bath at the right is for tempering. (From Skinner, E. W., and Phillips, R. W.: The Science of Dental Materials: Philadelphia, 1960, W. B. Saunders Co.)

and to restrict and confine the material in the tray when the impression is taken. These steps also aid in maintaining stability during the critical period of gelation.

Tylman[8] divides the procedure of using the reversible hydrocolloid into seven steps:

"1. Liquefying the material by boiling it for at least 8 minutes. [4 minutes for junior jacketed tubes]

"2. Storing the boiled material in the syringes or tubes at a temperature of 150° to 155° F. and holding it at this temperature until ready for use.

"3. Lowering the temperature of the tray material by placing it in the tempering chamber at a temperature between 102° and 115° F., and holding that temperature between 5 and 15 minutes.

"4. Injecting the fluid hydrocolloid through the needle in the small syringe into the prepared teeth.

"5. Removing the tray with its tempered material from the tempering bath and carrying it to the mouth, after scraping off the top layer which was exposed to the water.

"6. Changing the sol into the gel by circulating water at 50° to 60° F. through the tray.

"7. Removal of the impression from the mouth and pouring of the dies or casts in artificial stone."*

Boiling water is a convenient means of liquefying the material. A minimum of 8 minutes is essential, and longer periods of boiling is not harmful. Phillips[9] calls attention to the fact that "whenever the material is reliquefied after a previous use it is more difficult to break down the agar lattice-work, so approximately three minutes should be added each time the material is reboiled."

After the liquefaction process the syringes and tubes of material in the sol condition are stored in the water bath at a temperature of 150° to 155° F. until ready for use.

After the preparations are completed, and before the retraction of the gingival tissue is started, the tray is filled and placed immediately in the tempering bath at 115° F. for about 10 minutes. The purpose of tempering is to increase the viscosity of the impression material so that it will not flow out of the tray and also to reduce the temperature to prevent discomfort to the patient. "It must be remembered that gelation depends on coordinating the two factors of time and temperature."[8]

By the time the hydrocolloid material has been properly conditioned, the toilet of the cavity preparation and retraction of the gingival tissue have been completed, and all is in readiness for taking the impression of the prepared teeth. The small syringe is removed from the storage bath, and that portion of the colloid within the needle is expelled in an area outside of the cavity before the sol is first ejected at the gingival portion of the preparation and then carried distomesially over the cavity. The needle must be held close to the tooth, beneath the surface of the ejected material, in order to prevent a trapping of air bubbles.

After the preparations and adjoining teeth have been covered, the tray material, which has been tempering, is removed, and the water-soaked outer layer of hydrocolloid is scraped off. Failure to remove that layer may prevent a firm union between the tray material and the hydrocolloid which has been previously injected into the cavity preparation.

The tray is immediately brought into position and completely seated with passive pressure. The tray, with the water circulating very slowly, must not be allowed to move in any direction during the gelation period. Gelation is accomplished by circulating water at a temperature of approximately 50° to 60° F. for not less than 5 minutes. It is advisable not to use ice water.

The impression must not be removed before complete gelation has taken place because, if the hydrocolloid material is incompletely gelled, there will be a distortion of the impression and an inaccurate die or cast will result.

After the gelatin process, the impression is withdrawn by placing a finger on the periphery of the material on each side of the tray and then quickly pulling

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*From Tylman, Stanley D.: Reversible and Irreversible Hydrocolloid Impression Materials, D. Clin. N. America, pp. 713-725, Nov. 1958.

the tray vertically away from the teeth. Removing the tray with a rocking motion will result in distortion; also, fracture is more likely to occur.

"The brush-heap structure of the gel is of such a nature that a sudden force is always resisted without distortion or fracture more successfully than a force which is applied slowly. Consequently, when the impression is removed, it is necessary to remove it suddenly, with a jerk rather than to tease it out. The removal is accomplished in a direction as nearly as possible parallel to the long axes of the teeth."*

After the tray has been removed from the mouth, it must be examined carefully for sharpness of cavity outline or distorted and ruptured areas. If satisfactory, the impression is gently washed in room temperature water to remove the saliva and small particles and placed immediately in a 2 per cent aqueous solution of potassuim sulfate.

Treatment of impression before and after pouring of stone. All impressions should be poured within 15 minutes after removal from the mouth. It must be kept in mind that no hydrocolloid impression should be left exposed in air longer than 2 or 3 minutes. If an impression is allowed to dehydrate, subsequent immersion in water before pouring does not produce an accurate die. The hydrocolloid will imbibe the amount of water lost, but it will be done at the expense of a distorted die or cast caused by the release of stresses within the impression. Phillips[9] sums it up thus: "Consequently, the dental stone cast should be constructed as soon as possible after the impression has been obtained, not only to prevent troublesome effects due to imbibition and syneresis, but also to minimize the possible distortions due to relaxation of stress."*

The impression was placed in a 2 per cent aqueous solution of potassium sulfate to accelerate the setting of the stone die or cast which is poured in the impression and to give a smooth, dense surface to the stone (Figs. 530 and 531). The impression can be poured after 5, 10, or 15 minutes in the potassium sulfate solution, but the period of time must not exceed 15 minutes. "It has been shown that the hardening solution may affect the dimensional stability of the hydrocolloid impression. This effect varies with the chemical employed, its concentration, and the composition of the gel. For this reason, the hydrocolloid impression should not be immersed in the hardening solution for more than 10 to 15 minutes since only the surface layer of the gel need be saturated with the solution. Usually, a period of 5 minutes is sufficient to provide such a saturation."*

While the impression is undergoing this treatment, preparation is being made for the stone mix. Before pouring the cast, all excess and droplets of potassium sulfate solution are carefully blown out of the impression. Do not dehydrate the hydrocolloid surface, or the gel will adhere to the surface of the cast upon its removal. The surface of the impression should have a moist appearance.

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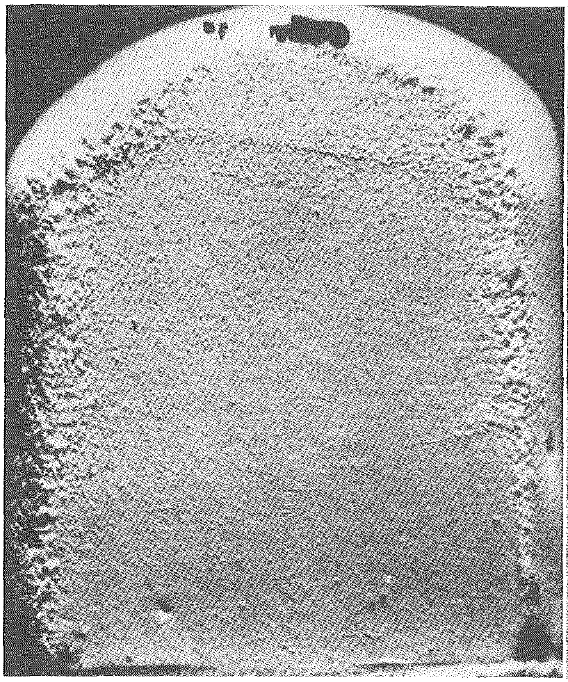
*From Skinner, E. W., and Phillips, R. W.: The Science of Dental Materials, Philadelphia, 1960, W. B. Saunders Co., pp. 103, 105, 106.



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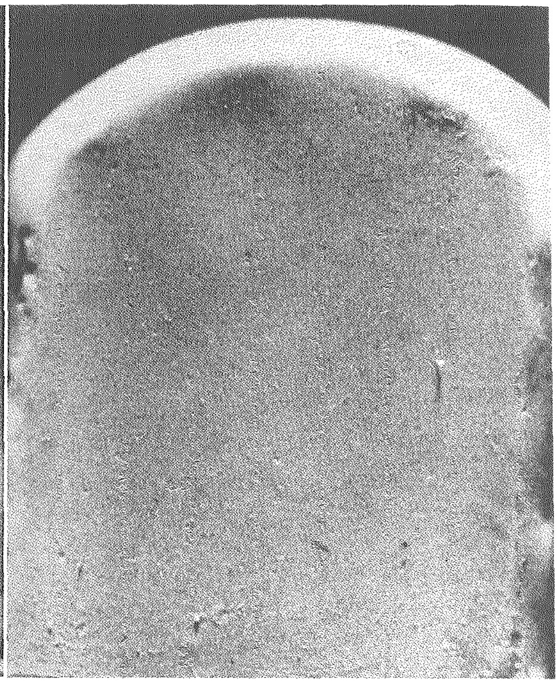

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Fig. 530. A stone surface obtained after the stone had set in contact with the surface of a reversible hydrocolloid impression material. (From Phillips, R. W., and Ito, B. Y.: Factors Affecting the Surface of Stone Dies Poured in Hydrocolloid Impressions, J. Pros. Den. **2**:390-400, 1952.)

Fig. 531. Stone surface obtained in the same manner as that in Fig. 530 except that the hydrocolloid impression was immersed in a solution of potassium sulfate (2 per cent) just before the stone mix was poured. (From Phillips, R. W., and Ito, B. Y.: Factors Affecting the Surface of Stone Dies Poured in Hydrocolloid Impressions, J. Pros. Den. **2**:390-400, 1952.)

Types and correct use of stone. The type of stones to be used for the dies and casts are the newer hydrocal stones which have been specially prepared for the indirect technique; these stones possess a minimum amount of setting expansion and a maximum surface hardness and smoothness.

Routine fabrication of dense, smooth dies and casts is very essential and can be accomplished by following the manufacturer's directions and adherence to a careful, standardized procedure.

The water-powder ratio should always be measured correctly, following the manufacturer's directions, because variation influences surface smoothness as well as strength and setting expansion.

Mechanical spatulation, preferably under vacuum, is valuable in assuring a smoother, denser, and stronger die or cast. Phillips[10] has shown that the rate at

*From Skinner, E. W., and Phillips, R. W.: The Science of Dental Materials, Philadelphia, 1960, W. B. Saunders Co., pp. 103, 105, 106.

which stone is flowed into the impression has a very significant effect upon the surface of the die, as does the amount of vibration which accompanies the flowing of the stone into the impression. Use mild agitation or vibration. It is also important that the stone be added slowly and in small quantities. Put the stone in one section of the impression and allow the stone to flow into the other parts of the impression from this initial point of application.

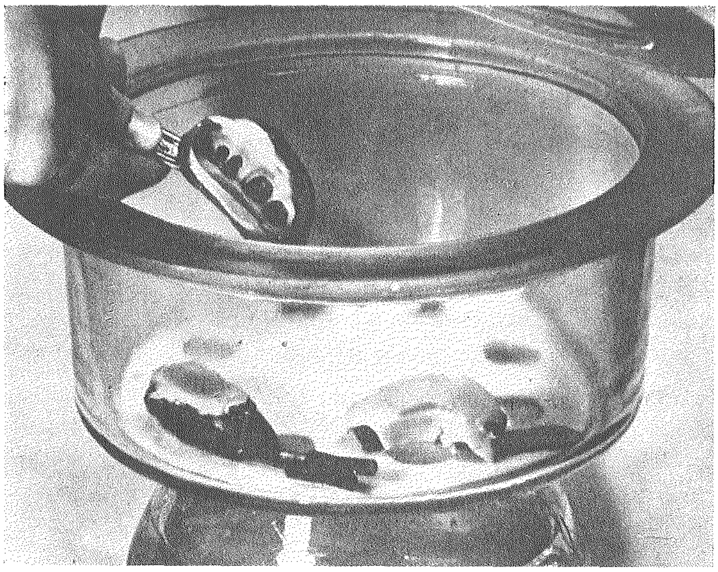

Fig. 532. If storage is necessary, the best storage environment for hydrocolloid is an arrangement such as shown. Water in the bottom of the container and a tightly fitting lid provide an atmosphere of approximately 100 per cent humidity. (From Johnston, J. F., Phillips, R. W., and Dykema, R. W.: Modern Practice in Crown and Bridge Prosthodontics, Philadelphia, 1960, W. B. Saunders Co.)

While the stone is setting, the poured impression is placed in a humidor (Fig. 532) in an atmosphere of 100 per cent humidity. Tylman[8] says that a second method that can be used "is to submerge the poured impression in a 2 per cent potassium sulfate solution for 15 minutes; after which, it is removed and allowed to set for one hour. The investigations of Phillips and Ito tend to favor the first method, as the dies made in this manner give a slightly smoother surface. They also found that the immersion of the poured cast in the potassium sulfate solution tends to prevent deleterious effects on the surface of the stone die if it is not removed from the impression within one hour. It is suggested, however, that stone dies and casts be removed from the impression one hour after they are poured."* Premature separation will cause a rough surface. No attempt should

*From Tylman, Stanley D.: Reversible and Irrversible Hydrocolloid Impression Materials, D. Clin. N. America, pp. 713-725, Nov. 1958.

be made to work on the die or cast until the stone has fully hardened, approximately 24 hours later.

Important factors in use of gypsum products. Docking points out some very important factors to consider when gypsum products are used:

1. "Particle size, setting time, expansion and strength are the important physical factors, and some manufacturers furnish this data on the product label.

2. "The mixing ratio is the key to the proper use of gypsum products. Plaster, artificial stone, and the extrastrength die stones differ physically, but are based on the same chemical entity—calcium sulfate hemihydrate. Their chief physical difference lies in the compactness and uniformity of the crystals. . . . With an artificial stone, less water is required for a given consistency than with plaster. . . . The water-powder ratio recommended by the manufacturer can usually be relied upon to give the optimum properties for a particular product.

3. "One of the ways of producing relatively gross distortion of the impression is to invert the filled impression and press it firmly down into a heap of stone on the bench.

4. "Soaking in water, glycerin, or oil was not found to improve the surface hardness or abrasion resistance, and it definitely reduced the crushing strength of the stones investigated.

5. "Although plasters and stones are commonplace materials, they require care in handling for best results. This entails the selection of suitable products for the work in hand, correct proportioning for optimum strength and hardness, careful spatulation and pouring to minimize porosity, and adequate precautions concerning any impression materials and separating media that come into contact with them."*

Conclusions from a research project on elastic impression materials. Hollenback reports on a very important research project on elastic impression materials that he recently conducted, with these conclusions:

"1. Most of the elastic impression materials on the market, when properly used, will meet clinical requirements.

"2. An expanding impression material will inevitably, when confined by an impression tray, produce an underdimensioned cast.

"3. Materials which shrink will have the opposite effect. When confined by an impression tray, they will produce an oversized cast.

"4. None of the materials now available are perfectly stable. Expansion is seldom encountered with the materials presently available.

"5. Contraction to a greater or lesser degree exists in all others.

"6. An expanding material owing to the fact that it will inevitably produce an undersized cast is worthless and should not be used.

"7. Contracting materials, if the contraction is not too great, can be successfully used providing impressions are poured immediately after being taken.

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*From Docking, Allan R.: Plaster and Stone, D. Clin. N. America, pp. 727-735, Nov. 1958.

"8. Very few of the materials available at this time will remain dimensionally stable for as much as an hour.

"9. The adoption of a standard accuracy test is essential to the continued improvement of elastic impression materials."*

Copper tube modeling compound impression

When to use. I will make use of the copper tube modeling compound impression when retraction of the gingival tissue to take a hydrocolloid impression is impossible without radical procedures. This applies only to full veneer crowns.

Technique. An annealed copper band is selected as soon as the peripheral outline of the preparation has been established. The band should fit the cervical margin snugly and should be festooned to fit slightly over the shoulder or chamfer. Be sure to smooth the edges of the band, to stone the inner surface of the band at the gingival edge for about 2 mm. which ensures a positive seal of the compound to the band, and to have the band parallel to the long axis of the tooth. Mark the labial or buccal surface of the band for identification.

The compound is softened by means of dry heat tempering the surface, which will contact the tooth in hot water. Seat the filled band carefully on the prepared tooth, and when it is in position, which will be evident when a little compound is forced out at the cervical area, put pressure on the impression material with a finger. Chill with cold water and remove the band with a steady vertical pull. Never rock or twist the band impression when removing it from a tooth. Examine the impression very carefully for all preparation details. In most instances the impression is rebased with George copper die electroconductive wax.

Making the die. The die from this impression can be copperplated, or a die can be made of stone.

If the impression is to be poured in stone, the band should be wrapped with a piece of 30-gauge casting wax extending 8 to 10 mm. beyond the cervical margin.

Again keeping in mind the need of following the manufacturer's instructions as to the recommended water-powder ratio, carefully spatulate the mix and introduce small increments of stone into the impression by the use of mild vibration, thereby avoiding any imperfections or voids in the finished die. When the impression has been filled with stone, a Jelenko or Ney brass dowel pin is inserted to ensure a good handle when the pattern is being waxed.

WAX PATTERN

It has been pointed out that wax variables are probably the greatest material obstacle to accurate reproduction of cast restorations. We were taught that pattern waxes were not relatively stable and, therefore, had to learn to minimize and control these materials in order to get satisfactory results.

We have to take into consideration that (1) the wax is best applied in a

*From Hollenback, George M.: A Standard Accuracy Test for Elastic Impression Materials, J. South. California D. A. 29:3-9, 1961.

melted state since fewer strains are set up in this way, (2) a hard inlay wax should be used instead of a soft wax to be able to detect undercut areas by fracture of the wax, (3) the wax pattern must be invested immediately upon removal from the die, (4) with the indirect technique all gingival margins of the patterns must be remelted and carefully readapted to the extent of 1 or 2 mm., (5) investment of more than one pattern on a single sprue former is contraindicated because of the danger of distortion through uneven expansion, (6) blunt instruments rather than sharp ones should be used to carve wax over stone dies to avoid damaging the die, (7) the wax pattern should not be chilled too rapidly because this will increase strains and distortions, and (8) temperature changes incident to investing of the wax pattern and the setting of the investment serve to change or release pattern strains which may produce both pattern and mold distortion.

A series of extremely important, accurate, and scientific experiments recently reported by Hollenback and Rhoads[13] indicate the following:

"A review of the data will indicate that the studies conducted on wax patterns using the measuring microscope corroborate those conducted with gross specimens. The changes shown in the microscopic studies indicate that extremely small changes in dimension take place. In most cases the change occurring is insufficient to be detectable by clinical methods. [This was illustrated by the study of the castings made in these classic experiments.]

"Extreme changes have been produced in wax patterns when the wax has been handled carefully so as not to deform the body of the softened wax by pressure. On the other hand, when the wax form was materially deformed by pressure during adaptation to the mold or cavity, either by a complete change of its previous form or by merely inducing severe angular bends, the evident change occurring upon storage, even at unrealistic temperatures for extended periods of time was either absent or so minor as to be insignificant. This has been borne out in gross studies and microscopic measurement as well.

"The question immediately arises then as to the reason for the discrepancies, seen in many castings, which have been attributed to the wax pattern. Most of these discrepancies revolve around the marginal adaptation of the casting to the tooth or die and have been assumed to be due to distortions of the pattern after removal from the cavity and before the investing procedure has been completed. It is indicated [Hollenback and Rhoads[13]] from preliminary studies which are not being reported at this time that much of this discrepancy is due to improper primary adaptation of the wax to the cavity or die and/or the film thickness of the lubricant used. This investigation seems to indicate that it is difficult to produce adaptation of wax to the cavo surface closer than 15 microns. The reason for this, at the present time, is obscure.

"It has also been observed in another pilot study, not being reported at this time, that a shrinkage of wax, unassociated with thermal contraction of wax, exists. . . .

"Inaccuracies in the cavity preparation such as undercut areas and improper beveling of the margins may also contribute materially to the ultimate distortion of the wax pattern due to the inability of the wax to be withdrawn from these areas without deformation. Relatively minor discrepancies of this type may pass unnoticed until the casting is examined and checked against the hard unyielding surface of the die or tooth.

"It has been demonstrated by this study that perhaps inlay casting wax, and wax patterns made therefrom, have been unjustly accused of being a prime cause of dimensional error in the casting process. It is strongly indicated by this study that inlay waxes are a comparatively stable group of materials and that if they are not mistreated during pattern fabrication, or the patterns severely abused by prolonged storage at high temperatures, it can be expected that a comparatively accurate reproduction of the cavity surfaces can be obtained.

"It should be emphasized, however, that nothing is to be gained by prolonged storage of the wax pattern before investing. It has been shown that approximately one half of the dimensional change which does take place occurs during the first 30 minutes of storage. This would indicate that immediate investing of the completed pattern should be the rule. Such a procedure, in addition to preventing the small dimensional change, would also materially lessen the danger of accidental mechanical damage to the pattern.

"*Conclusion.* Inlay casting waxes, as employed in this study, show dimensional changes, when subjected to storage times and temperatures encountered in average office and laboratory conditions, which are insignificant from the standpoint of clinical evaluation. These products, although they possess a comparatively high thermal expansion, are nonetheless relatively stable materials."*

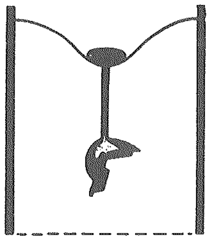
SPRUING

Importance of correct spruing

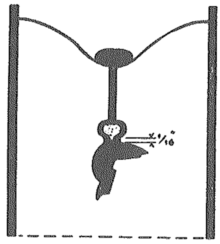
Attaching the sprues to the wax pattern is much more important to the success of the inlay than is generally realized. Many small type castings are ruined by failure to carry out this step correctly. The purpose of the sprue is to lead molten metal from the crucible into the mold cavity. The diameter and length of the sprue is a vital factor, and so is its positioning. Large sprues should be used (for inlays and crowns using the centrifugal machine make use of 10, 12, or 14 gauge, and for pressure casting never thicker than 14 gauge), and they should be attached to the most bulky portion of the pattern. "The sprue must be large enough to allow the molten gold to flow into the mold cavity as quickly as possible, but with the least amount of turbulence [Fig. 533]."[15]

"A very common error, which results in 'shrink-spot' porosity or pitted castings, is the use of *too thin* a sprue."[14] To avoid this type of porosity the sprue must

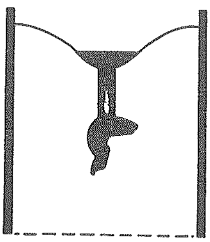
*From Hollenback, George M., and Rhoads, John E.: A Study of the Behavior of Pattern Wax, J. South. California D. A. 27:432-434, 1959.



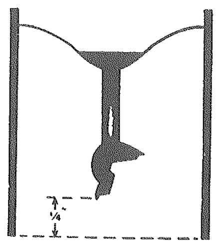
Incorrect sprueing; thin sprue freezes before the casting, causing "shrink-spot" porosity.



Correct sprueing for air pressure castings; by adding a reservoir to the thin sprue, the "shrink-spot" porosity is concentrated harmlessly outside the inlay.



Incorrect positioning; pattern too far from end of ring, resulting in casting with rounded margins.



Correct positioning and sprueing for centrifugal casting; pattern placed 1/4" from bottom of ring for sharp margins; thick sprue used to prevent porosity in the casting.

Fig. 533. Illustrations showing the importance of correctly spruing and positioning of wax patterns. (From Casting Procedures. In Ney Bridge and Inlay Book, Hartford, Conn., The J. M. Ney Co.)

be so situated and of a size and length to provide a reservoir of molten metal from which the casting can draw upon as it shrinks during solidification. In other words, the sprue by being large enough and properly positioned prevents the molten metal from solidifying before the metal in the casting proper solidifies.

Orientation

Shell states that sprue should be so orientated that "[1] the metal will flow directly into the mold cavity without encountering unnecessary turns, [2] that the metal should not strike directly against sharp projections of investment that might break off, [3] the metal should not strike directly against metal backings, bars or copings—allow molten metal to flow along rather than directly against metal forms, [4] it should lead into the mold cavity as directly as possible, [5] use a hopper on every bulky casting and on all castings when cast by pres-

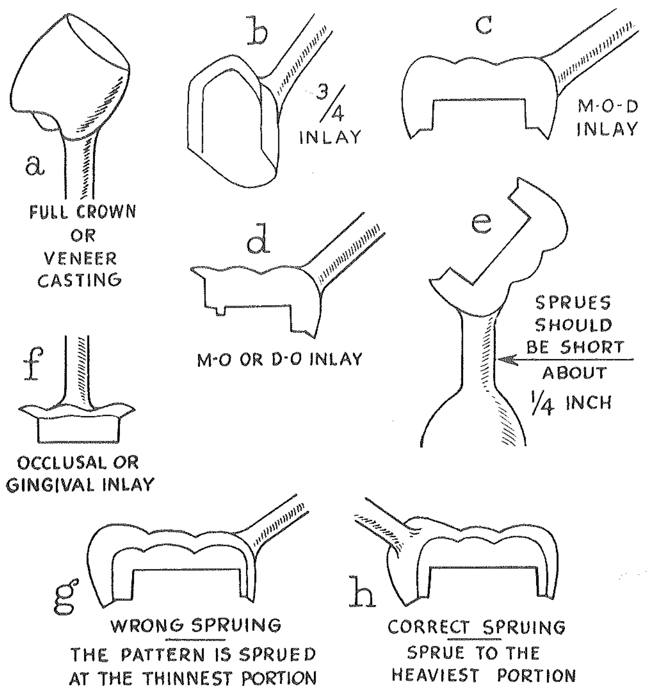


Fig. 534. Correct methods of spruing various types of wax patterns. (From Crown and Bridge Construction Using Hydrocolloid Impressions, New York, 1954, J. F. Jelenko & Co., Inc., p. 42.)

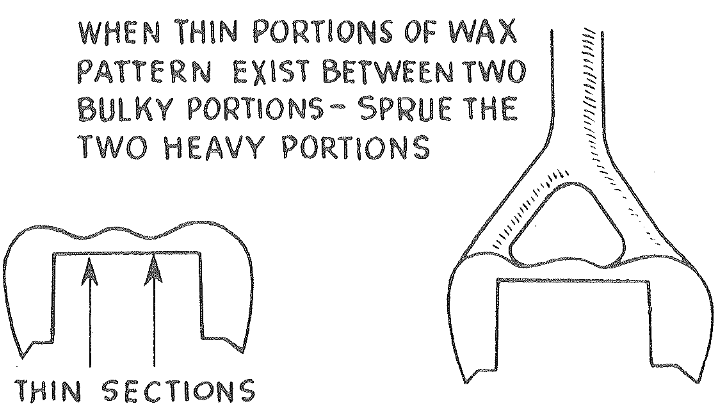


Fig. 535. Correct spruing when thin portions of wax pattern exist between two bulky portions. (From Crown and Bridge Construction Using Hydrocolloid Impressions, New York, 1954, J. F. Jelenko & Co., Inc., p. 42.)

sure, [6] never sprue at a point in the casting which may be subject to stress,"* and [7] use as few sprues as possible (Fig. 534). When the sprue pin (which should be made of brass or stainless steel) is attached to the wax pattern, the pin should not be overheated because of the chance of possible distortion of the pattern. Add a small ball of wax at the point of attachment and insert the slightly heated sprue pin very carefully. When there are two bulky sections separated from each other by a thin section, as in an MOD, it is helpful to attach a wax sprue to each bulky section (Fig. 535). Spruing plays a very important role in achieving proper fit, density, and soundness—both internally and externally.[15]

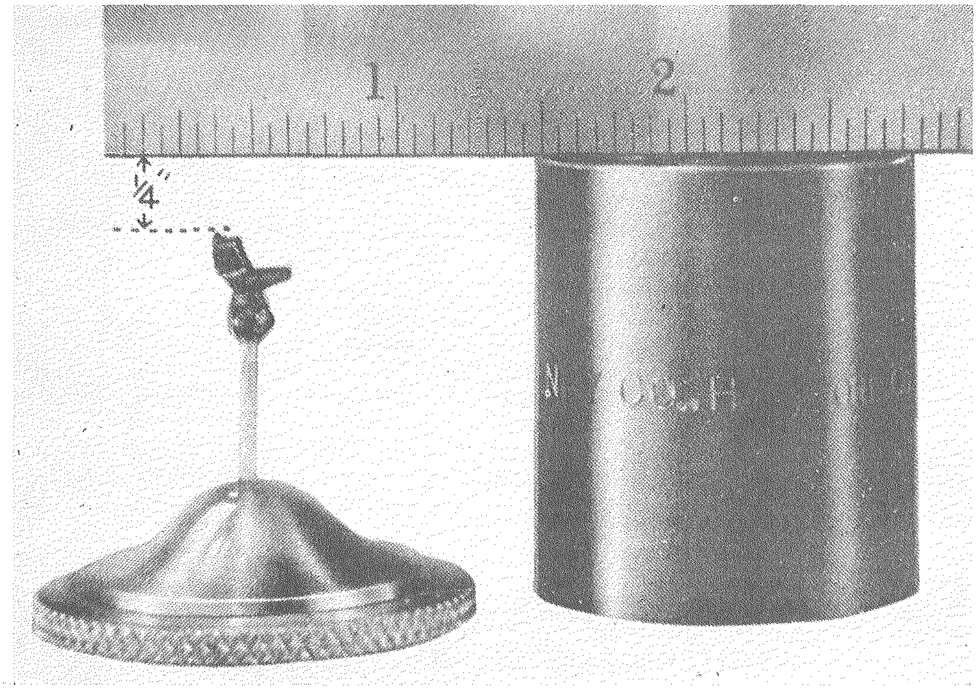


Fig. 536. Correct spruing and positioning of pattern. (From Casting Procedures. In Ney Bridge and Inlay Book, Hartford, Conn., 1958, The J. M. Ney Co.)

MOUNTING THE WAX PATTERN ON CRUCIBLE FORMER

Location of pattern in ring

In mounting the sprued pattern on the crucible former, it should be adjusted so that there is not more than ¼ inch separating the bottom of the casting ring from the nearest part of the wax pattern. The reason for this is that the air in the mold chamber must be forced out through the investment as the molten metal enters, and if the bulk of investment is too great, the escape of these mold gases may be so slow that the gold will freeze before the mold is completely filled.

*From Shell, John S.: Dental Casting Technics, J. California D. A. 9:158-161, 1933.

This is one of the principal causes of incomplete castings, and castings with rounded or short margins [Fig. 536]."*

Causes and remedies for back pressure porosity

O'Brien[17,18] points out that the temperature of the investment mold was found to influence "back pressure porosity," and this type of porosity is the result of mold gases not escaping quickly enough when the molten alloy shoots down

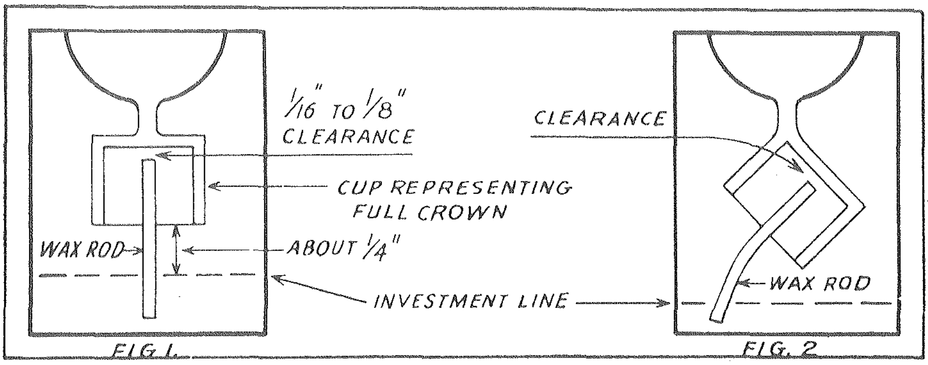


Fig. 537. Special type of venting which is a remedy for the situation in which gases pass too slowly from the mold cavity of a full crown. (From Crown and Bridge Construction Using Hydrocolloid Impressions, New York, 1954, J. F. Jelenko & Co., Inc., p. 45.)

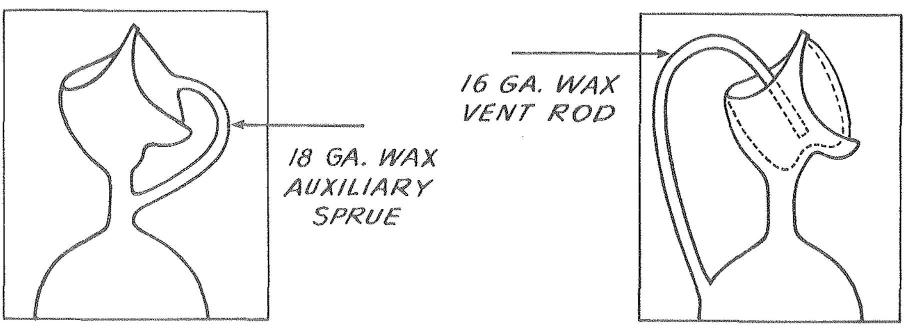


Fig. 538. Special type of spruing. (From Crown and Bridge Construction Using Hydrocolloid Impressions, ed. 2, New York, 1956, J. F. Jelenko & Co., Inc.)

the sprue channel. The air in the mold pushes back on the molten gold during the casting operation. Due to the fact that hygroscopic low burn-out techniques produce more of this porosity, he advocates "increasing the number of turns on a centrifugal machine [3 to 4], increasing the casting pressure on a pressure casting machine [minimum 20 pounds], performing the casting operation in a

*From Casting Procedures. In Ney Bridge and Inlay Book, Hartford, Conn., 1958, The J. M. Ney Co.

vacuum, flaring the sprue and its attachment to the casting, keeping the distance from the top of the pattern to the outside of the investment to ¼ inch, providing vents through which the mold gases can escape, and using more metal [Figs. 537 and 538]."*

Shape of crucible former

The crucible former and ring should be clean and free of all old-set investment. The shape of the crucible former is also an important factor. If a pressure casting machine is used, the crucible should be rounded at the sprue hole. If a centrifugal machine is used, the crucible former should be in the nature of a broad cone.

Asbestos liner

It is advisable to use an asbestos liner in the inlay ring. It is lined with a thin layer of asbestos (1/32 inch) which is ⅛ inch shy of the end which sets on the crucible former in order to maintain a complete seal of the investment. It is placed flush with the upper or open end of the ring. This liner is soaked with water before the investment is mixed. The investment and the metal ring do not expand at the same rate when heated, and the asbestos liner serves as a cushion which allows the investment to expand freely, therefore having more freedom for thermal and setting expansion, and also some hygroscopic expansion from the water in the liner. It also tends to prevent distortion or cracking of the mold due to this unequal expansion.

CLEANING THE WAX PATTERN

The wax pattern should be washed and thoroughly cleaned before investing with a 50-50 mixture of tincture of green soap and hydrogen peroxide. It is then rinsed in room temperature water and thoroughly dried. This will prevent a surface roughness which is capable of preventing a good adaptation of the casting to the die or tooth. A wetting agent should then be used to reduce surface tension. It aids in the flow of the investment over the wax pattern and can also help in eliminating small air bubbles.

CASTING TO DIMENSION

Concerning the problems of investing and investments, burn-out, casting, handling of gold alloys, soldering, and techniques for their implementation, I have decided to describe those techniques which I have experimented with and have used for a long enough time to be able to judge the results, if not by means of a measuring microscope, at least by experienced clinical approach and good judgment. Techniques using thermal expansion, hygroscopic expansion, and a

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*From O'Brien, William J.: Practical Application of Current Casting Research, J. Pros. Den. **10**:558-560, 1960.

combination of both will be considered at this time. It is a known fact that all methods have discernible advantages and limitations, and a complete understanding of the problem at hand, including one's own abilities, will enable one to select a technique than can work in his or her hands.

Inlay casting is not yet an exact science, but in spite of this fact, enough information is now available about the properties of the materials used and the effects of variations in manipulative procedures to enable one to standardize a technique so that consistently satisfactory results can be expected.

The thermal expansion method is perhaps the most easily and accurately controlled for compensating the casting shrinkage of gold. By putting the various variables together, keeping in mind what has already been considered as to cavity preparation, impressions and impression materials, die and cast materials, the wax pattern, spruing, positioning of the pattern in the ring, the asbestos liner, etc., and by referring to the charts or other information offered by the manufacturer of the materials to be used, it is relatively easy to develop a good technique and also a means of being able to detect and correct errors that might creep into the technique.

The hygroscopic expansion technique is also an excellent one. Properly controlled, it will yield outstanding results in the form of well-fitting castings with smooth surfaces. This property of hygroscopic expansion in investments was first given to the dental profession by Carl Scheu in 1932. Probably all dental investments have some hygroscopic expansion, which can be produced by lining the inlay ring with asbestos. However, the hygroscopic expansion method wasn't too well accepted until Hollenback simplified the technique and gave it to the profession in 1943.[19] Again, the variables must be carefully considered and handled in such a manner as to minimize their effects.

Thermal expansion technique

The wax pattern has been properly sprued, positioned in the ring on the crucible former, and thoroughly cleaned and treated as was previously explained. It is now ready to be invested. The materials of choice are Modern Materials and R & R Gray casting investment.

Single mix technique. The single mix technique is used for all two-surface inlays, and three-quarter crowns for anterior teeth.

1. Mix 50 grams of casting investment to 13 ml. of room temperature distilled water. The water-powder ratio must be adhered to strictly. The water for all techniques is measured by means of a burette and the powder by means of an accurate scale. To save time the assistant, in her spare time, can weigh the investment and place it in paper bags. To prevent moisture absorption about ¾ to 1 inch of silica gel is placed on the bottom of a wide-mouthed cookie jar, and a paper towel is placed over this material. The paper-filled bags are then placed on top of the paper towel, and the lid is screwed on very tightly. In time the dark blue color of the silica gel turns white, but heating these crystals in a pan

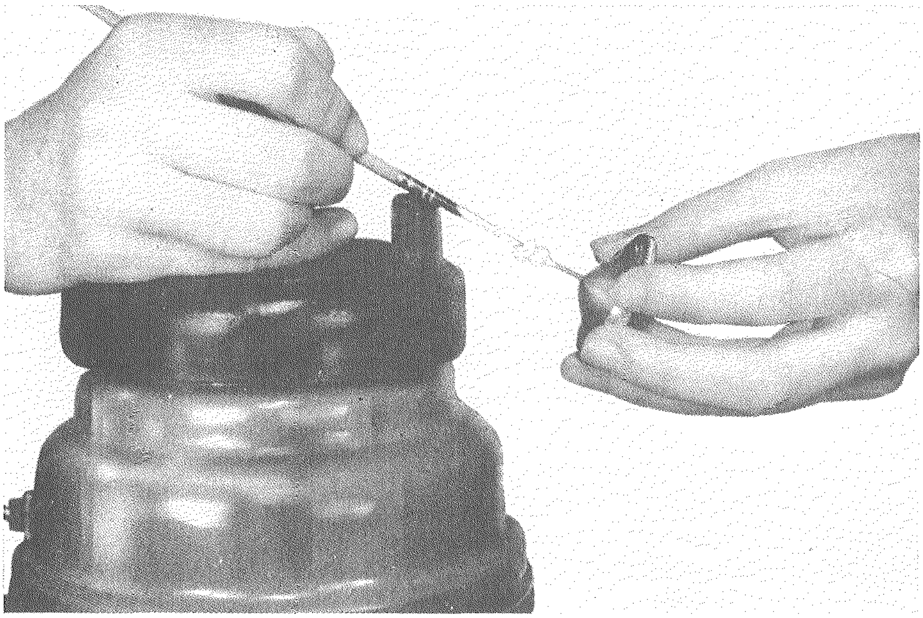

Fig. 539. Applying investment with a small brush held lightly against a vibrator. (From Casting Procedures. In Ney Bridge and Inlay Book, Hartford, Conn., 1958, The J. M. Ney Co.)

to around 300 to 350° F. will restore the dark blue color and drying properties. It can be used for a long time.

2. Paint the wax pattern carefully, being careful not to occlude air bubbles on the surface of the wax. The preferred method of mixing and investing is by vacuum. "When vacuum investing equipment is not available, it is advisable to use a good mechanical spatulator because this method produces a smoother mix, freer from entrapped air bubbles, than hand spatulation. . . . Paint the pattern carefully with the investment mix, being sure to carry it into all grooves and angles. A good method is to apply the investment with a small brush held lightly against a vibrator [Fig. 539]."* After the pattern is covered, the investment may be blown off the surface, leaving a thin film and disengaging any large bubbles. The pattern should then be repainted.

3. The ring is then seated on the crucible former and filled with the balance of the mix to overflowing. Pour the investment from one side of the ring so that it runs down the side of the ring, filling it from the bottom up, to avoid trapping air.

4. Allow the invested inlay ring to stand until it has thoroughly set—for at least 45 minutes to 1 hour. If it is allowed to stand overnight, it is advisable to

*From Casting Procedures. In Ney Bridge and Inlay Book, Hartford, Conn., 1958, The J. M. Ney Co.

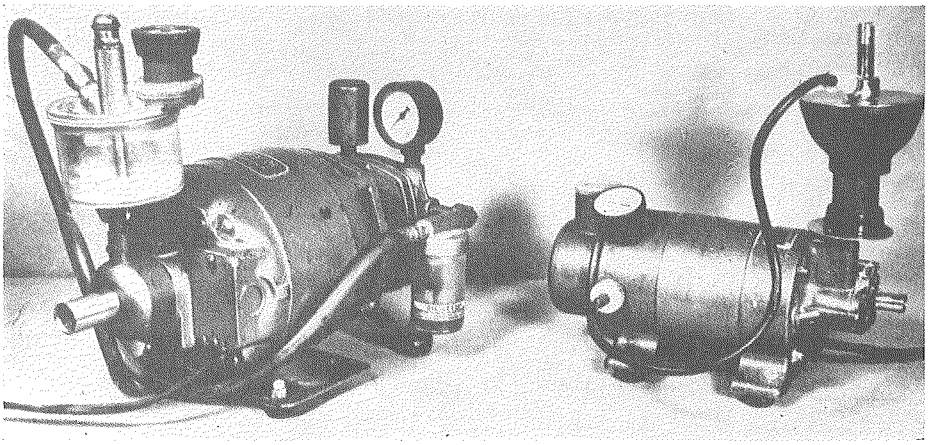

Fig. 540. Various types of vacuum equipment for investing patterns are available. (From Johnston, J. F., Phillips, R. W., and Dykema, R. W.: Modern Practice in Crown and Bridge Prosthodontics, Philadelphia, 1960, W. B. Saunders Co.)

soak the ring in water just before starting the burn-out to prevent roughness on the surface of the casting.

5. Remove sprue former and sprue pin from ring.

6. Burn-out the wax, heating the investment and ring until a dull red glow (1200° to 1300° F.) can be seen down the sprue hole. Cast immediately to avoid a drop in temperature and consequent shrinkage of the mold.

Double mix technique. The double mix technique is used for all other castings such as MOD's, three-quarter crowns for posterior teeth, full crowns, and occlusal inlays. No liner is required in the ring.

1. Mix 25 grams of Modern Materials casting investment to 7 ml. of room temperature distilled water. Spatulate mechanically or by vacuum (Fig. 540).

2. Paint the wax pattern carefully, being careful not to occlude air bubbles on the surface of the wax.

3. With a soft brush, dust dry casting investment over the painted pattern and vibrate gently, with a serrated instrument, until powder is absorbed. Repeat three to four times (this procedure allows for greater setting and thermal expansion). Allow to set 5 to 10 minutes.

4. Then make another mix, 50 grams of casting investment to 14 ml. of water.

5. Fill inlay ring with mix (asbestos liner not necessary). Immerse the painted pattern in water for a moment and then insert into the filled ring.

6. Allow the invested ring to stand for 45 minutes.

7. Remove sprue former and sprue pin from ring.

8. Burn-out the wax, heating the investment and ring until a dull red glow (1200° to 1300° F.) can be seen down the sprue hole. Cast immediately.

Excellent results are possible with this technique.

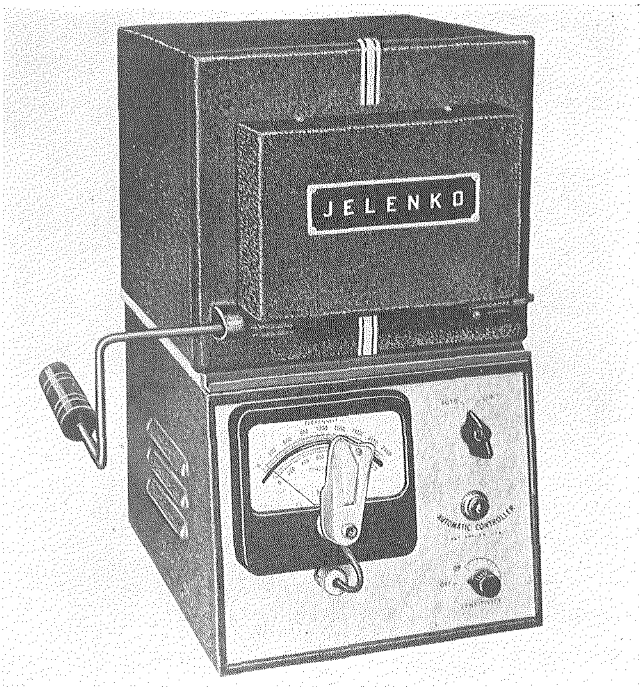

Fig. 541. Jelenko Furna-Matic furnace. (Courtesy J. F. Jelenko & Co., Inc., New York, N. Y.)

Burn-out: objective and importance of time plus temperature

An electric burn-out furnace (Fig. 541) equipped with a pyrometer should be used, and be sure to spot check temperature indicators periodically. This can be done with Jelenko Tempils. Do not start the burn-out until the investment has thoroughly set. Heat the mold slowly at first (preheat at 600° F. for at least 30 minutes) until the free water and water of crystallization of the plaster have been evaporated. If it is heated too fast or before investment has set, rough castings will result. Next heat the mold to a high enough temperature and for a long enough time to eliminate the wax completely (1200° to 1300° F.), being careful at the same time not to allow it to get too hot.

The objective of the burn-out is to eliminate all the wax and residual carbon to arrive at a pattern chamber whose surfaces are a replica of the wax pattern. The temperature to which the mold is heated must be high enough, and the mold must be soaked at that temperature long enough to eliminate the wax and also provide the necessary thermal expansion to produce an accurately fitting small type casting. The length of time held at the burn-out temperature is important since only time plus temperature can completely dissipate the carbon resulting from the burning of the wax.

It is necessary to avoid heating the mold too hot because the binder in most investments is plaster of Paris or some similar form of gypsum which chemically is calcium sulfate. At high temperatures above 1350° F. the calcium sulfate slowly decomposes and gives off sulfur or sulfur compounds. The sulfur combines with certain metals in the casting gold, especially copper and silver, forming a surface film of sulfides which causes discoloration which is hard to remove from the casting. This sulfur also attacks the metal inlay rings, the heating element of electric furnaces, and other metal parts, causing rapid deterioration.

Modified hygroscopic investing and casting by vacuum technique

An investing and casting technique given to me by Dr. Peter K. Thomas[20] which gives excellent results is as follows.

"1. Attach a stainless steel sprue tube of 12 or 14 gauge to the finished wax pattern while it is still on the die. Coat the sprue with wax which will allow it to fall from the investment as the wax is eliminated in the furnace, leaving a smooth canal free of debris through which the gold will flow uninhibited.

"2. Thoroughly clean the wax pattern, line the ring with asbestos, and position pattern in ring as previously described. The casting ring must fit snug into the crucible former so that no air is drawn into the pattern area when the investment is vibrated to place.

"3. Miner's clean cast inlay investment is the investment of choice. A water-powder ratio of 50 Gm. of investment to 13 ml. of water is used for all full crowns, veneer crowns, reverse pin patterns, average or large MOD's, posterior three-quarter crowns (for all preparations having long and parallel walls). A water-powder ratio of 50 grams of investment to 13.5 ml. of water is used for small inlays, small MOD's, etc. (for all preparations with conical or short walls).

"4. Completely wet the investment by hand mixing and then complete mix under vacuum. We apply this mix to the pattern with a small brush held lightly against a vibrator. As the brush is vibrated, the bristles work their way into all corners and cover all areas of the pattern thoroughly with investment, eliminating any air that might be entrapped in the investment. The lined ring, which fits snugly into the crucible former, is positioned and filled with investment. While filling is proceeding, the ring should be held in the hand, and hand rested on the plate of the vibrator in order that the mild vibrations may cause the ring to fill evenly without entrapped air.

"5. Immediately place the ring in the water bath at 100° F. for 30 minutes. Keep the water level ¼ inch below the top of the ring, so as not to affect the water-powder ratio.

"6. On removing ring from water bath, trim excess and let stand for 10 to 15 minutes more before removing the crucible former.

"7. Place the ring in a furnace preheated to 600° F. with the sprue hole down. By having the furnace preheated, the wax is eliminated rapidly through the assistance of residual moisture in the investment, thereby flushing the wax from the mold. As the wax melts, the sprues, which were coated with wax, will fall out. Hold the temperature at 600° F. for 30 minutes; then turn ring-to-sprue hole up and raise the temperature to 1100° F. and let the casting ring remain at this temperature for at least one hour."*

The casting machine used is the Schmitz Vac-O-Cast. The reason for using the vacuum is to assist in removing "back pressure" from the mold, thereby assuring more density of the casting. It will minimize back pressure porosity.

With the vacuum in force, remove the ring from the furnace and mount it in position on the casting machine. The casting is now made, using gas and oxygen as the flame for melting the gold.

Hygroscopic technique (submerging in water bath)

The property of hygroscopic expansion in investment was given to the dental profession by Scheu in 1932, but not until Hollenback[19] in 1943 showed a simplified technique for obtaining accurate small castings did the hygroscopic method gain acceptance. In this method there is a larger setting expansion and a smaller thermal expansion, which is the opposite of a thermal expansion technique. According to Coy and Hall, "the value of this technique is that it expands the wax pattern to approximately its volume at the flow point of the wax, which reduces the problem to one of compensating for the casting shrinkage of the gold."[21]

Cavity preparation must be accurately executed; the wax pattern must be properly developed, keeping in mind the physical properties of wax; use the largest possible sprue that the pattern will accommodate, varying from 18 to 12 gauge. Thoroughly cleanse the wax pattern with a 50-50 mixture of tincture of green soap and hydrogen peroxide and then rinse it in room-temperature water and dry it carefully. A wetting agent can now be applied. Position the sprued pattern correctly in the ring which has been lined with asbestos 1/32 inch in thickness which is placed flush with the upper or open end of the ring and is shy of the end which has the rubber base by ⅛ inch in order to maintain a complete seal of the investment. The asbestos liner is soaked with water. The function of the asbestos liner is to permit free lateral expansion of the mold which otherwise would be prevented by the ring's unyielding wall. The ring is now placed on the crucible former.

The process of investing the pattern by means of a vacuum was developed by Hollenback[23] and is a method of mixing an investment material and surrounding the wax pattern in the prepared ring, both under the negative pressure of a vacuum.

The distilled water for the mix is accurately measured, using a burette, and placed in the rubber mixing bowl after the hole in the bottom of the bowl has been closed by a rubber cork. The investment is accurately weighed with a metric scale. (Keep in mind that the water-powder ratio used will control the size of the casting. Varying the water-powder ratio will give oversized and undersized castings; thicker mix has less water and gives more expansion, and thinner mix

*From Thomas, Peter K.: Personal communication.

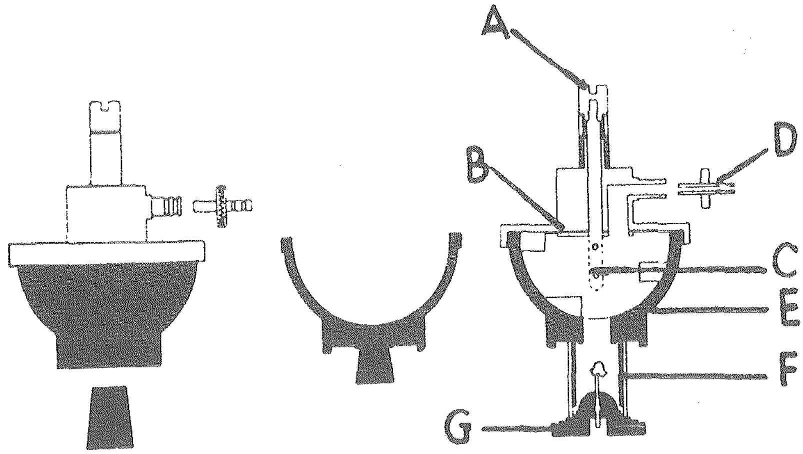

Fig. 542. Left, Side view of vacuum mixer. Center, Cross section of bowl with rubber plug in position. Right, Cross section of vacuum mixer with casting ring and crucible former in position. *A*, Drive coupling; *B*, cover; *C*, agitator; *D*, friction coupling for vacuum line; *E*, rubber bowl; *F*, casting ring with asbestos liner; *G*, crucible former with sprue former and pattern. (From Hollenback, George M.: Simple Technic for Accurate Castings: New and Original Method of Vacuum Investing, J.A.D.A. **36**:391-397, 1948.)

has more water and gives more shrinkage. Water bath temperature, and burn-out oven temperature are also important factors.) The investment powder is placed in the bowl and puddled with a spatula; after which, the cover, which has built into it the mechanical spatula and drive shaft, is tightly placed on the bowl, and the intake tube of the vacuum pump is attached (Fig. 542). The cork is then removed, and the casting ring assembly is substituted. The vacuum pump is then turned on, and the drive shaft of the mixer is engaged by the chuck on the lathe (Fig. 540). Under slow speed, the mix is completed in about 10 to 15 seconds, and the drive shaft is disengaged. Phillips has shown that "vacuum investing produces a denser mass of investment, which results in slightly greater crushing strength of investment, and also that the increased density of the investment in turn produces a denser gold surface."[24]

Now the entire assembly is held upright with the rubber base resting on the vibrator for about 30 seconds, in which time the investment will flow smoothly and evenly around the pattern and completely fill the ring. The rubber base is now placed on the bench, and the vacuum intake tube is slowly and carefully disconnected, allowing the ring to separate from the mixing bowl.

As soon as the investing process is completed, the ring is placed in a thermostatically controlled water bath at 100° F. and left there for 30 minutes (Fig. 543). The water must be deep enough to completely submerge the ring. The setting of the investment in a supersaturated condition will show much more than the normal setting expansion. Expansion suitable for the various gold alloys can easily be secured. Any desired degree of expansion can be obtained by merely changing the water-powder ratio.

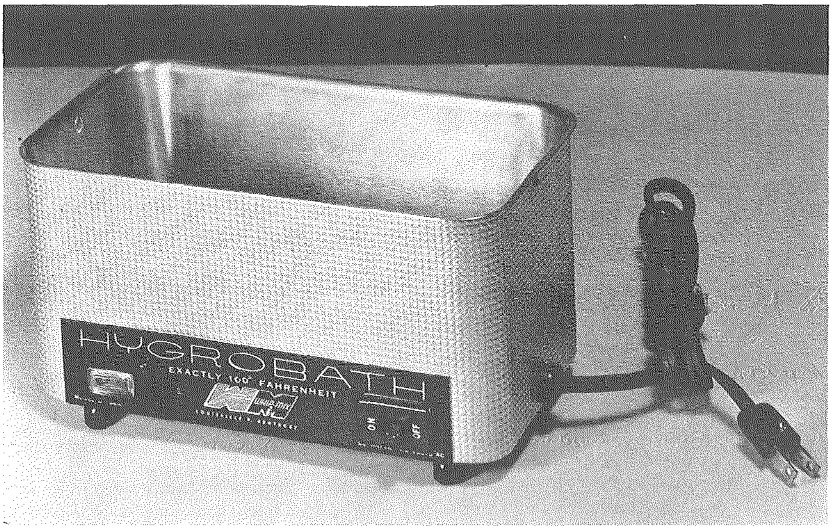

Fig. 543. Whip-Mix Hygrobath. (Courtesy Whip-Mix Corp., Louisville, Ky.)

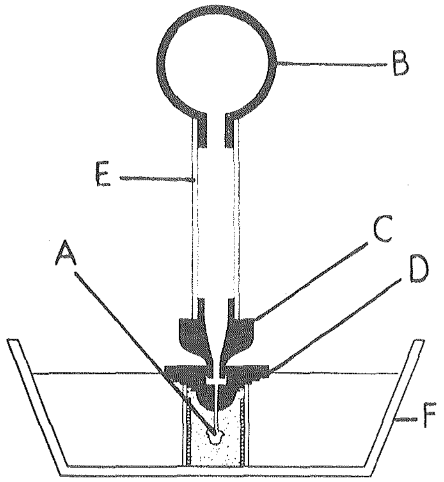

Fig. 544. Wax eliminator attached to crucible former. Sprue former has been removed, leaving an open channel to the pattern, *A*. Rubber bulb, *B*, is collapsed and soft rubber tip, *C*, is inserted in recess of the crucible former, *D*. When pressure is removed from rubber bulb, a partial vacuum will be formed in the glass barrel, *E*. Assembly is placed in receptacle of boiling water, *F*, and softened wax is drawn into the barrel of the eliminator (From Hollenback, George M.: Simple Technic for Accurate Castings: New and Original Method of Vacuum Investing, J.A.D.A. **36**:391-397, 1948.)

The excess investment is trimmed off when the ring is removed from the water bath, and the elimination of the wax is in order. Remove the sprue pin without disturbing the crucible former, press the rubber tip of the wax eliminator with the bulb fully collapsed into the recess of the crucible former (Fig. 544). The ring is now submerged into a receptacle of boiling water, thereby softening

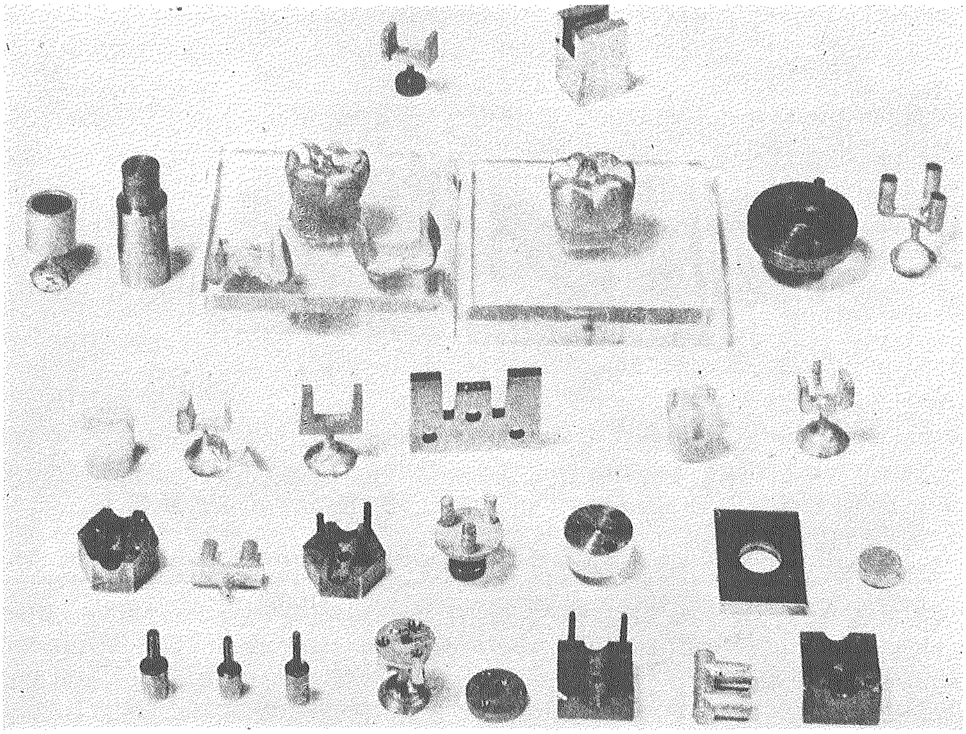

Fig. 545. Wide variety of castings made to fit preparations in porcelain teeth and various types of metal dies. These castings vary from 2 to 15 denarius weight. Regardless of size or complication, no change was made in the technic for these castings. (From Hollenback, George M.: Simple Technic for Accurate Castings: New and Original Method of Vacuum Investing, J.A.D.A. **36**:391-397, 1948.)

the wax which is sucked up into the glass barrel of the wax eliminator. This usually takes about 4 to 5 minutes.

After the wax is eliminated, the crucible former is removed, and the ring is placed into a burn-out furnace preheated to a temperature of 850° to 900° F. for at least 1 hour. Cast immediately.

Castings of great accuracy can be obtained by using this technique (Fig. 545). The investments that I use in practice and experimental work are R & R Hygroscopic, Whip-Mix Beauty Cast, and Baker's hygroscopic investment.

Hygroscopic technique using controlled amount of added water

In this hygroscopic technique, worked out by Peyton, Asgar, and Mahler[25] at the University of Michigan, controlled addition of water in varying amounts is used to influence the desired investment expansion. Their experiments showed more consistent results in obtaining well-fitting castings when the investment was allowed to come into contact with a specified amount of water rather than a maximum amount. They add a specified amount of water to the investment ring with a syringe, as against placing the invested ring in a water bath and allowing the investment to absorb a maximum amount of water. Although it was found that having warm water in contact with the invested ring was unnecessary, some clinicians feel that the technique is further improved if the ring is placed in a water bath at 100° F., keeping the water level below the top of the ring so that no additional water is supplied to the investment but allowing the pattern to be warmed, thereby letting the investment expand more evenly. To compensate for this wax expansion, less water (about 0.4 ml.) is added at the reservoir. It was also shown that investments which expand hygroscopically have a limit to the absorption of water and subsequent expansion. This limit is affected by the water-powder ratio, conditions of spatulation, age of the investment, and differences from one manufactured batch to another.

Before using the controlled water addition technique, read carefully the manufacturer's instructions accompanying the investment and equipment purchased (Fig. 546). R & R Hygro-Pak No. 2 and Whip-Mix Hygrotrol are the investments to be used in this technique.

After the sprued pattern is mounted on the sprue base, the pattern is treated with a 50-50 mixture of tincture of green soap and hydrogen peroxide; after which, it is dried. Next paint the pattern with a wetting agent. The investment is mixed, using the water-powder ratio advocated by the manufacturer, and the pattern is painted with investment, using the brush-vibrator method. The rubber ring is now carefully placed on the sprue base, and the investment is poured around the painted pattern. This is done by pouring down the side of the ring and allowing the investment to rise around the painted pattern. "If a vacuum is

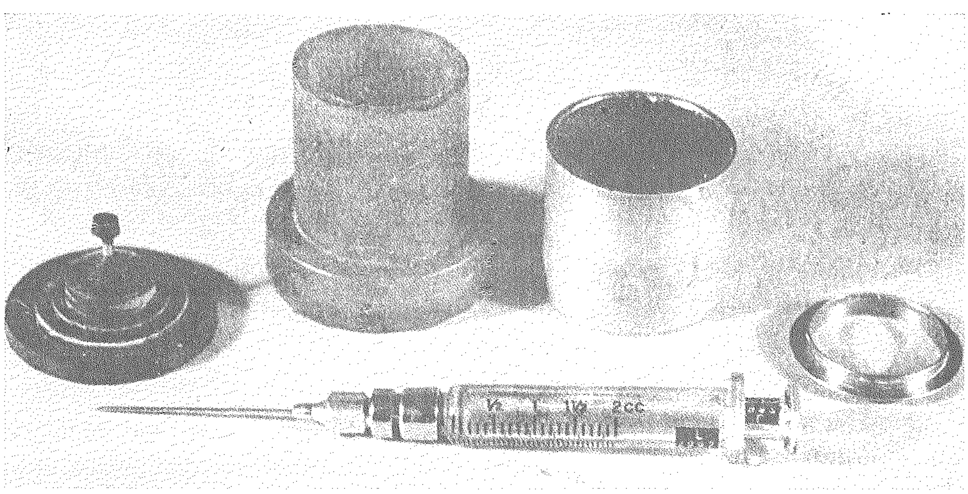

Fig. 546. Original equipment designed for use in the controlled water added technique. Consists of a sprue base, flexible ring, supporting ring, reservoir, and syringe. (From Asgar, K., Mahler, D. B., and Peyton, F. A.: Hygroscopic Technique for Inlay Casting Using Controlled Water Additions, J. Pros. Den. 5:711-724, 1955.)

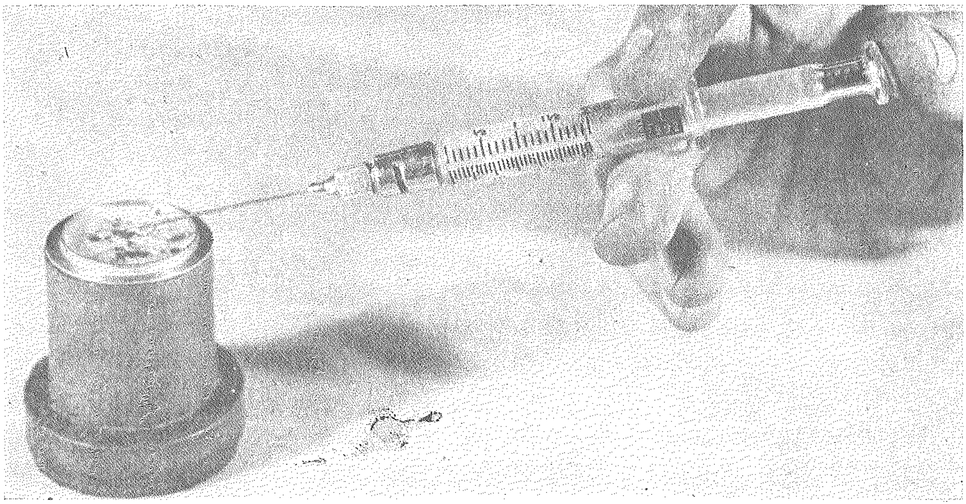

Fig. 547. Manner in which a controlled amount of water is added to the investment immediately after the investing procedure. (From Asgar, K., Mahler, D. B., and Peyton, F. A.: Hygroscopic Technique for Inlay Casting Using Controlled Water Additions, J. Pros. Den. **5**:711-724, 1955.)

used, the supporting metal ring must be placed around the rubber ring prior to investing but is removed immediately afterward. If this metal ring is allowed to remain around the flexible ring, the expansion will be restricted, and proper compensation will not be affected."

After the ring is filled, the level of investment is cut off flush with the top of the rubber ring. The metal band which acts as a reservoir is placed into the top of the rubber ring, and the required amount of water is added (Fig. 547). The exact amount of the water to be added is given in the manufacturer's instructions for the investment being used. The investment is allowed to set for 45 to 60 minutes before the reservoir, rubber ring, and sprue former are removed. The cylinder of investment is next placed into a furnace preheated to 900° F. and allowed to burn-out for 1 hour before it is removed from the furnace and cast.

Both investments used in this technique obtain sufficient hygroscopic setting expansion by adding a specified amount of water after being placed in a flexible rubber ring which offers no resistance to the expansion of the investment. The asbestos liner is eliminated since it would absorb some of the added water. The casting ring is also eliminated since it would also restrict setting expansion. The investments should be, and are, strong enough to be handled and cast into without a protective casting ring.

This hygroscopic technique produces excellent castings with a high percentage of reproducibility.

It is most interesting to note, at this point, that Markley[21] says that distortion caused by resistance of the wax pattern to hygroscopic and setting expansion is excessive with the so-called hygroscopic expansion techniques. It is necessary to use investments and methods that produce the least possible combined setting and hygroscopic expansion.[21] Hygroscopic expansion can be minimized by keeping the water level about ¼ inch below the top of the ring. Whip-Mix Denver investment (composed of 17 grams of Cristobalite and 33 grams of Gray investment) if it is spatulated with 15.5 ml. of water and raised to and held at 1100° F. for 15 minutes in the burn-out furnace, will have the best properties now available in a commercial investment. It sets slowly enough for water bath compensation even when spatulated mechanically.

Re-evaluation of casting process

The series of articles on the re-evaluation of the casting process by Hollenback and Rhoads, especially (1) A Study of the Behavior of Pattern Wax, (2) A Comparison of the Expansion of the Mold Cavity With the Linear Casting Shrinkage of Gold, and (3) The Correlation of Castings to Mold Dimension, is of such importance that certain sections from the last two papers are reported verbatim on pages 400 to 406 and sections from the first paper on pages 382 to 383. A careful study of the text and accompanying charts and illustrations will be of tremendous assistance to the student of precision casting.

"Two types of casting investment were studied: a Cristobalite type investment, and a silica type investment. The particular products used in this study were Kerr Cristobalite Investment for Inlays, and Ransom & Randolph Hygroscopic Investment. One of these investments, the Cristobalite type, has been compounded by the manufacturer to make use of a high thermal expansion to gain the necessary degree of compensation rather than to rely heavily upon the setting expansion. The silica type investment, on the other hand, has been developed to produce the greatest degree of compensation by means of its setting expansion (setting and hygroscopic) and to obtain a relatively small degree from the thermal expansion.

"Evaluation was made to determine both the setting expansion and thermal expansion (combined expansion) as evidenced by the enlargement of the mold cavity. Both determinations were made on each specimen so that the total combined compensatory changes could be observed.

"The investments were tested as follows:

"Cristobalite Type Investment

"1. Specimens in unlined test flasks.

"2. Specimens in test flasks lined with dry asbestos.

"3. Specimens in test flasks lined with wet asbestos.

"4. Specimens in test flasks lined with wet asbestos and which were immersed in room temperature water during the setting period of the investment.

"5. Specimens in test flasks lined with wet asbestos which was ⅛ inch short on both ends of the flask and which were immersed during the setting period of the investment.

"*Silica Type Investment*

"1. Specimens in test flasks lined with wet asbestos.

"2. Specimens in test flasks lined with wet asbestos and which were immersed at room temperature during the setting period of the investment.

"The specimens were prepared using water/powder ratios of 36/100 for the Cristobalite and 26/100 for the hygroscopic investment. The water and investment powder were incorporated with a broad spatula until homogeneous and then spatulated under vacuum (28.5-29 inch of mercury) using a suitable mechanical spatulator (the Kerr vacuum investor) for 20 seconds, after which the mix was vibrated into the prepared ring.

"*Results.* Values for setting expansion and thermal expansion were determined for investment allowed to set under different conditions as has been previously

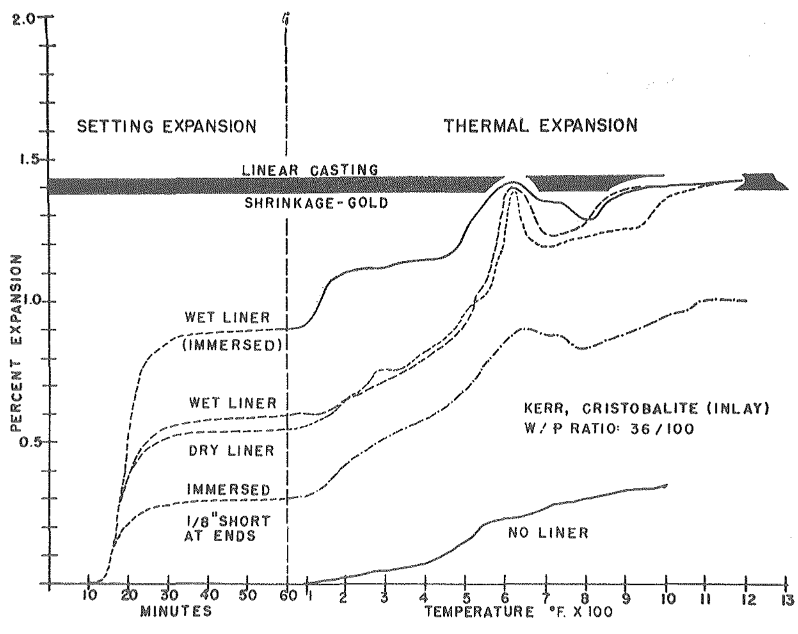

Fig. 548. Expansion of a Cristobalite type of investment. A full length asbestos liner is necessary if complete compensation of the mold cavity is to be expected. This is illustrated in the graph. Note that when a full-length asbestos liner, whether dry, wet, or immersed, is used that the total compensation (setting and thermal) is approximately the same and that it is in very close agreement with the linear casting shrinkage of the gold alloys used for cast restorations. A critical temperature of approximately 600° F. exists wherein the most accurate castings can probably be made. Castings made at the higher temperature range, although enjoying the same degree of compensation, do not exhibit the same marginal adaptation to the cavity surfaces as do those cast into molds maintained at the lower temperature. (From Hollenback, G. M., and Rhoads, J. E.: A Comparison of the Expansion of the Mold Cavity With the Linear Casting Shrinkage of Gold, J. South. California D. A. 28:73-80, 1960.)

outlined. The results for the Cristobalite type investment are shown [Fig. 548].

"It will be observed that apparently there is a complete restriction of setting expansion when no asbestos liner is employed in the casting ring or flask as evidenced by the fact that no enlargement of the mold cavity is discernible or measurable. A subsequent thermal expansion of investment samples allowed to set under these conditions shows a greatly restricted thermal expansion with a total expansion at 1200° F. reaching 0.4 per cent. This probably is allowed by the expansion of the flask. The use of a dry asbestos liner, on the other hand, is productive of a setting expansion of approximately .55 per cent with a subsequent thermal expansion of .84 per cent giving a combined total expansion of 1.39 per cent.

"The use of a wet asbestos liner is productive of slightly more setting expansion (.60 per cent), and subsequent thermal expansion of .80 per cent giving a combined expansion of 1.40 per cent.

"The use of a wet liner with immersion of the flask during the setting period of the investment is productive of a greatly increased setting expansion (.90 per cent) with a subsequent thermal expansion of .52 per cent giving a total expansion of 1.42 per cent.

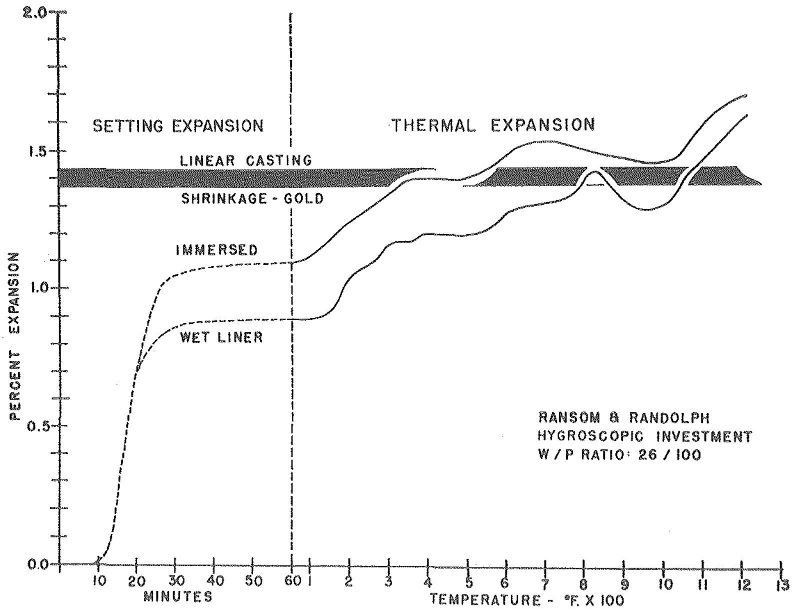

Fig. 549. Expansion of a silica type of investment. This investment produces compensation which closely approaches the linear casting shrinkage of the gold alloys used in making cast restorations. The use of either a wet asbestos liner or immersion during the setting of the investment produces total expansion values which correspond closely to the necessary degree of compensation. (From Hollenback, G. M., and Rhoads, J. E.: A Comparison of the Expansion of the Mold Cavity With the Linear Casting Shrinkage of Gold, J. South. California D. A. 28:73-80, 1960.)

"It should be noted that the use of a wet asbestos liner which is short of the ends of the ring exhibits a restrictive effect upon mold expansion. As seen in the graph, a setting expansion of .32 per cent with a subsequent thermal expansion of .68 per cent gives a total combined expansion of 1.0 per cent.

"There is a remarkable degree of agreement which these specimens show with the linear casting shrinkage of gold. It is also of interest, that although the setting expansion varies in these various specimens, the combined total expansion where a dry liner, a wet liner or a wet liner with the ring immersed is approximately the same. It is apparent that increased setting expansion is accompanied by a corresponding decrease in subsequent thermal expansion.

"The results obtained using a silica type investment are shown [Fig. 549].

"A setting expansion of .90 per cent is obtained when a wet asbestos liner is employed. When this is combined with a subsequent thermal expansion at 1200° F. of .71 per cent, a combined total expansion of 1.61 per cent is obtained. It should be noted that at the lower temperature range of approximately 850° F., the compensation of this investment approximates that of the linear casting shrinkage of gold.

"The immersion of a similar ring during the setting period of the investment, on the other hand, produces a setting expansion of 1.1 per cent followed by subsequent thermal expansion of .58 per cent which produces a combined total mold enlargement of 1.68 per cent. At the lower temperature range of 700° to 800°, the degree of compensation is slightly greater (1.53 per cent) than the linear casting shrinkage of gold, but still is in a comparatively close agreement.

"It is evident from this study, that the investments designed to gain the greatest part of their compensation from thermal expansion do, under normal conditions of use, exhibit a comparatively high degree of setting expansion. Depending upon the magnitude of the setting expansion, an inverse degree of thermal expansion is evidenced.

"*Discussion.* The graph on expansion of casting investments which compares measurement of the mold cavity with the measurement of the linear expansion of investment [Fig. 550] is of extreme interest and shows very clearly that the compensation of the mold cavity, as it has been studied, corresponds very closely to the linear casting shrinkage of gold. This is to be compared with the measurement of the linear expansion of these same investments wherein greatly increased values are evident.

"The examination of the graphs of the Cristobalite type of investments is of extreme interest in that it shows how closely several different methods of treatment of the investment can produce results which are very close to the range of the linear casting shrinkage of the gold. Thus the use of a dry liner, a wet liner or a wet liner combined with ring immersion during the setting period all produce total compensation in the mold which are within this range. It must

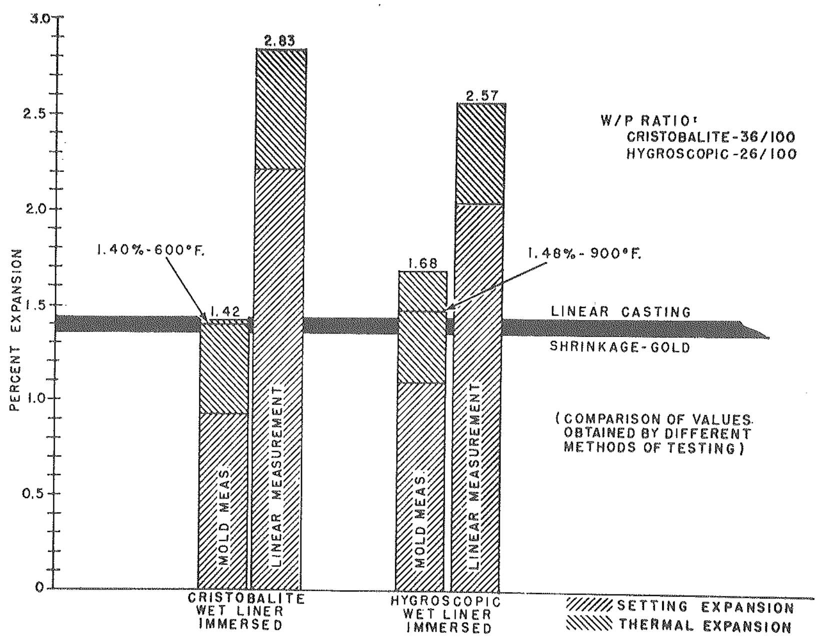

Fig. 550. Comparison of methods of measurement. It appears that the total linear expansion of the investment is not effective in the compensation of the mold cavity. Measurement of the mold compensation indicates values which correspond closely to the linear casting shrinkage of gold, whereas measurement of the total linear expansion indicates values which are much greater. Much valuable and heretofore unknown information can be gained through the investigation of compensatory changes that occur in the mold cavity itself. (From Hollenback, G. M., and Rhoads, J. E.: A Comparison of the Expansion of the Mold Cavity With the Linear Casting Shrinkage of Gold, J. South. California D. A. **28**:73-80, 1960.)

be noted that the use of an asbestos liner which is short of the end of the ring does produce an effective restriction of mold compensation and apparently gives enough restriction that it would seriously affect the fit of the casting.

"The graph of the Ransom & Randolph Hygroscopic Investment, that is, the silica type investment, also shows values which are more nearly in keeping with the known linear casting shrinkage of gold. When this investment is conditioned at a temperature recommended by the manufacturer, it will be seen that compensatory values approach the casting shrinkage of gold.

"*Conclusion.* . . . Although it appears impossible to reconcile the linear casting shrinkage of gold with the linear expansion of casting investments, under actual conditions of use (confined in an asbestos lined flask) they exhibit measurable mold expansions which coincide quite closely with the linear casting shrinkage of gold."*

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*From Hollenback, George M., and Rhoads, John E., A Comparison of the Expansion of the Mold Cavity With the Linear Casting Shrinkage of Gold, J. South. California D. A. **28**:73-80, 1961.

"Castings made at temperatures (600° to 625° F.) [using Kerr's Cristobalite inlay investment] were always of a very high degree of accuracy, being by far the best made throughout this entire investigation [Fig. 551]. Castings made after the secondary expansion had occurred always showed certain typical defects. It seems evident that the sudden and large shrinkage occurring at 650° to 700° F. produces a permanent mold distortion.

"The authenticity of the volume change of Kerr's Cristobalite Investment,

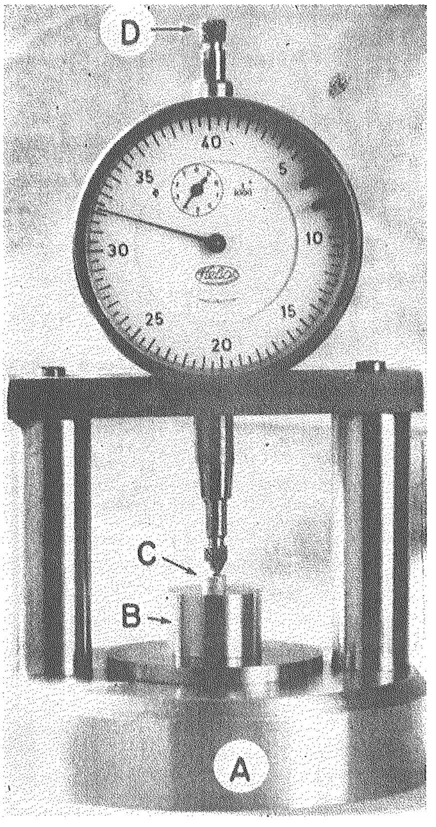

Fig. 551. *A,* Micrometer comparator; *B,* stainless steel die drilled lengthwise and reamed to a 1-to-50 taper; *C,* undersized casting which has been seated in the die; *D,* protruding end of the spindle of the dial gauge used with this device. In its upper aspect, a tapered depression has been drilled to receive the conical tip of the 1,250 gram weight. This apparatus is used as follows: The casting is first inserted in the large end of the die. Then the die is placed in the comparator, the dial gauge spindle in contact with the casting is adjusted, and the 1,250 gram weight is applied through the spindle of the dial gauge. Thus each casting is seated with exactly the same pressure. If the casting is correct in dimension when seated, it should be flush with the lower or smaller end of the die. If it is undersized, it will intrude into the die. If it is oversized, it will protrude from the upper or large diameter of the die. In all cases the die is then reversed in the comparator, and the protrusion or intrusion of the casting in the die is evaluated by the dial gauge. If the casting fits accurately, a zero reading will be given. (From Hollenback, G. M., and Rhoads, J. E.: The Correlation of Castings to Mold Dimension, J. South. California D. A. 28:183-185, 1960.)

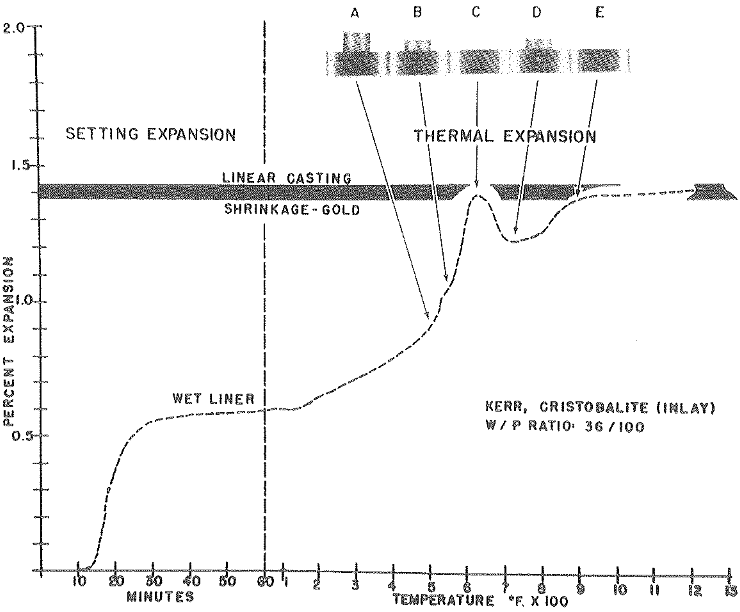

Fig. 552. Typical graph showing the composite of three individual experiments in which a wet liner was used in the flask. The heavy horizontal line represents the range of linear casting shrinkage of medium and hard inlay gold alloys. *A, B, C, D,* and *E* represent castings seated in the taper die. *A* shows the position of a casting in the taper die, the casting being made at 500° F. *B* represents the position of a casting in the die, the casting being made at 550° F. A study of the graph shows clearly that castings made at these temperatures should be greatly undersized, the one made at 500° F. being the smaller of the two. *C* represents a casting made at the peak of the curve, a temperature approximately 600° to 625° F. This casting is flush with the small end of the die, indicating a high degree of accuracy. *D* represents a casting made at 700° F. which is also considerably undersized. Again as indicated by the graph, this result is anticipated. *E* represents a casting made at 850° F. showing the same result as was obtained in casting *C*. Also, as indicated by the graph, this result would be anticipated. It would seem, therefore, that this series of tests made with actual castings at the indicated temperatures renders authentic the values previously reported (Fig. 548). All castings were seated using the comparator described in Fig. 551 with 1,250 gram weight. (From Hollenback, G. M., and Rhoads, J. E.: The Correlation of Castings to Mold Dimension, J. South. California D. A. 28:183-185, 1960.)

when confined in a flask using a wet asbestos liner and the quartz cylinder method of mold evaluation, has been amply authenticated by the series of castings which have been made and previously described in this paper [Fig. 552]."*

The development of a Cristobalite investment with a plateau instead of a peak will allow us to make good castings with ordinary skill. We haven't the perfect investment as yet.

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*From Hollenback, George M., and Rhoads, John E.: The Correlation of Castings to Mold Dimension, J. South. California D. A. 28:183-185, 1961.

CASTING AND MELTING GOLD ALLOY

Equipment

Casting equipment consists of a device for melting the gold and another for forcing it quickly into the mold cavity.

Equipment generally used for melting the gold is a blowpipe supplied with artificial or natural gas and compressed air and a gas-oxygen flame. The gas-oxygen flame must be used with care in order not to overheat the metal.

A properly adjusted blowpipe flame is made up of (1) a blue cone one third to one quarter the length of the flame, a mixture of unburned gas and air, (2) a reducing area in the center of the flame, and (3) oxidizing areas at the edges of the flame (Fig. 553). Blowpipes which do not have these sections well defined are common causes of casting troubles through oxidation. The light blue center cone is the area of almost complete combustion and is therefore the hottest part of the flame and slightly reducing. This part of the flame is the part that should contact the gold and cover it as completely as possible for rapid melting and protection from oxidation.

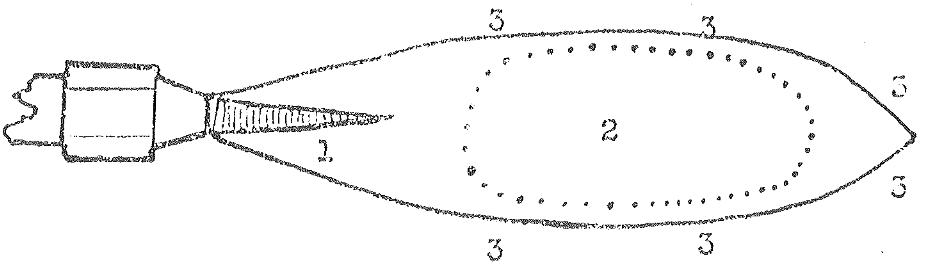

Fig. 553. A properly adjusted blowpipe flame is made up of a blue cone, *1,* one third to one fourth the length of the flame, a mixture of unburned gas and air, *2,* a reducing area in the center of the flame, and, *3,* oxidizing areas at the edges of the flame.

Melting and fluxing

Some oxidation will occur during melting regardless of how carefully the blowpipe is handled. It is therefore important that the metal be well protected from oxidation by the use of flux, preferably a reducing flux (such as Ney casting flux or Jelenko reducing flux), and also by keeping the metal covered at all times by the reducing portion of the flame. This type of flux forms a protective covering, and its effective reducing agent converts the oxides back to clean metal, thus retaining the original composition and properties of the alloy. Add this flux just after the metal has started to liquefy, and another pinch of flux should be added just before casting.

It is essential not only to completely melt the gold before casting so that it will flow freely into the mold, but also above all to avoid overheating the metal because high temperatures promote excessive oxidation and absorption of gases.

It leads to rough castings which are weaker and more brittle than normal.[14] It produces a subsurface porosity, with a pitting of the surface which causes discoloration. The ideal range for the melting of the gold alloy should be approximately 100° to 150° F. above the melting range of the alloy.[17,18]

Cast when the metal is completely molten, and if in doubt as to the fluidity of the gold alloy, do not attempt to move the button by moving the flame, but vibrate or shake the casting machine, which will serve the purpose as well and will at the same time prevent oxidation of metal. Keep the blowpipe properly adjusted—when the surface of the gold has a scum or film on it, it is being oxidized, and when the surface is bright, shiny, and clear or mirrorlike, the metal is being reduced. Sufficient metal should be used to fill the mold cavity and also to produce a dense sprue and a fair-sized button.

Treatment of residue buttons

Residue buttons should be thoroughly cleaned of investment and surface oxidation. Melt the button down on a clean charcoal block with liberal applications

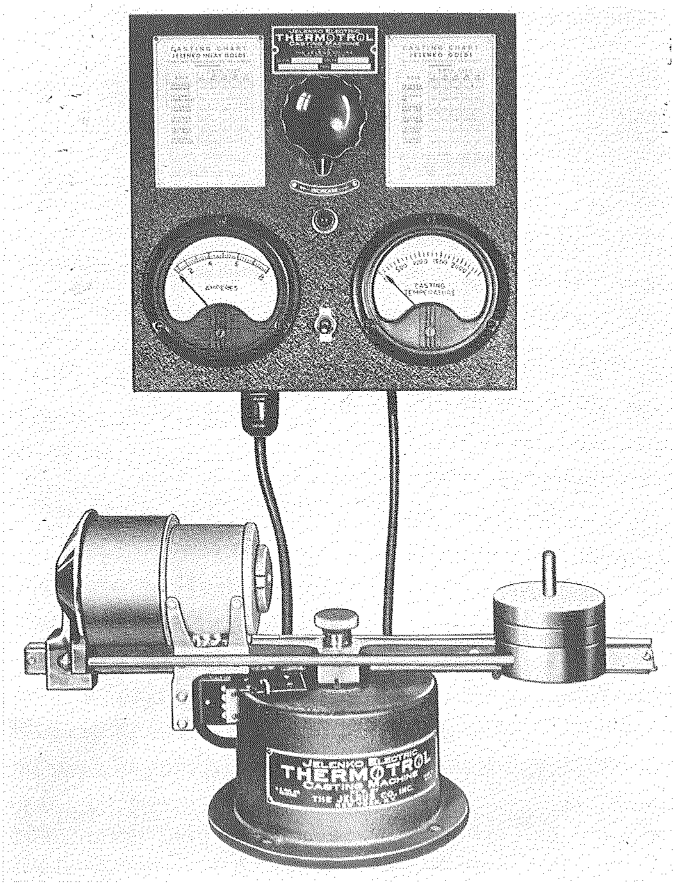

Fig. 554. Thermotrol. (Courtesy J. F. Jelenko & Co., Inc., New York, N. Y.)

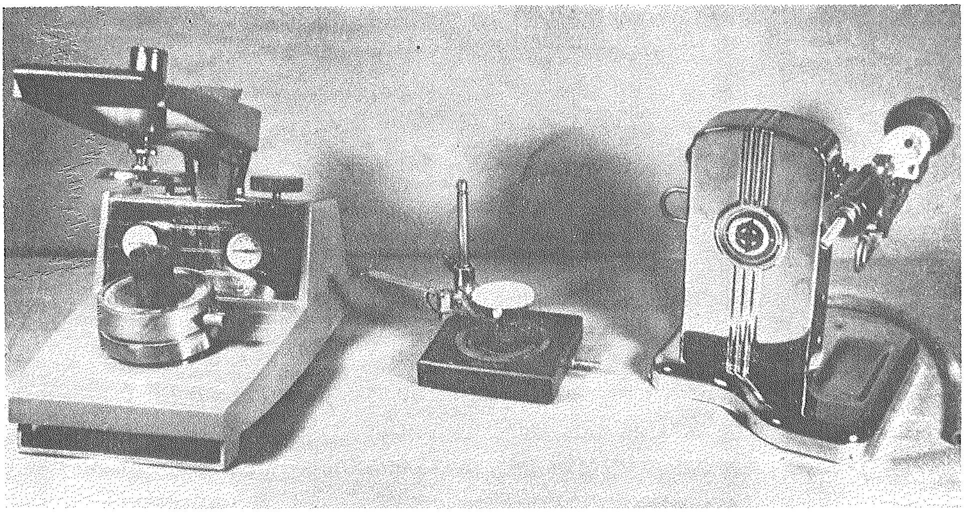

Fig. 555. Various types of vacuum casting machines available. (From Johnston, J. F., Phillips, R. W., and Dykema, R. W.: Modern Practice in Crown and Bridge Prosthodontics, Philadelphia, 1960, W. B. Saunders Co.)

of reducing flux, removing any slag with a clean slate pencil, and then plunge the hot button into an acid pickle. Never use an asbestos block for this procedure—only a charcoal block because it can be kept clean and thereby avoids contamination of the melted alloy. It also has a reducing action which in combination with reducing flux breaks up metallic oxides and converts them back to clean metal.

Phillips[28] calls attention to the important fact that when the button has been melted and treated with reducing flux, the flame is removed from the metal and it is allowed to freeze. This is a mistake because when exposed to the air the congealing metal will absorb gases, which is exactly what we do not want. His method is to turn off the air and allow only the gas flame to play on the surface of the metal until it congeals. The gas flame will protect the alloy from occluded gases, but it will not prevent solidification to take place.

Some think that hydrofluoric acid is a very efficient agent for removing adhering investment from both the casting and button as it cuts the silica. It should be soaked overnight in cold hydrofluoric acid. This acid should be used with great care and should be kept in tightly covered polyethylene bottles, as it attacks glass.

It is good practice to add at least 50 per cent new metal to all melts.

The types of casting machines in general use are centrifugal, air pressure, and vacuum. I am familiar with the use of all of these machines and lean in the direction of the Jelenko Thermotrol (Fig. 554) and the Schmitz Vac-O-Cast (Fig. 555).

The Thermotrol minimizes the human element and also combines the melting and casting functions into one machine. The metal is melted (by induction) within a carbon crucible in a platinum wound muffle, and the force used to throw the metal into the mold cavity is centrifugal. Another important factor, which was previously pointed out in the discussion of the melting process, is that it is equipped with a pyrometer to measure the casting temperature of the alloy used. Excellent results are obtainable even when thin sections or intricate patterns are involved. The density of the castings and their soundness are very high.

The Vac-O-Cast is a remarkable machine. The castings derived by this method show uniformly dense surfaces with no pits or voids. Thin sections and fine margins can be cast consistently by this method. Be sure the casting ring is carefully seated in order to retain the vacuum during casting.

Heat treatment

Soft and medium hard inlay golds (types A and B) are not affected by heat treatment, but the hard and extrahard golds (types C and D)—the platinum, palladium, gold, and copper alloys—can be hardened appreciably by slow cooling or left in a softened condition by rapid cooling.

It must be kept in mind that heating to soldering temperatures will destroy any previous hardening treatment. Also, that it is not always desirable to secure maximum hardness and strength since this process reduces ductility. A moderate hardening treatment is preferable. It is also important, if hardening heat treatment is contemplated, that the clinician or technician follow the manufacturer's recommendations as to the proper heat treating schedules for their alloys.

Rapid cooling by quenching in water, followed by heat treatment at a controlled temperature, produces the most satisfactory physical properties.[29] Methods available for this type of treatment are: (1) the gold alloys may be heated at some constant temperature between 840° and 480° F. for a definite period of time, or (2) they may be slowly cooled from 840° to 480° F. in a definite time interval. It is generally agreed that each alloy has an optimum heat treating temperature which means it has reached its maximum strength, but exhibits a minimum corresponding brittleness. Again the importance of obtaining these temperature and timing schedules from the gold manufacturer is pointed up. Heat treating furnaces and baths that operate at a constant temperature are available, and the manufacturer's treating schedules for their alloys must be used.

Softening or hardening heat treatment can also be carried out effectively by regulating the time the casting is allowed to cool in the investment after casting. For softening, plunge the inlay ring into water 1 to 2 minutes after casting. For hardening allow the ring to cool 3 to 6 minutes before quenching. If a larger flask than an inlay ring is used, it will take longer for the gold to cool through the hardening range; therefore a longer period should be allowed before quenching—6 to 10 minutes for a medium-sized flask and 8 to 12 minutes for a large flask.[14]

Heat hardening for fixed bridges or splints must take place after the bridge is soldered into a unit. Selection of the various materials for constructing a bridge must be carefully done so that everything is compatible for heat hardening by the same operation. Consultation with the manufacturer of the gold alloys and solders will elicit the information. A bridge will not heat harden as uniformly if it is allowed to cool out on the bench as if it had been done by the furnace or bath method.

SALIENT FACTS

1. The physical properties of the materials entering into the casting process, i.e., waxes, investments, and gold alloys, must be thoroughly understood and intelligently applied.
2. When the pattern wax is manipulated intelligently, it has a high degree of stability.
3. It is necessary that the cast be run very soon after the impression is taken.
4. Rapid cooling by quenching in water, followed by heat treatment at a controlled temperature, produces the most satisfactory physical properties.
5. Follow the manufacturer's directions as to the correct water-powder ratio for their product.
6. When vibrating investment, do not vibrate violently.
7. A soft asbestos liner 1/32 inch thick and 1/8 inch shorter than the ring is inserted in the ring dry and, when in position, is saturated with water. It is placed flush with the upper or open end of the ring.
8. Fresh acid pickles should be prepared frequently. All castings should be dipped in sodium bicarbonate solution after pickling to neutralize the acid.
9. One part nitric acid to two parts water should be used to remove fusible metal from inside castings. The metal can be boiled in this acid. Use a fume chamber.
10. All gold alloys do not have the same shrinkage. The degree of shrinkage varies with the alloy used, and this point must be kept in mind when determining water-powder ratios for investing patterns. By slightly changing the water-powder ratio, metals and their alloys of different coefficients of expansion can be cast to dimension.
11. An electric furnace with a pyrometer (which is checked frequently) should be used for the burn-out.
12. An intelligent selection of gold alloys for the case at hand should be made, taking into consideration such physical properties as ultimate tensile strength, proportional limit, elongation, Brinell hardness, and melting range.
13. In melting gold use the central flame just below the point of the blue cone—the reducing zone. Use reducing flux.
14. Rapid cooling (quenching just below red heat) after casting makes gold alloys as soft and malleable as possible. Slow cooling (in invested ring or in a furnace) after casting increases the hardness, strength, and brittleness of the harder alloys.
15. Pits in casting may be caused by improper spruing, improper melting of

the metal, inclusions of detached particles of investment or other foreign material, or too little or too much flux.

16. Rough castings may be due to (1) too rapid burn-out, (2) heating investment to too high a temperature, (3) heating gold to an excessively high temperature, (4) too heavy vibration during investing, and (5) investment improperly mixed.

17. Development of mechanical spatulation and use of certain wetting agents have aided tremendously in the elimination of surface irregularities.

18. Absolute adherence to a very careful and standardized technique cannot be overemphasized.

19. Smooth castings are produced by the proper water-powder ratio, mechanical spatulation, thin coating of a wetting agent, careful painting of the investment on the pattern, and proper burn-out and melting of the gold.

20. Permeability in casting investments is a very important factor. It can affect the completeness of, and the fine definition of a casting as well as its soundness, finish, and physical properties.

21. Bubbles on the surface of a casting may be caused by entrapment of air during investing or the use of too much wetting agent.

22. The pickling agent that I use is Jelenko Jel-Pac which is a harmless, nonirritating compound and is mixed with tap water to make a strong pickling solution which is nonfuming and produces no corrosive vapors. It doesn't ruin laboratory equipment and produces clean bright surfaces quickly. Jelenko Saf-T forceps are used to remove the castings from the pickling solution. Because of its specially treated tips, contamination is not a problem, as with metal tweezers. The possibility of flash copperplating of pickled restorations has been eliminated.

STRIPPING

Stripping is a method that is used to relieve the inside surfaces of small type castings in order to be able to properly seat them during cementation. The Lektro-Dip* stripping outfit is used (Fig. 556). This type of equipment uses an acid which removes metal from the surfaces of an inlay or crown, but it differs from aqua regia in that its action is fast (about 1 minute), and the gold surface inside the casting has a polished, etched appearance rather than the dull appearance produced by aqua regia.

"This equipment is somewhat the reverse of copperplating equipment. In copperplating, copper is removed from the anode and is deposited on the cathode. With this stripper, the gold inlay or crown becomes the anode, and the gold is removed and deposited on the cathode which, in this case, is the metal container containing the acid. Gold can be recovered by wiping it off the sides of this receptacle."† Because in this method the acid is heated, wax cannot be used to

*T-Flex, Inc., New York, N. Y.

†From Kovaleski, Theodore: How to Relieve Crowns and Inlays to Correctly Fit the Die. In The Thermotrol Technician, p. 3, Nov.-Dec. 1958.

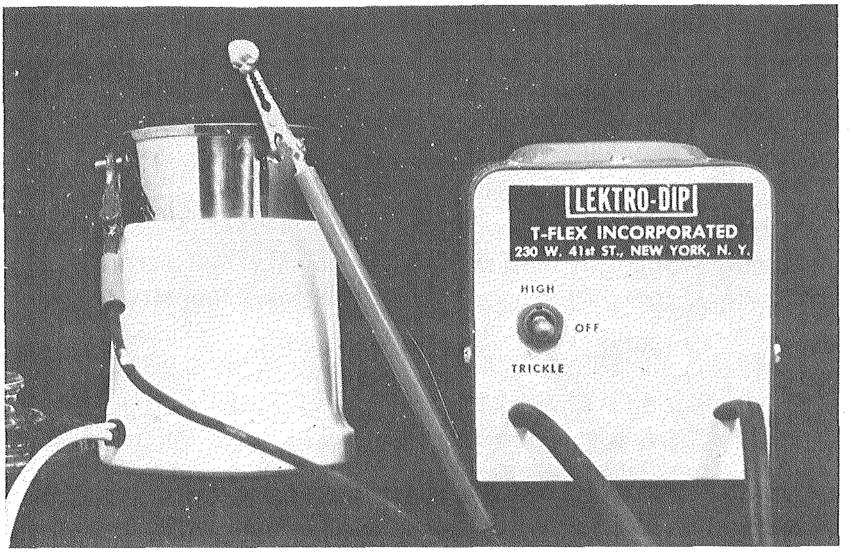

Fig. 556. Lektro-Dip stripper. (Courtesy T-Flex, Inc., New York, N. Y.)

protect the margins as in the etching method of aqua regia. To prevent damage to the margins, paint them with nail polish. This can be removed, after stripping, with a solvent such as acetone or chloroform.[30]

SOLDERING

In the process of soldering the need for a good strong joint is of great importance.

Use of blowpipe and flux

It is necessary to avoid oxidation of the castings being soldered because the solder will ball up and not flow as the heat is applied (and if some sort of attachment is accomplished, the result is a poor bond). To avoid this type of oxidation the proper handling of the blowpipe and the use of a good flux are of great assistance. The solder must flow easily, and the operation must be completed very quickly. If this doesn't occur, stop and start from scratch. Cleanliness is another factor to be taken seriously; a clean joint, free of investment particles, wax, rouge, etc., makes the best union. Therefore, the cleaner the surfaces to be soldered, the more easily the solder will flow. Another requisite for a good strong joint is a low surface tension between the molten solder and the gold. Careful heating to a dull red heat of the metal in the area of soldering helps reduce this surface tension.

Burn-out technique (temperature control)

Another factor that observation has shown to be taken lightly is the careless handling of the soldering investment during burn-out and soldering. As was pointed out, in the burn-out technique for casting, the investment must not be heated above 1350° F. in order to avoid the decomposition of the calcium sulfate which gives off sulfur or sulfur compounds. If it happens during the soldering operation, this sulfur compound will contaminate the surface of the gold castings and prevent a good bond. This necessitates liberally cutting the soldering investment away from the areas of the joint to be soldered.

The depth of the solder joint occlusogingivally should be as deep as possible. It increases the strength of the joint and thereby the bridge, and when many joints are involved, this factor becomes more and more important.

Solder gap

Besides cleanliness, controlled heating, proper fluxing, proper selection of solder, contact of joints and access to joints, which are the requirements for successful soldering, there is the necessity of maintaining a solder gap of .01 inch, which is the equivalent of three sheets of writing paper or one sheet of 30-gauge wax. Provision for this expansion, which occurs when the casting is heated, is necessary in order to avoid distortion. The solder gap closes during soldering approximately .01 inch; therefore, if there is compensation for this, the solder will flow into these contacts by capillary action without distortion. Keep in mind the necessity of avoiding wide joints because these wide soldered joints are weak, and more distortion occurs because of greater shrinkage during solidification.

Soldering investments

At this point attention should be called to the necessity of selecting the proper soldering investment. Soldering investments contain quartz and a calcium hemihydrate binder. In general they are designed to have lower setting and thermal expansions than casting investments. The particle size may not be as fine as casting investment because smoothness of mass is of less importance. It is necessary to avoid the possibility of hygroscopic expansion by contact of the soldered assembly with water during the setting of the investment.

The contraction of the solder must be balanced with the setting and thermal expansion of the investment. Modern Materials soldering investment fulfills all requirements for a good soldering investment.

Selection of gold solder

The gold solder selected should have the following properties: (1) it must melt at a temperature low enough to permit flowing without injury to the alloy being soldered (at least 100° to 150° F. below the temperature at which the gold alloy being soldered begins to melt); (2) it must not ball up and stay in one spot, but must flow smoothly into the joint; (3) it should be high-karat solder because high-karat solders flow better and resist tarnish more than those of low karat; (4) it must be strong enough to withstand stresses; and (5) it should approximate in color the alloy with which it is to be used.

Select the solder by fineness and not by karat. The karat (solder) refers to the fact that this is to be used in soldering 18-karat gold alloys, but gives no information as to fineness. Solder designated 18K does not contain 18/24 gold. Fineness, melting range, and color are the criteria for selection.

Construction of soldering cast

After the abutment retainers have been accurately fitted and adjusted and the hinge-bow transfer and centric relation bite are taken, a plaster impression is taken for construction of the soldering cast.

1. All castings being assembled on the model, the next step is the removal of the castings and grinding of spaces for solder gaps over areas designated for joints. Gaps should be .01 inch wide, the thickness of one sheet of 30-gauge wax. Always keep in mind that a minimum amount of solder should be required, and before the parts are united with sticky wax, they should be well cleaned. After the parts have been firmly united with sticky wax, occlusal stone indexes are made in order to hold the assembly together during investing. Invest the assembly, not too deeply, using a good soldering investment such as Modern Materials soldering investment and allow it to set hard, at least 1 hour, before removing the index. A good interrelation of the castings must be maintained.

It is impossible to get precision fits of retainers if all joints are soldered at one time because of the problem of expansions and contractions of the investment, gold alloys, and solder. Clinical judgment will dictate how many and what joints are to be soldered during each soldering operation, especially if a long span or a large fixed splint is under construction.

2. The wax is thoroughly removed by flushing with boiling water. Sticky wax must not remain on the metal because it would be carbonized during the burnout, and this carbon would act like an antiflux, making it hard for the solder to flow. The castings should be exposed so that there is free access to the solder joints; the joints must be left well exposed to the flame so that all parts may be heated evenly. Trim the investment liberally and again flush the joints with boiling water followed by chloroform.

3. The joints should be well covered with a good reducing flux in order to prevent the formation of oxides while soldering (do not use ordinary borax). Antiflux can be applied to all areas where solder is not wanted and should be applied before application of soldering flux. Be careful in its use. Apply the soldering paste flux immediately after flushing while the metal parts are still warm so that it will be melted and flowed over all exposed surfaces.

4. Do not burn-out the soldering assembly over an open gas flame, with or without an intervening sheet of asbestos. "Sulphur gas, from the calcium sulphate in the investment will be generated if the investment is heated to a high temperature which in turn will embrittle the gold and make the solder sluggish. Also, since the assembly is hotter at the bottom than at the top the greater expansion

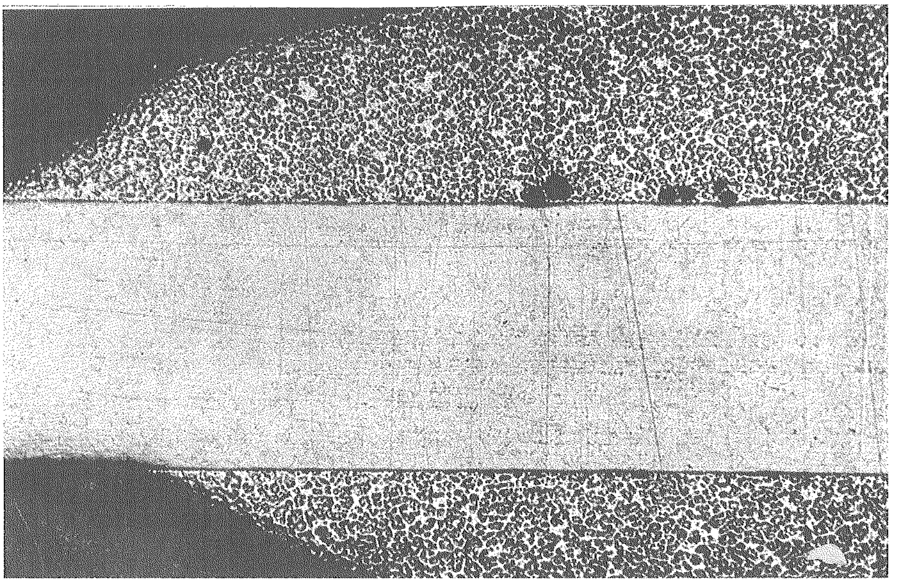

Fig. 557. Section through a soldered wire. As soon as the solder flowed, the flame was removed. There was no overheating and no solution of the wire in the solder. (From Ney Gold Handbook, Hartford, Conn., 1956, The J. M. Ney Co.)

at the bottom will cause warpage of the assembly. Put the soldering assembly in a preheated burn-out furnace at 800° F. for 30 minutes or longer."*

5. After the soldering assembly is removed from the temperature controlled furnace, place it on an asbestos soldering block, apply a little more soldering paste flux to the joints, and heat the whole assembly for a while with a rather large blowpipe flame which is kept moving before adjusting the flame to the pointed cone to be directed toward the joints involved. Use the reducing area in the center of the flame. When applying the solder, be sure it is also fluxed.

If all precautions have been taken (cleanliness, proper preparation of the assembly block, fluxing, proper burn-out and adjustment of the flame) and if a good solder whose upper limit of melting range is 100° to 150° F. below the lower limit of the melting range of the parts to be soldered is used, the soldering should be accomplished in a few seconds (Figs. 557 and 558). The solid metal will not be dissolved to any injurious degree in the molten solder if this technique is followed. The solder will pull through the joints rapidly, an excellent union will result, and grain growth will be avoided.

Allow the soldered piece to cool slowly in the soldering investment for about 5 minutes before quenching. Pickle in Jel-Pac solution.

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*From Brumfield, R. C.: Soldering the Bridge. In Crown and Bridge Construction Using Hydrocolloid Impressions, New York, 1954, J. F. Jelenko & Co., Inc., pp. 83-86.

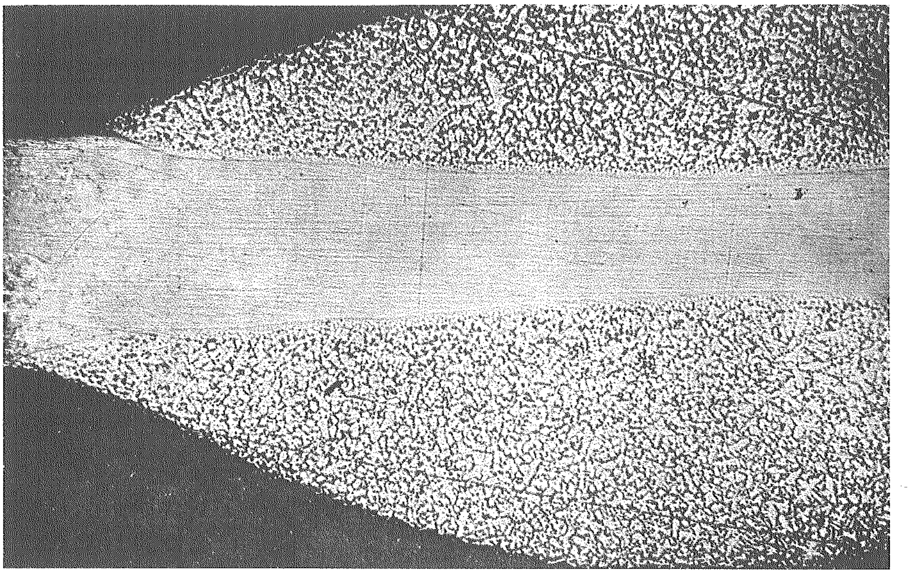

Fig. 558. Same wire and same solder flowed in the same way, except that the solder was kept molten for 45 seconds. Solution of wire was very marked; weakening of the wire at the edge of the solder is obvious. (From Ney Gold Handbook, Hartford, Conn., 1956, The J. M. Ney Co.)

The foregoing procedures lead to sound, gas- and oxide-free joints between the parts. It also gives strength to bear occlusal loads.

All remaining joints are to be soldered by the same procedures as just outlined. Don't solder too many joints at any one time. Reassemble the units on the master cast or in the mouth for each successive soldering operation. I reassemble the parts for soldering the various joints in the mouth, keeping the patient in the office until all soldering operations are completed and the restoration fitted. This is done by the use of plaster core index impressions.

Ask gold manufacturers for instructions for a hardening heat treatment of the products involved in the bridge or splint and follow them to obtain optimum properties.

FINISHING AND POLISHING THE CASTING

After the sprues have been cut off and the casting has been pickled and sandblasted, it is ready for final fitting, finishing, and polishing. The necessary tools consist of an assortment of burs, mounted stones, discs, rubber wheels, felt wheels, tripoli, rouge, and chalk.

"A primary rule to remember is that a good polishing job must be a thorough job."[31] Start with the coarser abrasives such as separating discs, heatless stones, various types of mounted stones, burs (round, inverted, and tapered) and move progressively on to the various types of sandpaper discs and rubber wheels, No. 11 soft Robinson bristle brushes with tripoli, rag wheels and fine brushes with rouge until the scratches become finer and finer and are finally all eliminated, resulting in a smooth, finely polished job.

The importance of highly smooth surfaces on any restoration going into the mouth cannot be overemphasized. Rough, poorly polished areas of metal or porcelain tend to hold the saliva and debris and greatly accelerate the formation of deposits. Because such deposits become stained and unsightly, the cause is often and wrongly attributed to tarnish of the metal instead of to inadequate polishing. Discoloration of this kind can easily be removed with an ordinary toothbrush and dentifrice.

After an inlay, crown, or bridge is cemented, it is treated lightly with a rubber cup and prepared chalk.

CEMENTATION

Both the selection of a satisfactory cement and the proper manipulation of the cement are most necessary. If it is used properly, the desirable physical and chemical properties can be brought out.

Properties of cement

Zinc phosphate cement consists of a powder and a liquid. The powders are essentially calcined zinc oxide and magnesium oxide, and the liquids are phosphoric acid, partially neutralized by the addition of metallic salts as buffers, and water. Setting time is controlled by the addition of definite concentrations of water.

It is necessary to remember, when working with these cements, that the water balance is critical and should be preserved. Addition or loss of water through exposure to room atmosphere of the open liquid bottle will alter the setting time—either accelerate or retard it. Relative humidity percentage varies constantly and is hard to control in our offices. This phenomenon will also vary the consistency of the mix. Therefore, keep the liquid bottle tightly stoppered and never place the liquid on the mixing slab until exactly ready for the mixing operation. Moisture from a chilled slab, unless carefully dried, gets incorporated into the mix, accelerating the set.

There are also other variables which affect dental cements. Liquid deterioration, relative humidity percentage, and room temperature have already been mentioned, but we can't overlook slab temperature, dew point, and the fact that the powder is hygroscopic and will absorb moisture. These variables must be controlled to the best of our ability because the weakest link in the casting process is the cement. Cements have a relatively low strength and are somewhat soluble in mouth fluids.

Manipulative procedures in mixing cement

All these facts point to the importance of correctly executing proper manipulative procedures in mixing the cement:

1. The maximum amount of powder must be incorporated into a given quantity of liquid because solubility is directly related to the amount of powder used.
2. The liquid must be placed on the slab just prior to starting the mix.
3. The slab should be chilled to 60° to 70° F., being sure it is not below the dew point.
4. To accurately seat well-fitting castings, even after stripping, will necessitate a thin mix with a maximum amount of powder in it.
5. Small increments of powder should be added when the mix is being made, using a rotary motion to incorporate it. The mix should be very smooth.
6. The time of mixing should be approximately 1½ minutes. These procedures all tend to dissipate the heat of the reaction.

I am now experimenting with the Kile system of mixing dental cements with the hope that the variables just mentioned can be controlled with greater accuracy.

Seating the castings

After the cement has been properly mixed, the cavity is filled with cement, and the margins of the inlay are also covered; after which, the inlay (or any type of small casting) is seated and kept under a sustained pressure until the cement has thoroughly set. Many times it is advisable to allow the assistant to hold the inlay while the operator burnishes the margins, i.e., before the cement has thoroughly set, and thereby in many cases eliminating even the finest cement lines.

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CHAPTER 19

Remounting

Remounting is the procedure whereby the restorations are accurately positioned to each other and to the masticatory mechanism for the purpose of minute refining of the various surfaces. It is one of the most important single steps in mouth rehabilitation, for it enables us to observe with accuracy just how the restorations are working, something that is difficult to do in the patient's mouth.

Remounting procedures have other applications, too, in the course of constructing certain restorations. These will be considered later.

ESTABLISHING THE FIT AND CONTACT OF THE RESTORATIONS

After the castings have been made and cleaned, the restorations are carefully fitted to the teeth and to each other for proper contact and contour.

In establishing the fit and contact of the restorations, the Handy-Sandy* sand blaster is a very practical accessory. The inside of the restorations, as well as the proximal surfaces, are frosted by the sandblast, and any contacting areas will show up as bright spots on the frosted surfaces. Careful adjustment of these will make for better-fitting restorations.

A very useful adjunct to any reconstruction procedure is a stripper or deplating apparatus, such as the Lektro-Dip† unit used in our office (Fig. 559). This device quickly removes minute particles of gold from the surface of a casting, reducing tiny nodules so that the casting can be easily fitted to the die and thus more readily to the tooth. The deplating action also makes room for the cement. Usually 15 to 30 seconds is sufficient time to deplate. The margins can be protected with a coating of nail polish or some such solution if the deplating is to be extensive.

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*J. F. Jelenko & Co., Inc., New York, N. Y.
†T-Flex, Inc., New York, N. Y.

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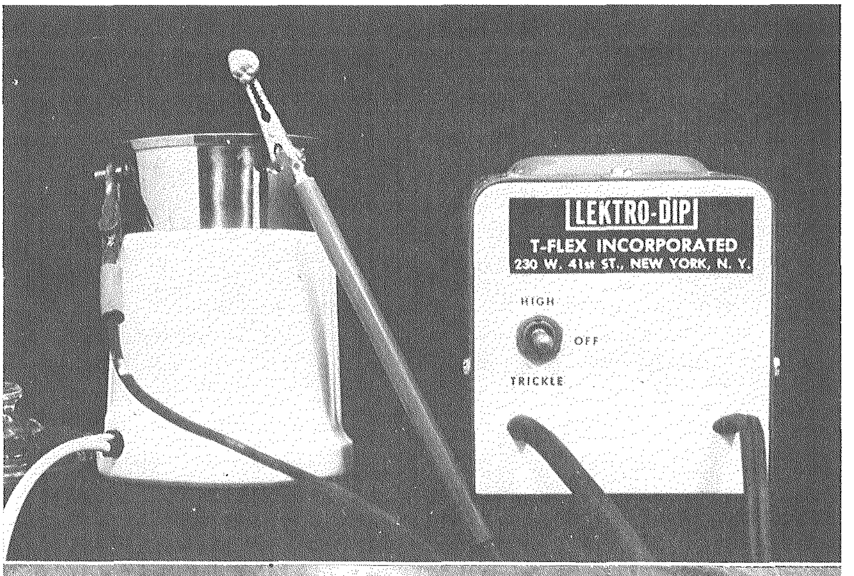

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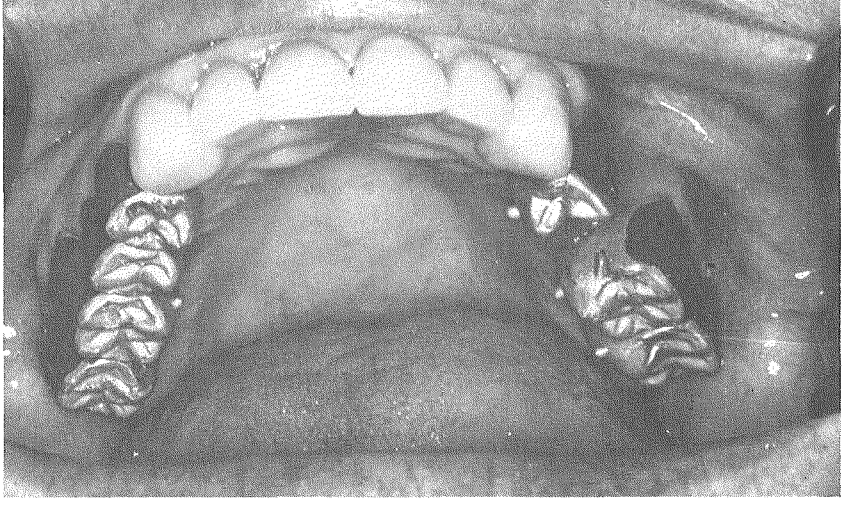

Fig. 559. The Lektro-Dip. (Courtesy T-Flex, Inc., New York, N. Y.)
Fig. 560. The restorations in place preparatory to a remounting procedure.

When the fit and the contact of the restorations are satisfactory, we are ready for the remounting procedure (Fig. 560).

All the restorations *must* be in place and remain in place during the steps to follow. If any of them tend to move out of their seats, a little denture adhesive powder or a thin mix of temporary cement with plenty of petrolatum will suffice to prevent their dislodgement. This is very important, for if a restoration is related off its tooth seat, it will not be properly related to the rest of the mouth after it is adjusted and reseated on the tooth.

If the teeth are sensitive, a little Xylocaine ointment* is placed in the restorations.

At least one other remount is made after the restorations have been temporarily worn for some time. In making this remount, we do not remove the restorations until all the steps in the procedure have been completed, i.e., face-bow setting, securing of a centric relation record, and taking of the remount impressions. The reason for this is to have the restorations as nearly as possible in the same relation to the teeth as they will be after cementation. In other words, the thickness of the temporary cement should approximate the thickness of the permanent cement. This points up the care required in the temporary cementation if the restorations are to be properly seated in place.

MAKING A FACE-BOW TRANSFER

The first step in the remounting procedure is to obtain a face-bow setting. The hinge axis was previously located and permanently marked on the patient, as was the axis-orbital plane.

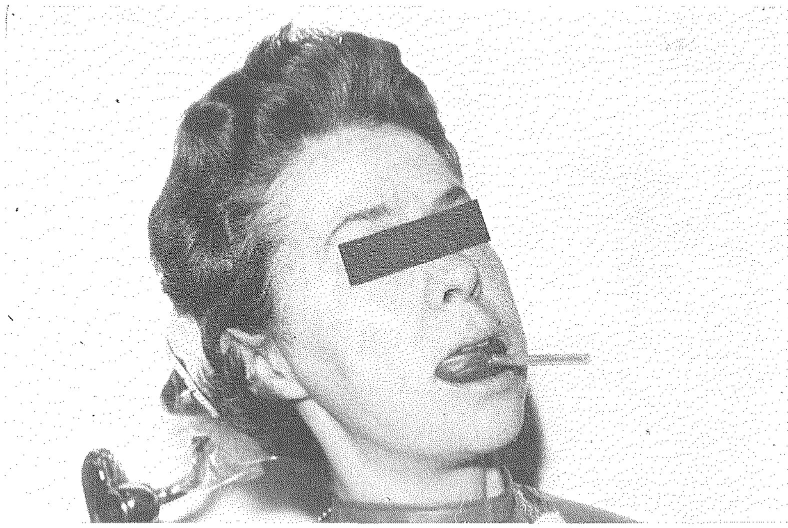

Fig. 561. The patient closes the teeth into the softened compound on the fork.

The face-bow fork is lined with a roll of red compound and placed in the mouth to register accurate imprints of the upper restorations and teeth. The patient is instructed to close the jaw lightly in order to support the fork in place (Fig. 561). We must make sure that the imprints on the face-bow fork are clear and do not penetrate through to the metal and that the compound is trimmed, showing only the imprints of the tips of the cusps (Fig. 562). If there is any rock to the fork as it is tested, it must be refitted until it fits accurately

*Astra Pharmaceutical Products, Inc., Worcester, Mass.

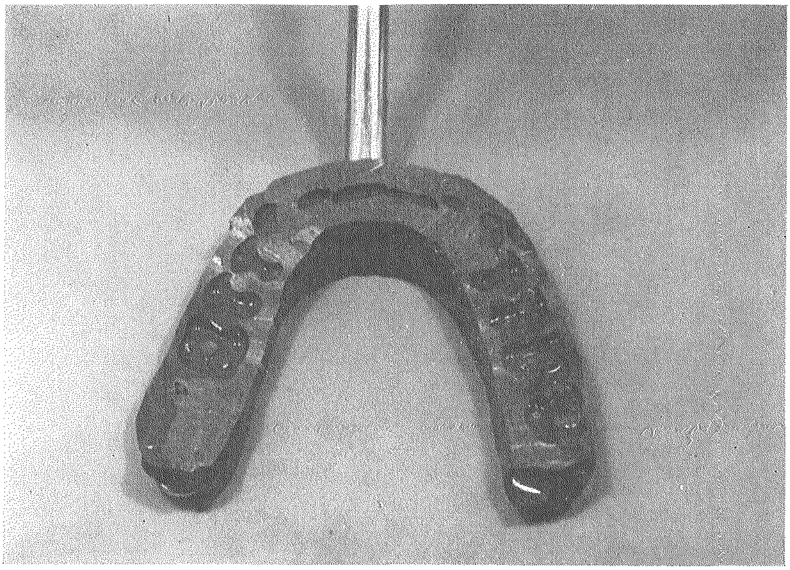

Fig. 562. The indentations in the compound are trimmed so that only the imprints made by the tips of the teeth remain.

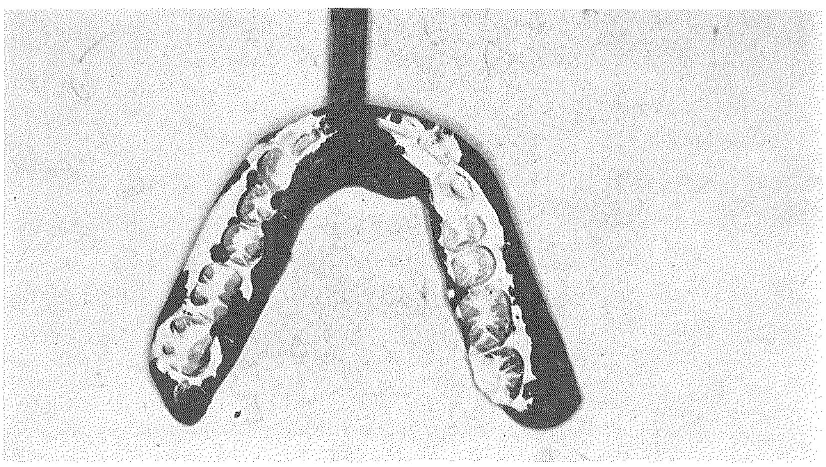

Fig. 563. The imprints in the face-bow fork are relined with zinc oxide and eugenol paste to perfect them.

without rocking. Then reseat the face-bow fork to make sure that the compound has not warped in the chilling process.

A thin mix of a zinc oxide and eugenol paste, such as Luralite,* Ackerman's,† or Kydac,‡ is applied over the cusp tip indentations in the compound on the

*Kerr Manufacturing Co., Detroit, Mich.
†Ackerman Dental Co., Santa Monica, Calif.
‡The Motloid Co., Inc., Chicago, Ill.

maxillary surface of the fork. The fork is placed in position, and the paste is allowed to set. The fork is removed, and the paste is trimmed so that only the cusp tip indentations remain (Fig. 563). This is very important! The manner in which the remount model fits into the face-bow fork is an indication of the accuracy of the remount impression and cast. The only way to determine whether

Fig. 564. The face-bow on the patient adjusted to the hinge axis points. Note that the patient is in an upright position to minimize skin distortion.

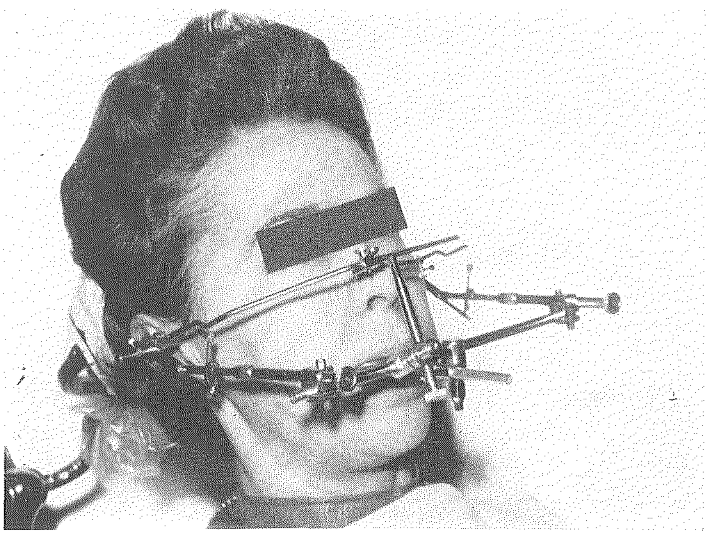

Fig. 565. The axis-orbital plane indicator in position.

the cast really fits into the fork is by seeing the cusp tips and how they seat into the indentations. If the sideboards of the imprints are left in place, it is not possible to see this too well.

Now lock the face-bow securely in place. The patient, remember, should sit upright during the final adjustment of the stylus pins (the same position as when the initial mark was made on the patient immediately after locating the axis). This upright position ensures against any skin movement that could result were the patient to lean against the headrest (Fig. 564). Now set the axis-orbital plane indicator in place and adjust it to the tattoo mark on the side of the patient's nose (Fig. 565).

OBTAINING A CENTRIC RELATION RECORD

Satisfied that the face-bow transfer is accurate, we go on to the next step—securing the centric relation record (Fig. 566).

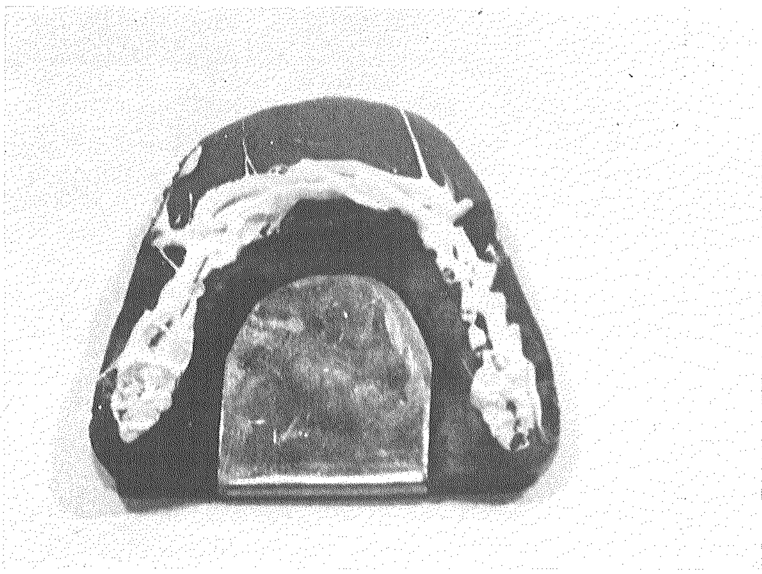

Fig. 566. Centric interocclusal record.

The procedure of obtaining the registration of centric relation is so important and complicated that an entire chapter was devoted to it earlier. Therefore, it will now suffice to say that an accurate centric interocclusal record, without strain in any direction, is secured, and the hingelike action is frozen in the terminal position at a convenient vertical dimension.

For a centric relation record to be satisfactory, it must meet the following requirements:

1. There must be no penetration of the cusps through the recording medium.
2. The only indentations should be those of the cusp tips.

3. When it is placed on the patient's upper teeth, the patient should be able to close the mouth repeatedly and effortlessly into the indentations of the lower teeth.

4. With the centric interocclusal record between the teeth, the patient should be aware of no strain whatsoever. There should be a feeling of equal pressure throughout the contact.

5. It must be stable on the upper teeth. There should be no rocking.

6. With the teeth closed into the centric relation record, it must not be displaceable in a vertical direction.

When this most important step is accomplished—and it is the most important step because an error here will destroy everything that has been done up to this point—we are ready to take the remount impressions.

TAKING THE REMOUNT IMPRESSION—COMPOUND AND HYDROCOLLOID TECHNIQUE

The purpose of the remount impression is to produce a cast showing all the restorations in their proper relation to each other and including the natural teeth and the gingival contours. To accomplish this, certain materials must be used in a special way. It is necessary to have a material into which the restorations can be accurately seated. In addition, it should be possible to remove the impression from the mouth in one piece without causing injury to the oral tissues.

One way to fulfill these requirements is to use a combination of compound and hydrocolloid.

Kerr's red compound is softened in a water heater (130° F.) and placed in the bottom of a water-jacketed tray (Fig. 567). The tray is placed in the mouth and

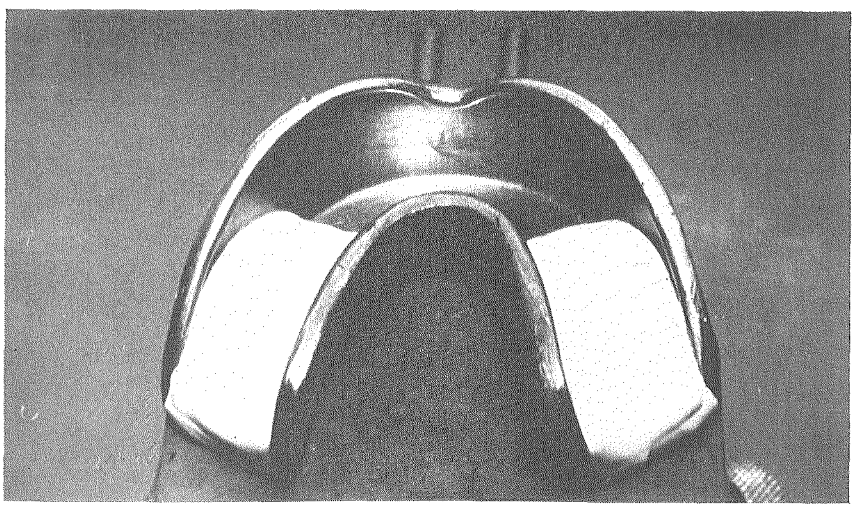

Fig. 567. Compound placed in the tray in areas where restorations are to be seated.

Fig. 568. Imprints on the compound after the first insertion.

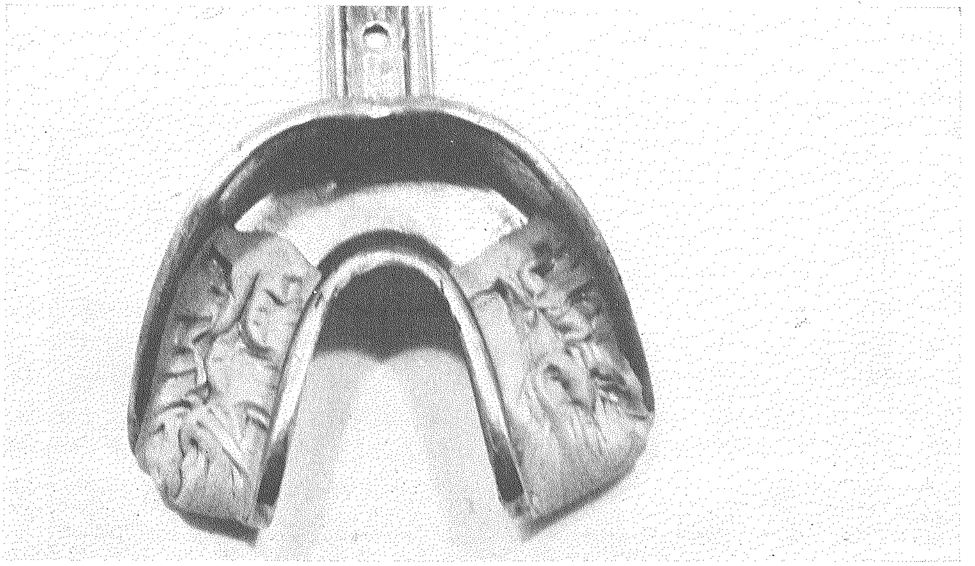

Fig. 569. While the compound is soft, it is trimmed from the unprepared teeth and folded over on itself to prevent it from locking buccally and lingually around the restorations.

then quickly removed (Fig. 568). The purpose of this insertion is to see that the compound is placed only over the areas which will come into contact with the restorations—usually the posterior segments. Trim away any compound that may cover natural teeth not involved in the restoration (usually the anteriors) and fold over the indentations of the compound if they include the proximal areas (Fig. 569). The reason for this is to have the compound only in the occlusal area so that it does not lock interproximally and create a problem when the impression is removed.

With the compound thus adjusted, heat the surface with an alcohol torch (Fig. 570). Then, into the rest of the tray and over the softened compound, place softened hydrocolloid—a thinner material than that generally used for preparation impressions (Fig. 571). The filled tray is immersed in a water bath at 110° F. for 30 seconds. During this brief interval, check to see whether all the restorations are home, tapping them with an automatic mallet to make sure. The patient, meanwhile, is not permitted to close the mouth lest something should happen to dislodge any of the restorations. Now seat the tempered impression firmly to place and chill it thoroughly. The entire impression must be so well chilled that there is no possibility whatsoever of a warped area in the compound. With 70° F. water running freely through the jacket tray, this should be accomplished in 5 minutes. In any event, 5 minutes is the minimum time one should allow for chilling.

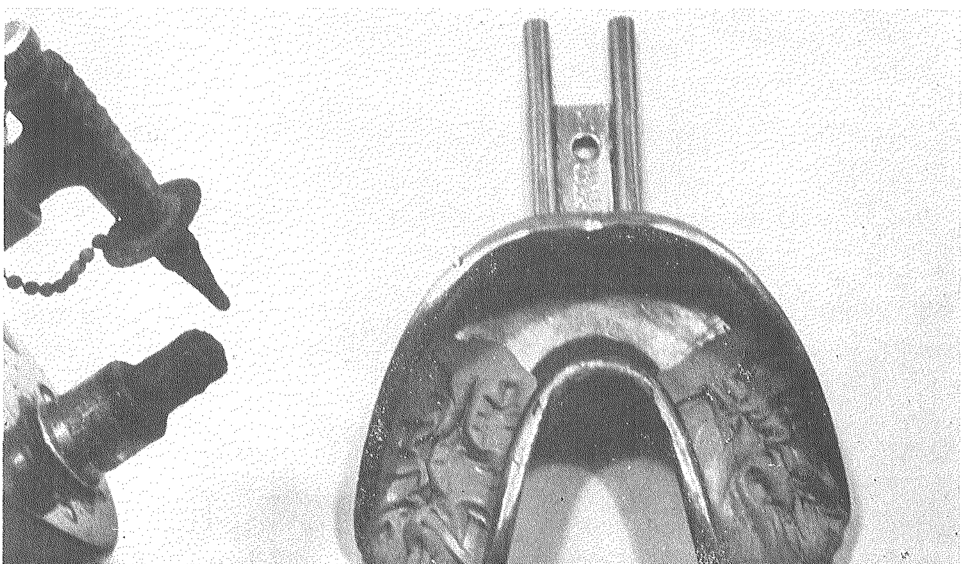

Fig. 570. The surface of the compound is softened with an alcohol torch.

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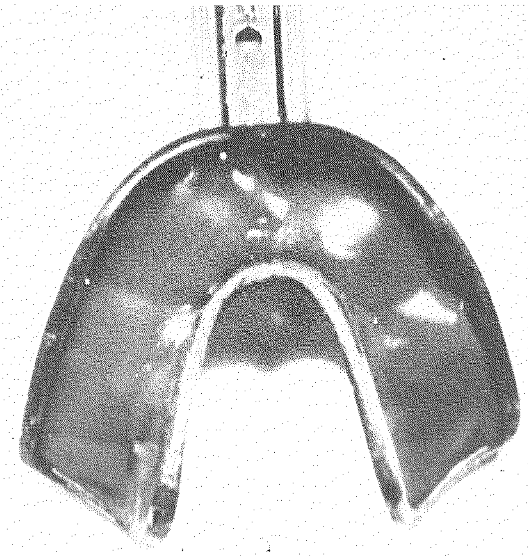

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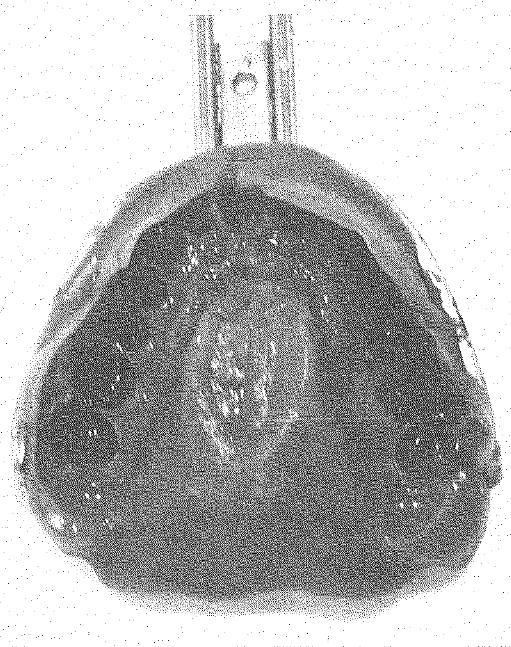


Fig. 571. Softened hydrocolloid (Kerr's Deelastic) is placed in the tray over the softened compound.
Fig. 572. A compound and hydrocolloid remount impression removed.

The impression is removed and examined (Fig. 572). Usually some restorations will come out with the impression, and the others will remain on the teeth. The compound should show through the hydrocolloid, offering a very definite seat for the restorations. Carefully place the restorations in their proper seats and check the ones that came out with the impression to make sure that they are seated against the compound and not just half-suspended in position. The impression is now ready to be poured.

MAKING THE REMOUNT CAST

The way the impression is handled is important. In addition to one's personal preference, certain conditions will determine the type of materials to be used in making the cast.

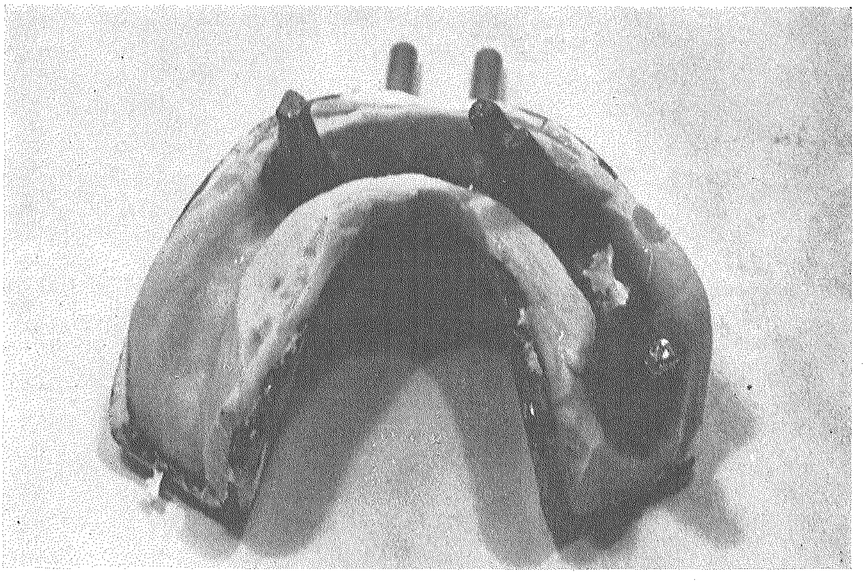


Fig. 573. Dies waxed to place in the remount impression.

If the restoration consists of abutments for bridgework or requires any soldering operations, it may be wise to place dies in the restorations involved (Fig. 573). If metal dies are not used, the transfer dies can be made by pouring die metal into the restorations before the remounting procedure is attempted. The purpose of the metal dies is to permit the restorations to be returned to the cast after soldering.

If dies are used, pour the cast in stone after lubricating the dies. If no dies are used, pour the cast with a low-fusing metal like Cerro-Low 117* or S. S. White No. 160.† Cerro-Low 117 is very accurate because of its low melting point. If poured into the hydrocolloid section of the impression, it will give strong anterior teeth which will not break during the subsequent procedures of adjustment. With this material, however, we must be careful not to use warm water or in any

*Belmont Smelting Works, Brooklyn, N. Y.
†S. S. White Dental Manufacturing Co., Philadelphia, Pa.

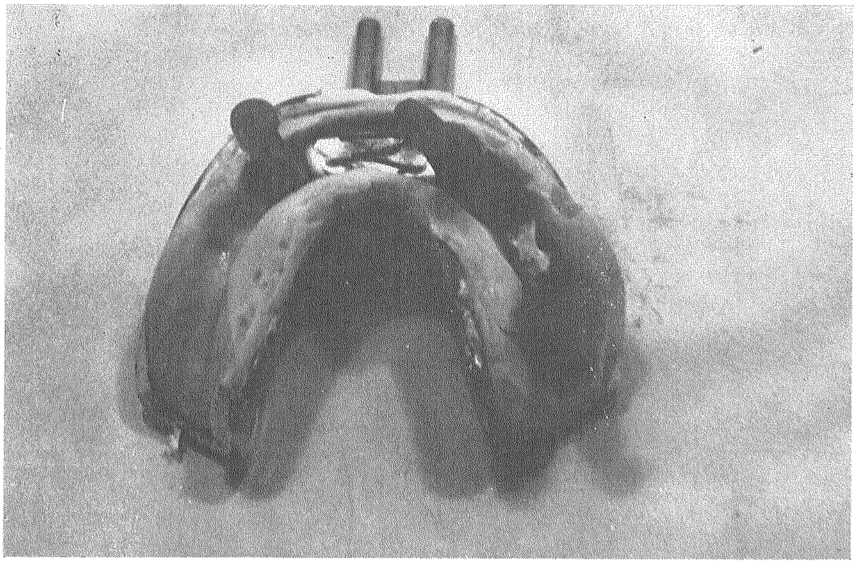


Fig. 574. Unprepared teeth poured in low-fusing metal.

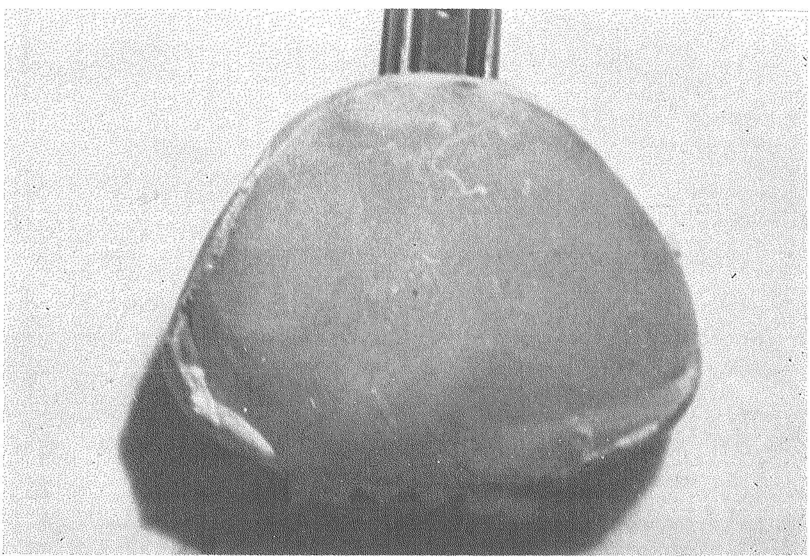


Fig. 575. Cast stone poured around the dies and into the retention loops in the metal portion of the cast.

other way raise the temperature above 117° F.; otherwise, the cast will be lost. S. S. White No. 160 is a safer low-fusing metal to use. It is wise to place a thin film of wax in the proximal areas to facilitate removal of the restorations from the cast. In order to reduce the weight of the cast, only the tooth portion of the

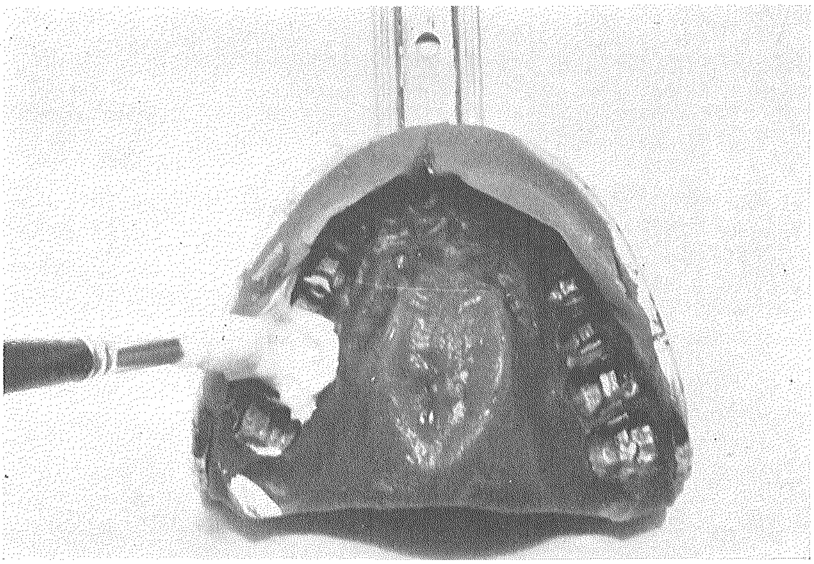


Fig. 576. Painting the stone in a remount impression.

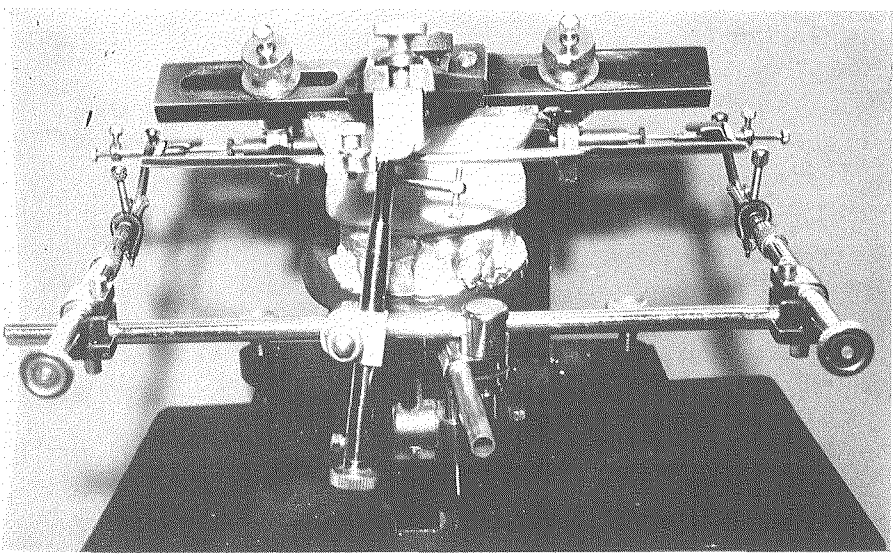


Fig. 577. Face-bow relating the upper remount cast to the upper bow of the articulator by means of the mounting frame.

impression is poured in metal (Fig. 574). The remainder of the impression is poured in a good cast stone after retention has been established by bent pieces of paper clips fused in the metal (Fig. 575).

If no soldering is anticipated, it is possible to pour the entire impression in

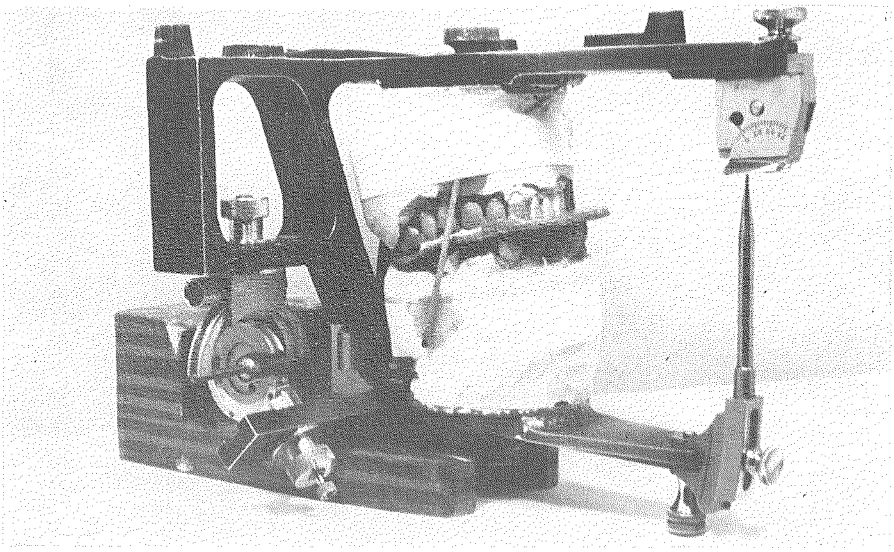


Fig. 578. The lower remount cast related by means of the centric interocclusal record.

a good cast stone, but make sure that the restorations do not move during the pouring. This can be prevented by taking a thin mix of stone and painting it into the restorations with a brush (Fig. 576).

When the casts have thoroughly set, remove the tray and impression material with a steady pull, remembering to avoid immersion in warm water if Cerro-Low 117 metal has been used. Generally, they will separate very easily.

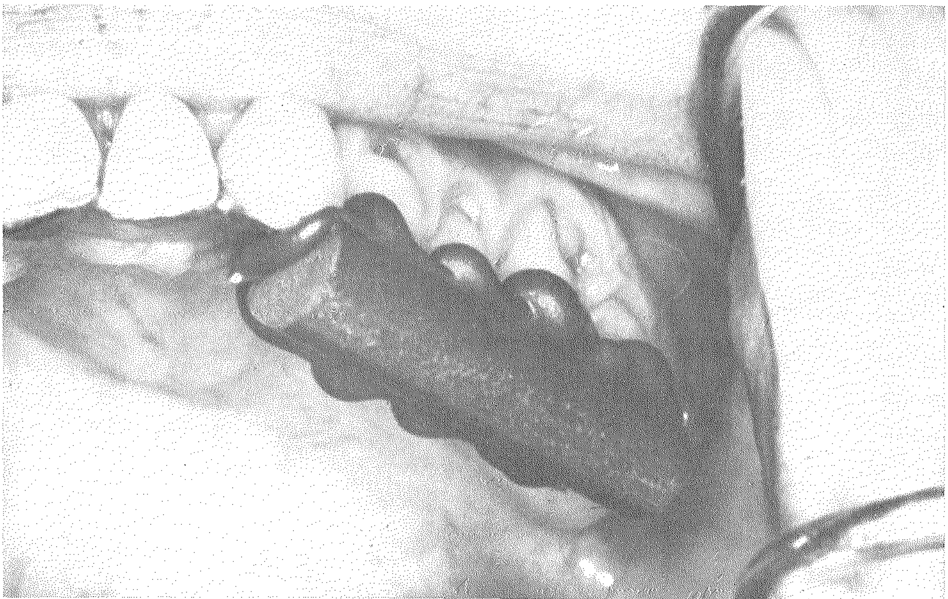
After the casts (containing the restorations) are trimmed, the upper cast is mounted on the articulator by means of the face-bow transfer. It is held in place by the mounting frame and is fastened to the articulator with a good cast stone—*never* plaster (Fig. 577). The articulator is set according to the records previously taken. When the stone attaching the upper cast to the articulator has set, position the lower cast against the upper by means of the centric interocclusal record and then attach the lower cast to the lower member of the articulator, making sure that the articulator is in centric position before the stone sets (Fig. 578).

The next step is to examine and adjust the articulation.

SPECIAL CONSIDERATIONS IN REMOUNTING

Before that phase of the procedure is discussed, however, there are some very important points to be considered.

When individual teeth are extremely loose, it is necessary to exercise additional care and precaution. It is essential that the teeth be captured in their normal position, not displaced in any direction. This is sometimes difficult to do. One method is to temporarily tie the restorations interproximally with quick-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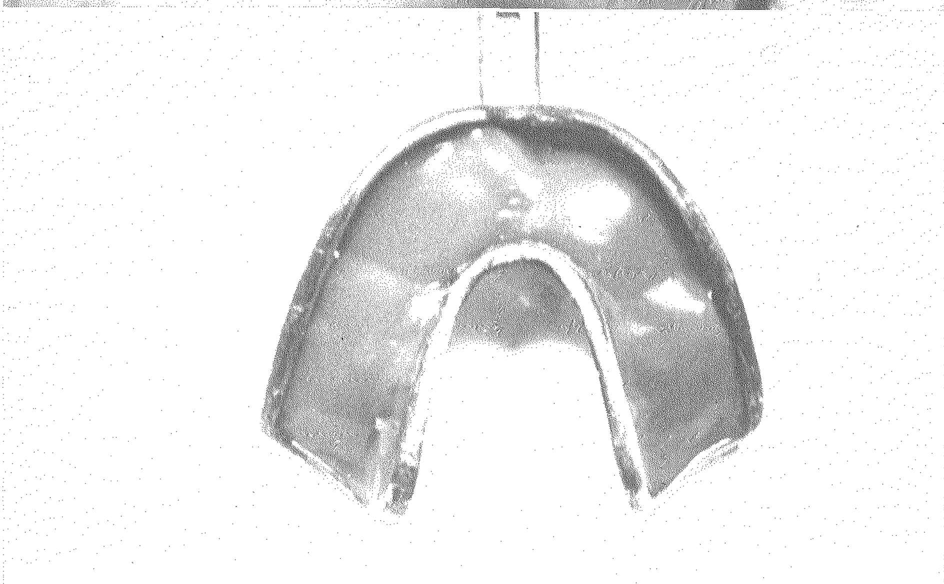
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Fig. 579. Compound stick on the teeth.
Fig. 580. The tray filled with hydrocolloid prior to being seated over the compound sticks.

curing acrylic. This will tend to stabilize the teeth while the centric relation record and the remount impression are being taken. Care in seating the impression tray must also be observed, and here is a possible dilemma. We want to get through to the compound; yet we must not displace the teeth. One practical measure is the use of a piece of stick compound, carefully heated on one side and very carefully placed on the dried occlusal surfaces of the restorations (Fig. 579). Here again, care must be taken not to displace any of the teeth. If this procedure is followed, a definite seat in the compound strip will be obtained. However, the compound stick must not be dislodged when the impression tray is placed in position. In this instance, the tray is filled only with heavier hydrocolloid, such as Surgident* (Fig. 580).

Another possible way of handling this situation is to use a specially prepared impression plaster. Because of the inaccuracy of plaster due to its expansion, this is the least desirable method. Still, if it overcomes the displacement problem, it may be the lesser of two evils.

Zinc oxide and eugenol impression paste in a custom-made self-curing plastic tray will also enable the restorations to be related without displacement of movable teeth.

It should be obvious why there is such concern over tooth displacement when individual teeth are mobile. The end result would be exactly the opposite of not having a restoration properly seated on its tooth. After adjustment, the relationship in the mouth would not be the same as that established on the articulator. A displaced loose tooth will never tighten up to the position from which it was displaced because it will be constantly traumatized. Before it can tighten up, it must be stabilized. A displaced loose tooth will be *in premature contact* after the restoration is adjusted; a restoration that is not properly seated on the tooth will be *out of occlusal contact* after it is adjusted.

OTHER USES FOR THE REMOUNTING PROCEDURE

There are other circumstances in which a modified type of remount technique is extremely helpful. If we wish to work with metal dies and copings, the remount impression technique is adequate to produce a very accurate working model (Fig. 581).

In the case of removable partial dentures, the relationship of the base to the abutment teeth can be established very nicely by means of a coping, a quick-setting acrylic, and a remount impression utilizing compound and hydrocolloid. This will produce an accurate representation of the rest of the teeth for purposes of articulation and contouring.

As an example, let us consider the construction of a lower bilateral precision attachment appliance against natural upper teeth. Before the face-bow transfer and centric relation record are taken, the lower base is placed in position. The copings for the lower abutment teeth are then positioned. These copings may have distal extensions for attachment to the base. The base has self-curing acrylic rims in the edentulous areas which are at approximately the level of the occlusal plane. With powder and liquid quick-curing acrylic, fasten the coping extension to the acrylic occlusion rim on the base, making sure that the copings are

*Surgident, Ltd., Los Angeles, Calif.

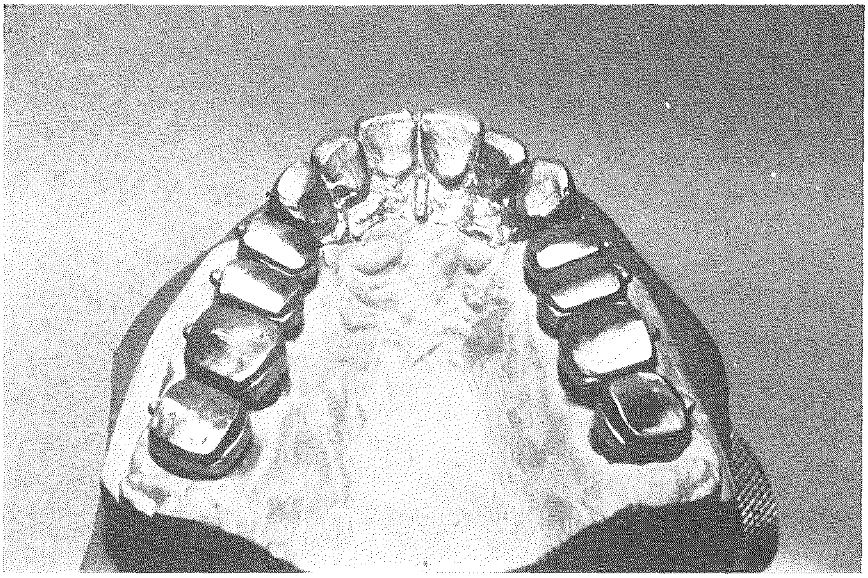


Fig. 581. The working cast with dies and copings.

seated on the teeth and the base properly seated on the tissue. When the quick-curing acrylic has set, there will be a rigid attachment in proper relationship of the base to the prepared teeth.

The working casts can now be mounted. The upper cast may be a stone cast of the prepared teeth or may consist of dies and copings. After making the face-bow transfer for mounting the upper working cast and then obtaining the centric relation record, take a remount type of impression of the lower jaw. This will give a working cast of the prepared abutment teeth properly related to the removable base. On these casts the final appliance can be carved (Fig. 582).

It is wise, after casting the abutment restorations, to relate these castings again to the base before final soldering of the attachments. This will correct any slight inaccuracy in the fit of the abutment restorations. It is an additional minor step, but a worth while one.

If porcelain jackets or anterior veneers are involved in a restoration and if these are constructed after the posterior restorations are adjusted, the tray for remounting the anterior segment is prepared as in Fig. 583.

When the entire arch is involved, as in Fig. 584, the compound is placed in the water-jacketed tray as shown.

When we are dealing with edentulous areas which are going to be treated by a fixed prosthesis, and individual dies are used, the following procedure is helpful. Copings are made with a gold sprue extension into the edentulous area. If a large area is involved between two abutment teeth, one projection is extended from each coping. Place these copings on the teeth and unite the projections with

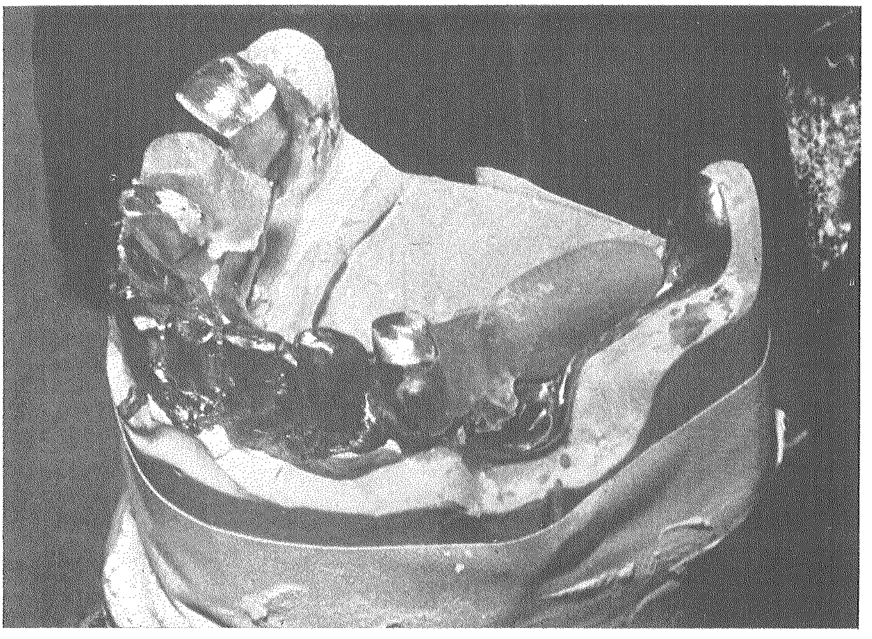


Fig. 582. The lower master cast—base, metal dies, and copings.

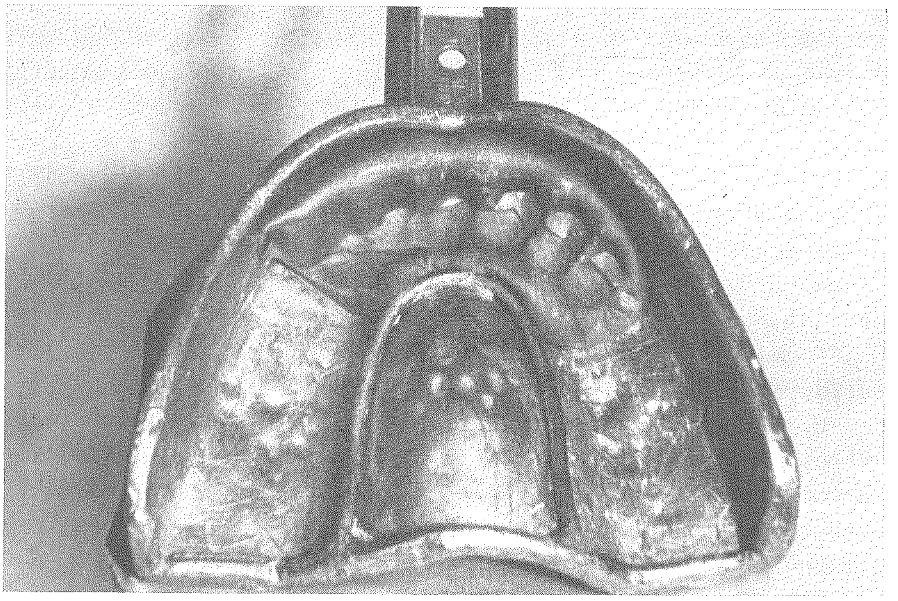


Fig. 583. The tray prepared for the anterior segment remount.

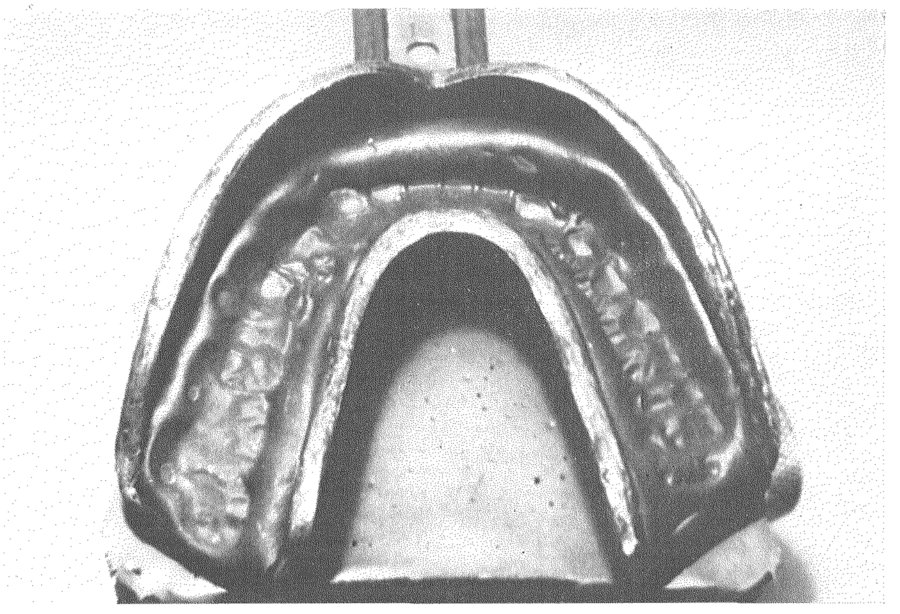


Fig. 584. The tray prepared for an appliance in which the entire lower arch is involved.

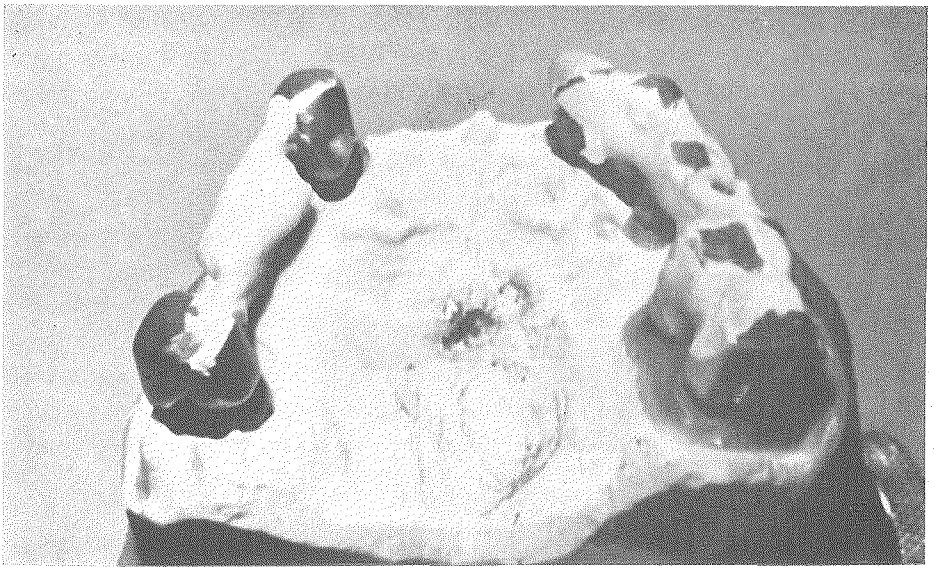


Fig. 585. Quick-curing acrylic used to unite the copings with the extensions into edentulous areas.

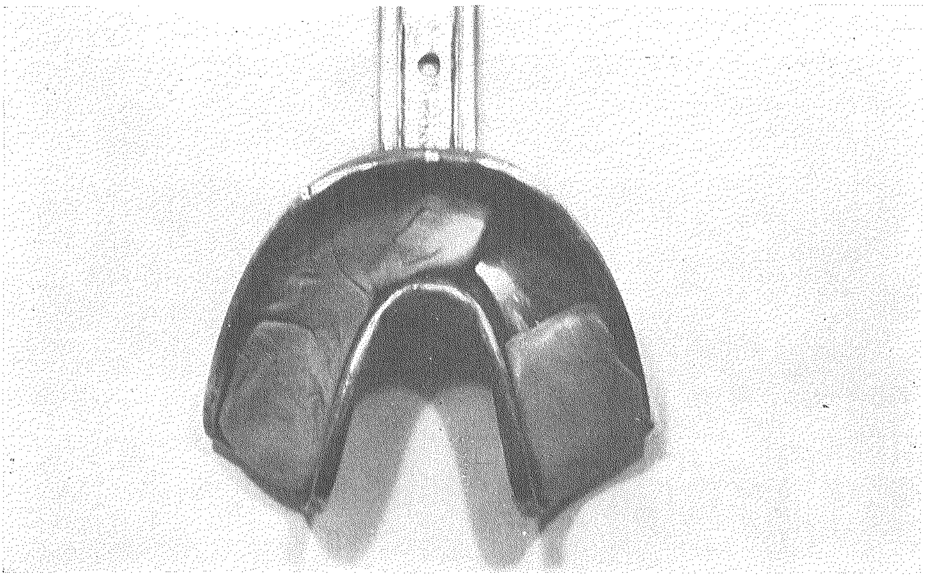


Fig. 586. The tray prepared for the remounting of the restorations, with the compound removed from the area where the restoration is to be remade.

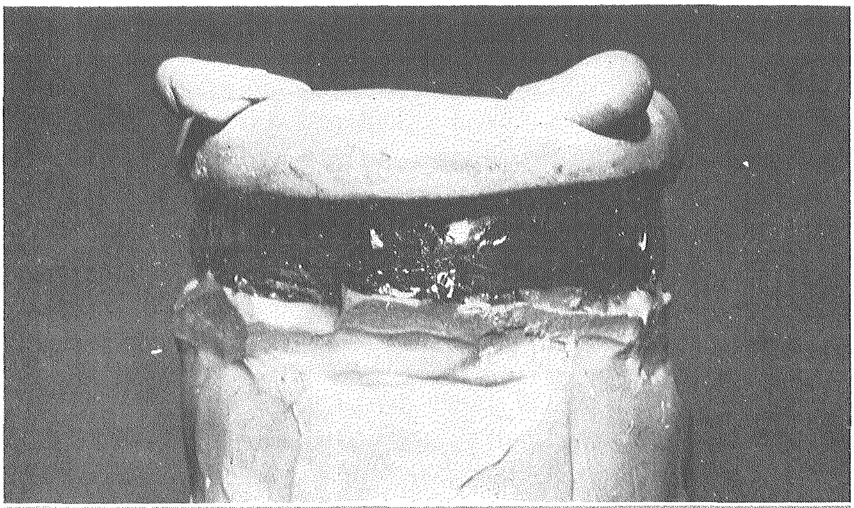
quick-curing acrylic (Fig. 585) and then proceed with a combination compound and hydrocolloid impression as described earlier.

Occasionally it becomes necessary to remake a restoration because of improper fit or a change of preparation. If such is the case, it usually happens at the remount stage of the reconstruction. Proceed as described for the regular remount, with this exception. Remove the compound in the tray from over the area of the tooth for which the restoration has to be remade (Fig. 586). The other restorations are properly seated. The compound in the tray over the restorations to be remounted is heated as before, and hydrocolloid is placed in the tray. (In this case Surgident is used because the primary interest is in getting a good impression of the tooth to be restored.) While the material in the tray is being tempered, dry the preparation and inject some softened hydrocolloid into the preparation as for a master impression. Then seat the tray over the teeth and chill thoroughly. When the tray is removed, there should be an impression in which all the restorations can be seated, as well as an accurate impression of the prepared tooth. This impression is poured in die stone.

ZINC OXIDE AND EUGENOL REMOUNT PROCEDURE

In a patient with critical periodontal disease, one must take advantage of every possible factor. Where there are several teeth which can be depressed in their sockets, it is necessary to change the remount procedure slightly. Such teeth must be recorded in their passive position; otherwise they will never tighten up.

When confronted with this situation, take a couple of quick impressions of



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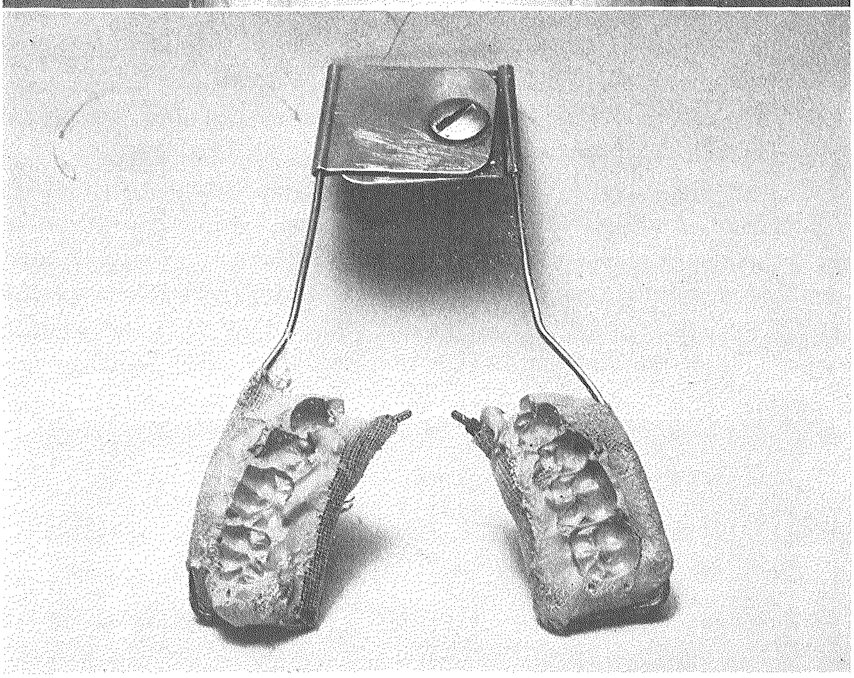

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Fig. 587. Quick-cure plastic tray for the remount procedure, with zinc oxide and eugenol paste as the impression material.
Fig. 588. Gauze, zinc oxide, and eugenol centric interocclusal record.

the reconstruction in place, using alginate material for this purpose. On the casts from these impressions construct special trays of quick-curing plastic (Fig. 587). The teeth are first covered with two layers of Tenax* wax; after which,

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*S. S. White Dental Manufacturing Co., Philadelphia, Pa.

tin foil is adapted over the wax. The tray material, flattened into sheet form, is adapted over the teeth to cover the occlusal surfaces and one third of the buccal and lingual surfaces. This is done around the anterior teeth as well. When the material is set, the trays are trimmed and are ready to be used with a zinc oxide and eugenol paste for the remount impressions. The casts will not be so attractive as the compound and hydrocolloid combination but will serve this particular purpose more efficiently.

With this critical type of remount, zinc oxide and eugenol paste must be used throughout the procedure. After adapting the compound to the face-bow fork and having the patient close the teeth into it, as is normally done, reline the maxillary portion of the compound with the paste and gently hold the fork in place until the paste has set. This will give an accurate imprint of the upper teeth in their undisturbed position (Fig. 563).

A gauze, zinc oxide, and eugenol record is now taken, as described in Chapter 7. This sandwich is carried into position by means of a wire frame, and the patient is instructed to close the jaw carefully in the terminal hinge position. The tip of the thumb is used as an anterior stop to steady the patient's jaw until the paste has set. This again will give an accurate relationship of the restorations in a passive position (Fig. 588).

We are now ready to take the remount impression from which the remount cast will be made. A mix of zinc oxide and eugenol paste is applied to the occlusal surface of the tray—just deep enough to reach all the restorations without going over the contours. Interest is in the articulating surfaces only. The loaded tray is carefully carried to place and gently vibrated so that the paste contacts the restorations. No pressure of any kind is required. Care must be taken to place

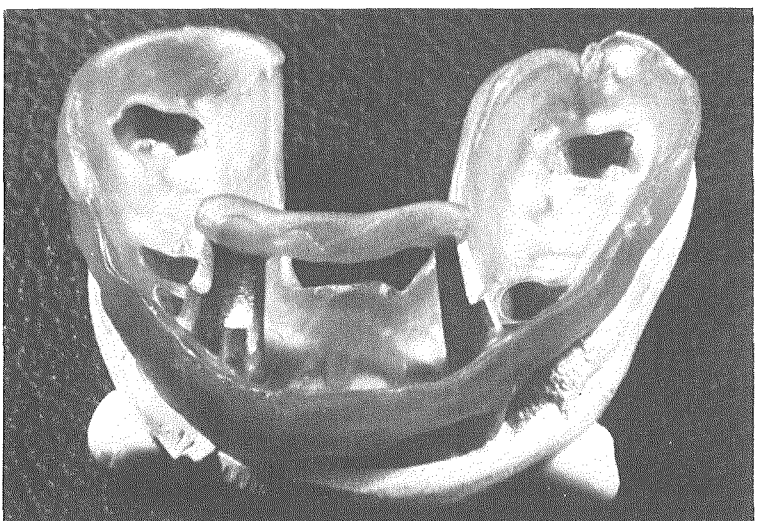

Fig. 589. Zinc oxide and eugenol remount impression prepared for pouring.

the tray accurately in order that the short flanges will not displace any of the teeth. After the material has set thoroughly, the tray is removed, and the same procedure is repeated for the lower impression (Fig. 589).

These impressions are so accurate that great care must be taken in placing the restorations in their seats. It may be necessary to remove some of the interproximal edges of paste.

When all the restorations are positively seated, the casts are made as previously described, using Cerro-Low 117, S. S. White No. 160, or stone.

If a restoration has not been properly *seated in the impression* and if the appliance is adjusted (as described in Chapter 20), it will be found when the appliance is returned to the mouth that the restoration which was improperly seated in the impression is the only one that comes into contact. It is grossly premature. The following example will serve to clarify this.

If an upper bicuspid is not completely seated in the remount impression, this means that it is slightly above the occlusal plane in relation to the other restorations. When the articulation is adjusted, the other restorations will be ground (or the short bicuspid added to). In each case, all the restorations will be functioning properly on the articulator. But, when the restoration is tried in the patient's mouth, the bicuspid that was not seated in the impression now assumes its normal position on the tooth, and the restoration is in premature contact.

This is exactly what happens when a tooth is displaced in its socket while the other type of remount impression is being taken. The depressed tooth—assuming it is an upper tooth—will be above the plane of occlusion. When adjusted to the rest of the articulation and returned to the mouth, it assumes its natural position, and the restoration is in premature relationship. This causes a constant pumping of the tooth in its socket, and it will never tighten up. Only when the articulation of the restorations stabilizes the teeth in their natural position will they become firm again.

Sometimes single restorations may be found to be short or out of articulation with the opposing surfaces. There are two possible reasons for this.

First, this can happen if the tooth is periodontally involved, and there is a considerable time lapse between the making of the remount casts and the adjustment and the return of the restoration to the mouth. During that interval, the tooth can settle down in the socket, with a thinning of the periodontal membrane; consequently, the restoration will be short. This must be corrected by another remount. Situations like this have occurred even when teeth have been temporarily splinted together.

Another reason for a restoration to be short of occlusion is an improper compound and hydrocolloid remount impression. Sometimes a film of hydrocolloid is interposed between the restorations and the compound in the tray. If this thin film of hydrocolloid is lifted or displaced, a restoration that is seated too deeply in the impression will result. The restoration will be overground in the adjustment procedure and will therefore be short in the mouth.

THOMAS'S REMOUNT PROCEDURE

Recently, a method of remounting was demonstrated to me by Dr. Peter K. Thomas of Los Angeles which embodies the various principles of the techniques I have described and has some positive features of its own.

1. No heat is involved in the over-all impression; thus the possibility of compound core warpage is minimized.
2. A very definite and accurate seat for the restorations is always obtained.
3. There is never any flexible impression material between the compound core and the restorations.
4. Loose teeth can be registered in their undisturbed position.
5. An accurate reproduction of the unprepared teeth and adjacent tissues is possible.

In short, all the advantages of all the other remount methods are found in this one technique.

This technique can be used for most remount impressions. The only exception might be when a restoration has to be remade while the other restorations are remounted. Here, the compound and hydrocolloid procedure might be better.

After an accurate face-bow transfer (zinc oxide and eugenol surface on compound face-bow fork, as in Fig. 590, with only cusp tip imprints present) is obtained, the centric interocclusal records are taken. When the accuracy of these records is satisfactory (Fig. 591), the remount impressions are taken.

Let us assume that all the posterior restorations are seated and that there are natural anterior teeth without restorations. A piece of wire (either a heavy paper

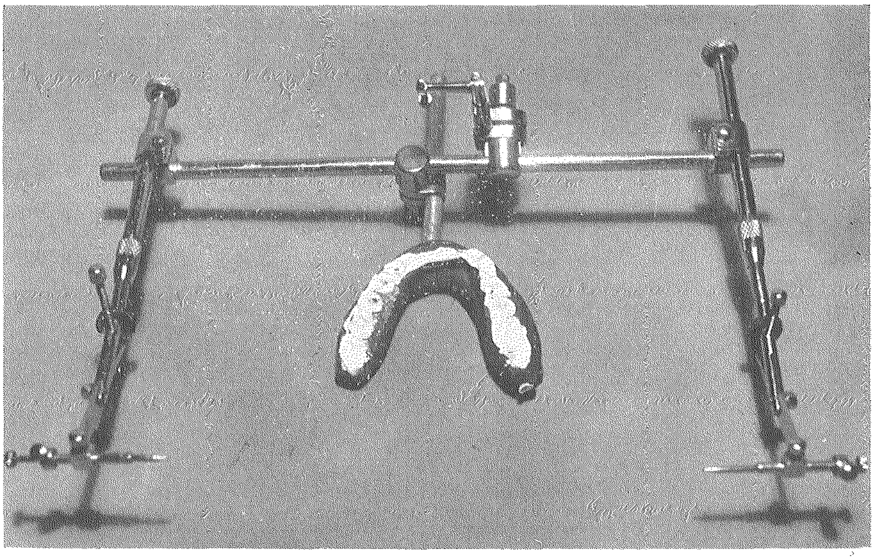

Fig. 590. Zinc oxide and eugenol paste on the face-bow fork.

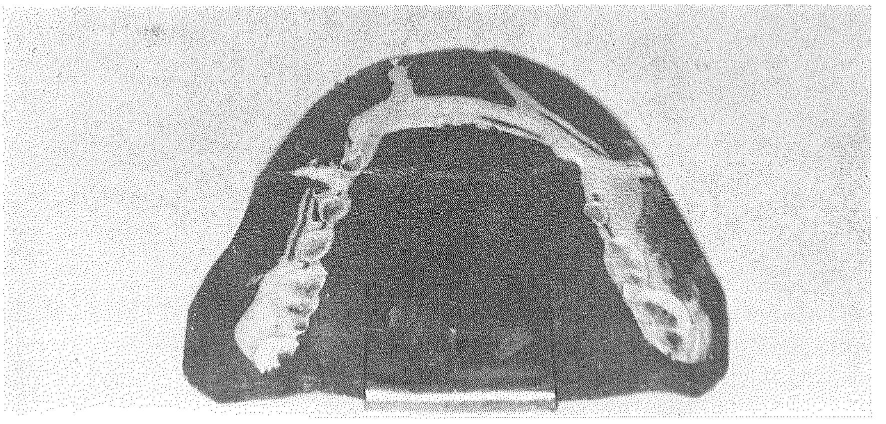

Fig. 591. Centric interocclusal record.

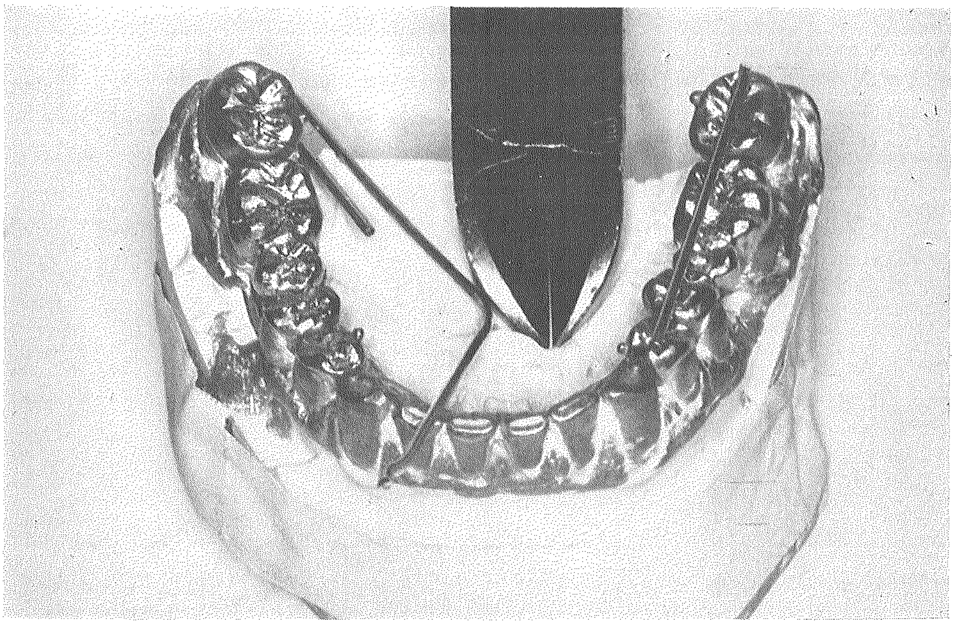

Fig. 592. Heavy paper clip cut the length of the restored areas in each quadrant.

clip or a piece of thin coat hanger wire) is cut to extend over the occlusal surfaces of the posterior restorations on one side (Fig. 592). This wire is to be a reinforcement for the compound core. Softened compound is placed around the wire and seated over the restorations (Fig. 593), care being taken not to displace the restorations or the teeth. When the compound core has hardened, it is removed and carefully trimmed. The sides of the core are trimmed so that only a slight overhang is left to serve as a guide in reseating the core onto the restora-

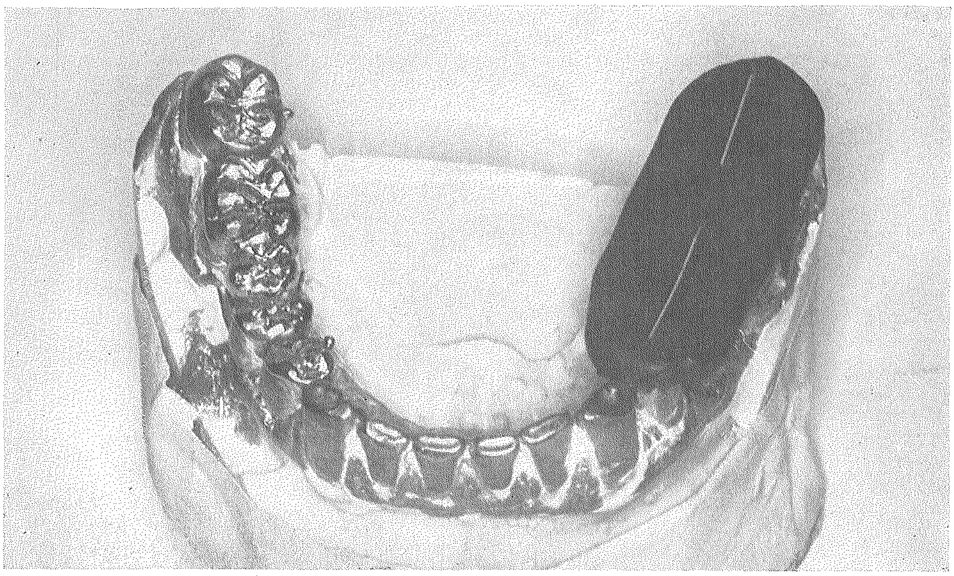

Fig. 593. Wire is imbedded in the softened compound to reinforce the core.

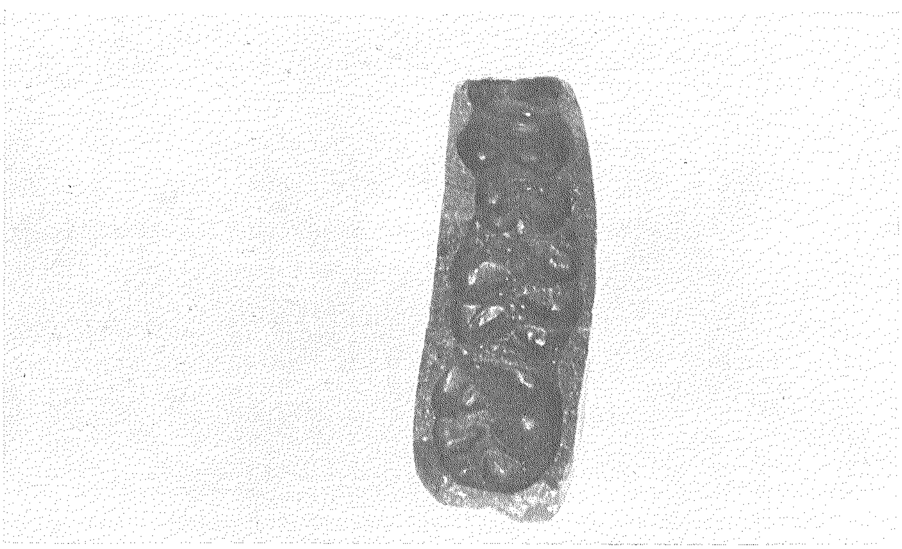

Fig. 594. The core is trimmed of all excess.

tions. The core is thinned so that it will not be too bulky, and several notches are cut into the sides (Fig. 594). These notches will be useful as keys should the core have to be seated in the over-all impression soon to be taken. A similar core is made for the opposite side of the mouth, and the cores are marked to indicate the mesial and right and left sides.

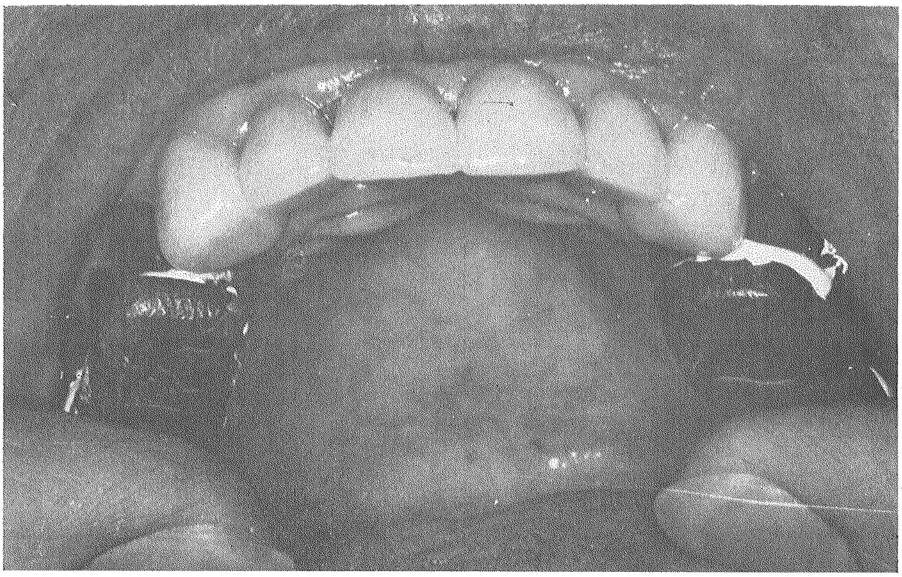

Fig. 595. Zinc oxide and eugenol paste, such as Kydac, is applied to the core to ensure a more accurate impression medium.

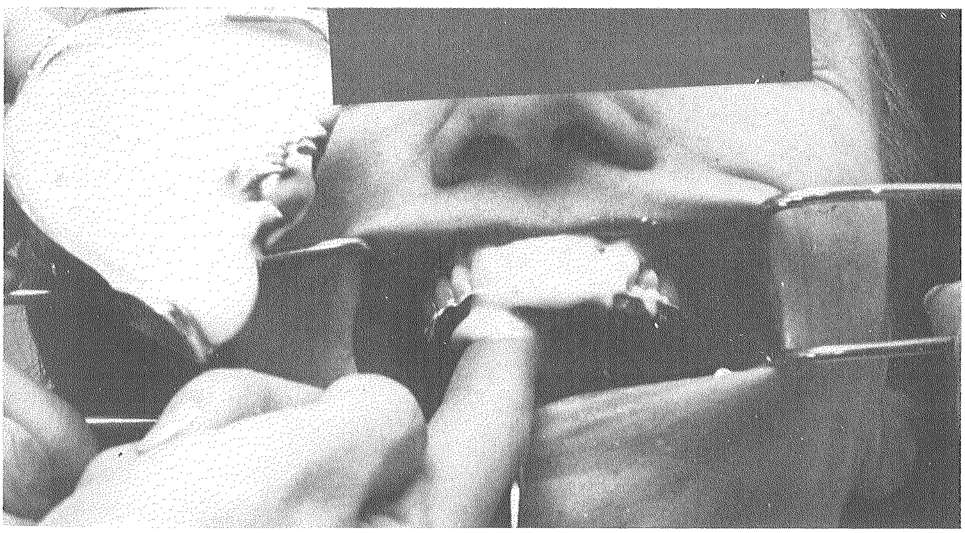

Fig. 596. Alginate in the tray and swabbed over the anterior teeth to eliminate the trapping of air.

A rim lock tray is selected which will fit over the compound cores and which is large enough to record the anterior teeth as well.

A small amount of zinc oxide and eugenol paste, such as Kydac, is mixed and applied to the dried compound cores. The cores are then carefully seated in their respective quadrants and held lightly in place until the paste has set (Fig. 595).

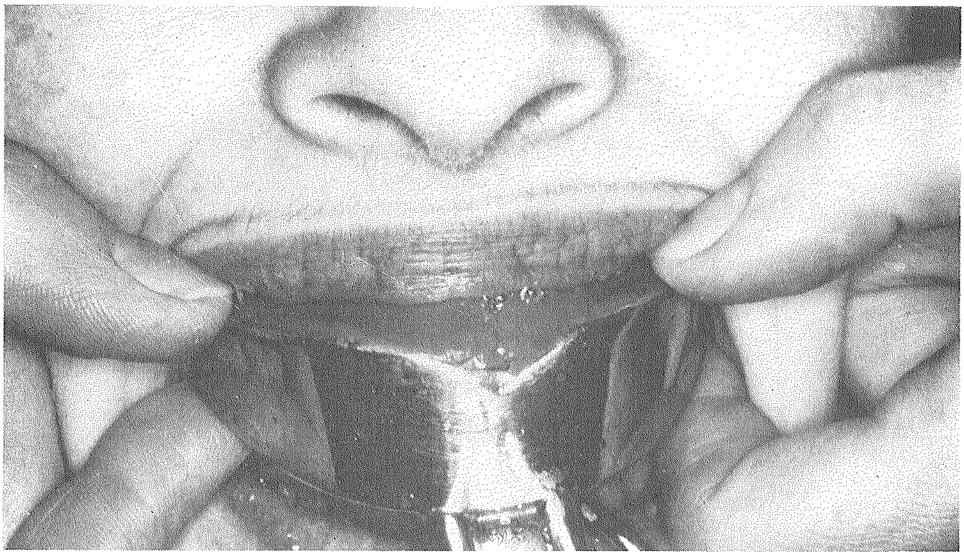

Fig. 597. Position of the fingers during tray removal to minimize distortion.

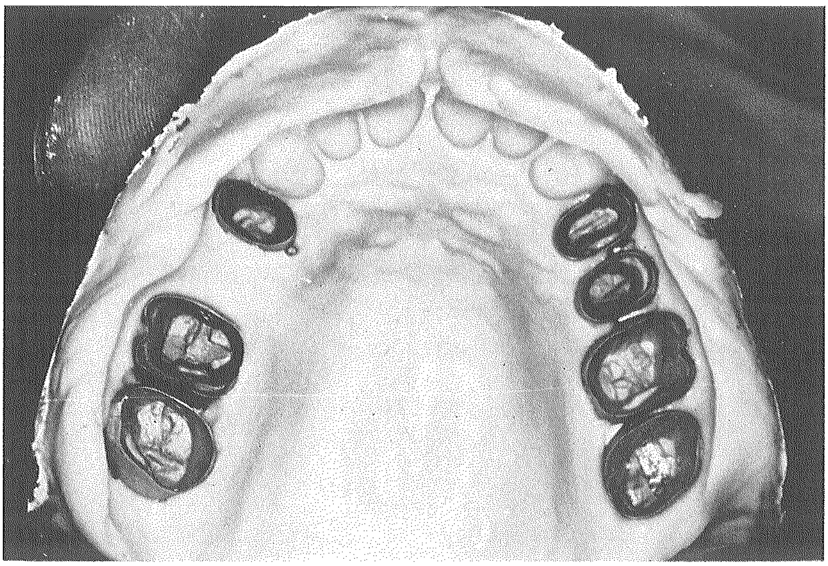

Fig. 598. The remount impression.

Alginate material, such as D/P,* is carefully mixed with a mechanical spatulator and under vacuum, then packed into the rim lock tray, and placed over the compound cores and anterior teeth. It is advisable to apply a small amount of the alginate to the anterior teeth with the fingers to reduce the possibility of trapping any air (Fig. 596). The positioned tray is held in place for 3 minutes

*Dental Perfection Co., Inc., Glendale, Calif.

to ensure complete setting of the impression material. The tray is removed by applying pressure on the *sides* of the tray, *not the handle* (Fig. 597). Usually the cores and restorations will come out in the alginate impression although some of the restorations may remain on the teeth. These are removed and placed in their respective positions. There are definite, clear-cut imprints of zinc oxide and eugenol paste into which the restorations can be accurately seated (Fig. 598).

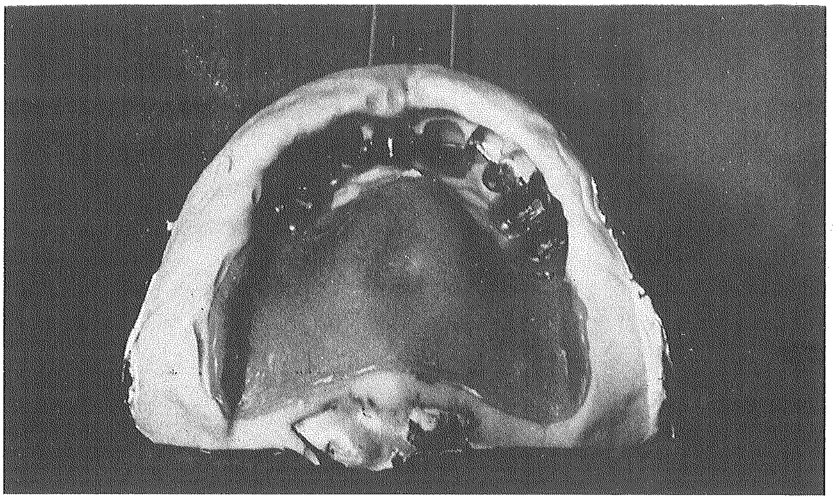

Fig. 599. View of another appliance showing wax placed between the restorations to hold them in place and to facilitate their removal after the adjustment is completed.

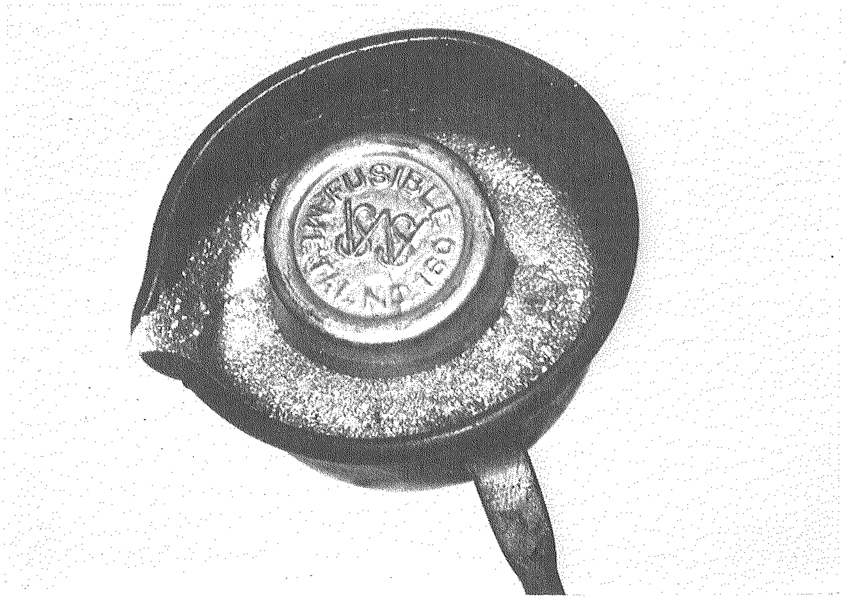

Fig. 600. Low-fusing metal softened in water-filled ladle.

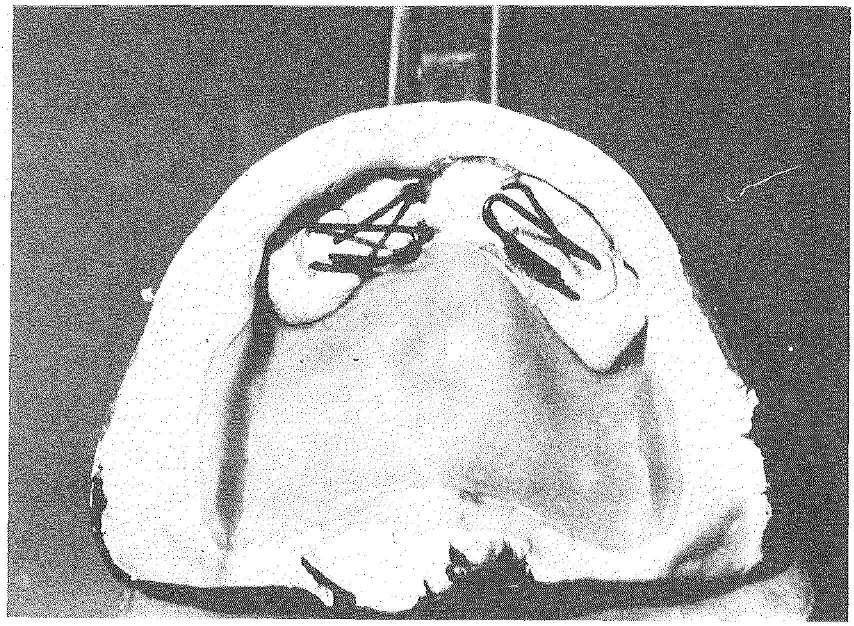

Fig. 601. Paper clips used for retention loops.

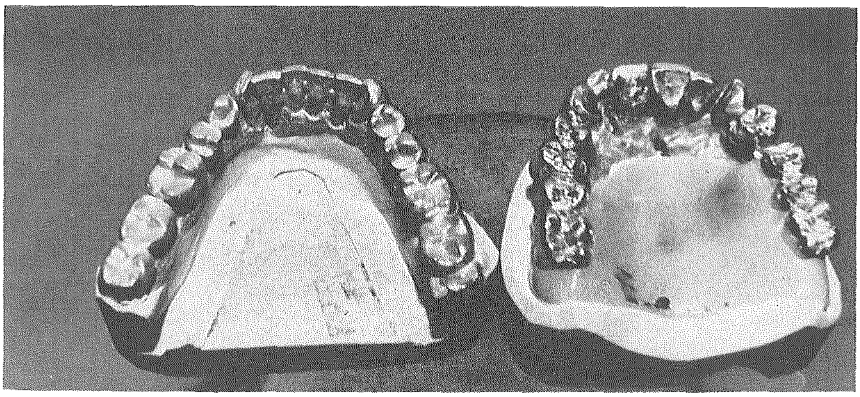

Fig. 602. Completed casts.

Sometimes one or both of the cores may remain on the teeth. This is not desirable, but if keyways have been cut in the cores, it is usually possible to replace the cores in the alginate with sufficient accuracy.

The method of producing a remount cast from the remount impression is extremely important.

The restorations are checked to verify that they are all in their definite seats. Melted Tenax wax is carefully applied interproximally to seal the restorations to each other to prevent their dislodgement when the cast is poured (Fig. 599).

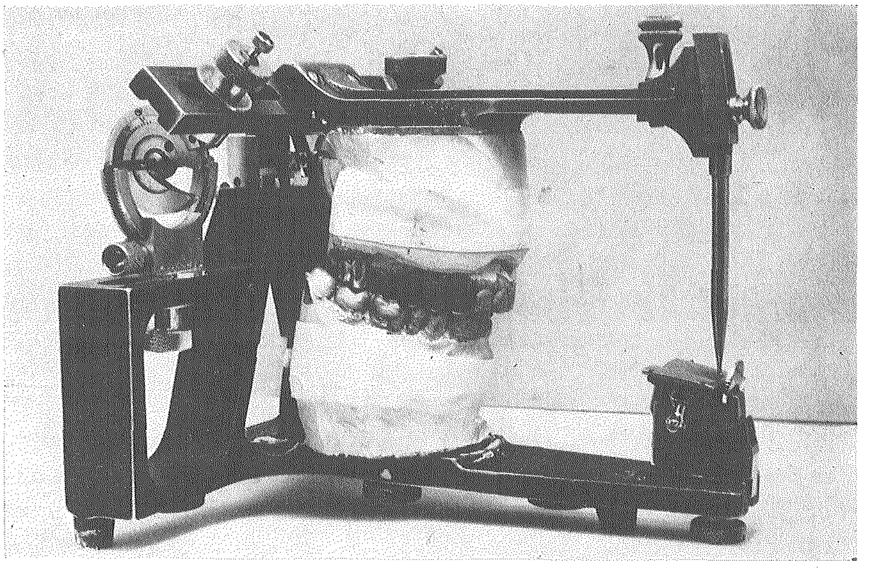

Fig. 603. Mounted casts.

This also facilitates their removal after the remounting procedures are completed and the restorations have to be returned to the mouth. S. S. White No. 160, a low-fusing metal, is melted in a water-filled ladle (Fig. 600) (water will prevent the metal from overheating). When the metal is softened, the water is blotted out of the ladle, and the molten metal is carefully poured into the impression—filling the restorations and the impressions of the anterior teeth. Retention loops are placed in the soft metal and are held there until the metal freezes (Fig. 601). The cast is completed by pouring a good cast stone, such as Vel-Mix,* into the retentions and forming a base for the cast (Fig. 602). When the stone has set for 35 minutes, the impression is removed, and the remount cast is examined for accuracy.

The opposing remount impression and its subsequent remount cast are handled in the same manner.

If these procedures have been carried out carefully, the upper remount cast should fit into the face-bow fork indentations with extreme accuracy, and the lower cast should fit exactly into the imprints of the centric interocclusal record. These are the tests for determining the accuracy of the remount impressions and casts.

The casts are now mounted on the articulator, and the restorations are examined and corrected to perfect the articulation (Fig. 603).

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*Kerr Manufacturing Co., Detroit, Mich.

CHAPTER 20

Refining the articulation after remounting

After the finished restorations have been accurately related to each other and to the oral mechanism by means of the remounting technique, the next procedure is to refine the articulation.

Discrepancies and their causes

The errors which are observable at this stage of the procedure may astound us. They are due in part to the inaccuracy of the materials used and to the technique necessarily employed. The cutting and transfer of wax patterns from a master cast to an individual die will create some discrepancy. The establishing of adequate contact points may alter the seating of a wax pattern on the preparation. Further error will be introduced by the investing and casting techniques.

In addition, considerable time has elapsed since the centric interocclusal record for the relation of the master casts was taken. In the interim, the patient has been wearing a temporary appliance from which some of the previous prematurities have probably been eliminated. This has enabled him to forget a bad reflex action, and he is therefore more likely to produce a better centric interocclusal record at this time. This being so, why not wait until now to take the master cast relationship? The answer is that most often it is to minimize these discrepancies. However, if a patient has to travel a considerable distance, it is not always practical to do this. An attempt to overcome this situation is made by using the trainer described in the earlier chapters, a device that enables us as much as possible to record a relationship that is close to this new position.

Also, during the interval in which the patient has been wearing a temporary appliance, the periodontally involved teeth will begin to heal and, in healing, may assume a slightly different position in the alveolar bone. This will show up as a discrepancy in the articulation that will have to be corrected. In patients with pathologically involved joints, the changes may be shocking—sometimes beyond simple correction—and it may be necessary to remake part of the appliance.

In the majority of patients, however, only careful adjustment is required for the desired results. Occasionally, it may be necessary to make slight additions by soldering to perfect an appliance. As a general rule, when the articulation is established in wax, a slight degree of opening is arbitrarily allowed, and thereby adjustment at this point is anticipated. It is easier to remove excess gold than to have to build up gold, which often will have to be done if a too nearly finished result is attempted at the wax stage.

The remounted gold restorations represent considerable time and effort, but careless adjustment at this stage could very easily nullify our labors. The procedure of refining the articulation is a delicate, painstaking operation. On its end result will depend the success or failure of the appliance.

The restorations are mounted on an adjusted articulator and examined to determine how much adjustment is necessary. The procedure for adjusting the articulation in gold is the same as that for establishing the articulation in wax—with one exception. As previously indicated, it is not so easy with gold to add a surface to a cusp which is short. It can be done by soldering, but this is difficult. So, the method is one of careful reduction of surfaces until the desired relationships are achieved.

Technique for locating prematurities

Gross interferences may be removed by sight location. We might even begin with carbon paper. Before very long, however, it will be seen that a much more accurate means of locating the prematurely contacting surfaces is required. For this purpose a very thin paste of alcohol and whiting is used, which is painted over the occlusal surfaces of the restorations and allowed to dry. When the articulator is moved through the examined excursion, the high spots will show through the whiting. Another excellent marking material—though somewhat messy to use—is rouge dissolved in alcohol. With either of these, it is frequently necessary to wash off the accumulated material and begin again. Sometimes alcohol alone can be applied to help prevent too much whiting from building up on the occlusal surfaces. However, if acrylic veneer crowns or dummies are involved, they must be protected as much as possible from the alcohol. A coating of Tectol* or mineral oil is useful for this purpose. Today, the better plastics when properly handled are more resistant to crazing. Even so, alcohol is no help to the best plastic material.

ADJUSTMENT OF THE LATERAL PROTRUSIVE EXCURSION

The correction of the articulation is begun by examination of the contacts in the lateral protrusive position (the cusps are tip to tip, and the articulator is in the full Bennett movement). This is the excursion in which the cusp height is established. This relationship must be brought into proper contact first before the adjustments in the other excursions can be made. The greatest cusp height required for any restoration is the height of the cusps in the lateral protrusive

*Cosmos Dental Products, Inc., Long Island City, N. Y.

position. Once these heights are finally set, they cannot be altered without ruining the articulation. In other words, once these cusp tips are corrected, they will in turn be used to determine the interferences in the other excursions. The adjustments hereafter will have to be made not on the cusp tips, but on the surfaces over which they will travel. The cusp tips are reduced until they are in harmony with the anterior guidance, particularly the cuspid guidance.

If, in examination of the tip-to-tip relationship in the lateral protrusive position, it is found that the prematurity is in one area, it is best to correct it by grinding an even amount off the upper tooth cusp tip and the lower tooth cusp tip. If the curve of Spee is not a gentle curve, confine the tip reduction to the member which will enhance a gentle curve. Sometimes the tooth preparation will dictate which member is to be reduced. However, this should not be necessary at the expense of a good curve of Spee because it should have been a consideration at the time of treatment planning when the preparations were determined.

ADJUSTMENT OF THE STRAIGHT PROTRUSIVE EXCURSION

After completing the lateral protrusive contacts, examine the straight protrusive excursion. The contact areas will now be between the tips of the lower buccal cusps (just adjusted) and the crest of the upper buccal cusps. The adjustment is made on the mesiodistal contour of the distal half of the upper buccal cusps.

These newly adjusted areas will in turn be tested against the mesial slope of the lower buccal cusps as they interact in the various excursions. The grinding is confined to the mesial slopes of the lower buccal cusps.

ADJUSTMENT OF THE BALANCING POSITION

The tips of the upper lingual cusps are now corrected to the tips of the lower buccal cusps (established in the first step). As the upper lingual cusp tips travel from the balancing position to centric position, they will mark the mesiolingual aspect of the lower buccal cusps.* The reduction is confined to the inner mesial aspect of the lower buccal cusps. The interacting upper lingual cusp must be preserved because its height (length) was established by the tip of the lower buccal cusp in the balancing relation.

In the remaining excursions, the distolingual aspects of the upper lingual cusps may need slight adjustment.

ADJUSTMENT OF THE WORKING OCCLUSION

In the working occlusion, the mesiolingual slopes of the upper buccal cusps are adjusted to the distal slants of the lower buccal cusps.

Mark the contacts between the outer aspect of the lower buccal cusps and the mesial and distolingual slopes of the upper buccal cusps. Reduce the outer aspect

*This is an articulator movement; actually, the reverse is taking place in the patient's mouth.

if it is premature, the mesial and distolingual slopes of the uppers having already been corrected for their other excursions.

The mesiolingual aspects of the upper lingual cusps may need some trimming as they are moved through all the functional ranges.

The lower lingual cusps are next adjusted to function with the upper lingual cusps in the working and protrusive excursions.

ADJUSTMENT OF CENTRIC RELATION

Having established all the cusp tips to articulate in all the excursions, we are now ready for the last and most important adjustment—that of centric relation.

The fossae and marginal ridges are reduced to form an even contact with the established cusps. This adjustment is very critical, for it is this relationship that will permit the reduction of lateral stresses and make possible the transmission of chewing stresses to the long axes of the teeth.

It may be necessary to retrace some of the steps in order to make sure that there are good cusp-to-marginal ridge and cusp-to-fossa relationships. In other words, if the contacts for holding centric relation are not present, the slopes of the cusps may have to be altered until this condition is corrected. All other excursions may be slighted to make centric relation more accurate.

In the refined articulation in the working occlusion, the sides of the lower buccal cusps should ride on the marginal ridges of the upper teeth, and the sides of the upper lingual cusps should ride on the marginal ridges of the lower teeth. In the molar areas, of course, the corresponding cusps should ride on the sides of the fossae of the opposing teeth.

CORRECTION OF A PRACTICAL APPLIANCE

The preceding description has been offered as a review of a procedure for carving the articulation in wax, with its correlation to the refining of the gold restorations. However, it should be obvious that, in practice, the various steps cannot be followed exactly as they have been outlined. There may be interferences in areas other than the ones being examined which will prevent following this step-by-step procedure, whereas in the wax, only the preceding steps had been completed, and they could not interfere. In practice, the steps are actually combined, and both sides are adjusted simultaneously. Nevertheless, the basic principles governing the wax carving and the refining of the gold restorations are the same, and the end result should be identical.

On a practical appliance, then, the marking medium of alcohol and whiting are applied to the upper and lower occlusal surfaces. The alcohol will evaporate quickly, leaving a thin white covering over the occlusal surfaces.

Adjustment of lateral protrusive excursion

Now move the articulator to the lateral protrusive position—first one side and then the other—and make sure that the articulator is in the full Bennett move-

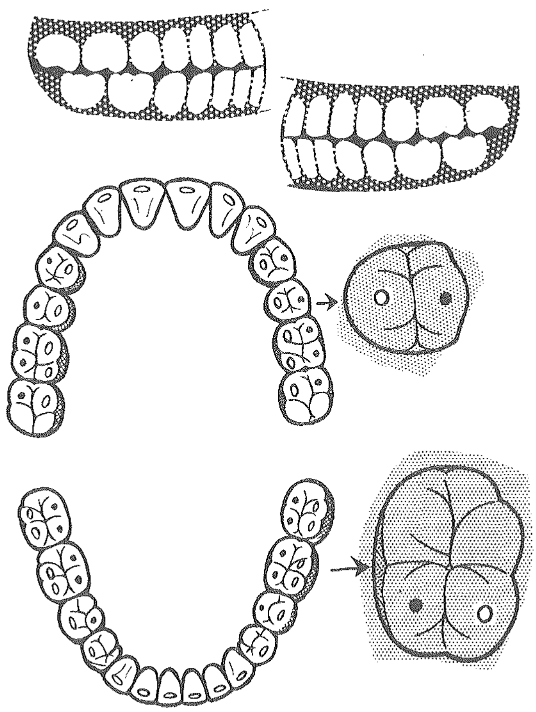


Fig. 604. The areas of contact involved in the lateral protrusive excursion when an ideal appliance has been perfectly adjusted (balanced appliance).

ment in each excursion. Then open the articulator and examine the occlusal surfaces for premature contacts. The whiting will be rubbed off wherever there is contact. The contact should be on the tips of the upper and lower buccal cusps on both sides, and there may also be some markings on the tips of the upper lingual cusps and the tips of the lower lingual cusps.

The lateral protrusive position is the only position in which there is *no* bilateral balance. In other words, when the restoration is in the lateral protrusive position on the right side, the left side should be completely out of contact, and vice versa. If this is not the condition, the appliance will have to be corrected; otherwise the patient will not be able to chew properly. In making the correction, carefully remove the interferences without destroying the centric relation-holding surfaces.

In correcting the articulation for the lateral protrusive position, confine the grinding to the tips of the cusps of the upper and lower teeth (Fig. 604). Usually only the buccal cusps are involved. In the ideal restoration, we may also be able to get the lingual upper and lower cusps of the same side to contact in the lateral protrusive position. It is obvious that any prematurities between the upper and lower tips of the cusps can be removed by grinding either the upper or the lower cusp tip. However, there are two considerations to bear in mind: (1) a gentle curve of Spee should be maintained so that there are no sudden steps in the occlusal plane and (2) the amount of gold covering the tooth structure should be taken into account so that the preparation is not penetrated.

Adjustment of straight protrusive excursion

After equal simultaneous contact between the cusp tips in the lateral protrusive excursion on both sides is established, procede with the next step in adjusting the articulation. A new coating of whiting and alcohol is applied, and the articulator is moved into the straight protrusive excursion. The markings will now appear on the tips of the lower buccal cusps and the areas on which they travel—from the marginal ridges to the crests of the upper buccal cusps, i.e., from the crests to the *distal* marginal ridges. The correction is made on this upper area, not on the tips of the lower buccal cusps (Fig. 605).

There may also be some interference between the tips of the lingual cusps of the uppers and the mesial slopes of the lingual cusps of the lowers. The mesial slopes of the lower lingual cusps are adjusted until there is equal simultaneous contact.

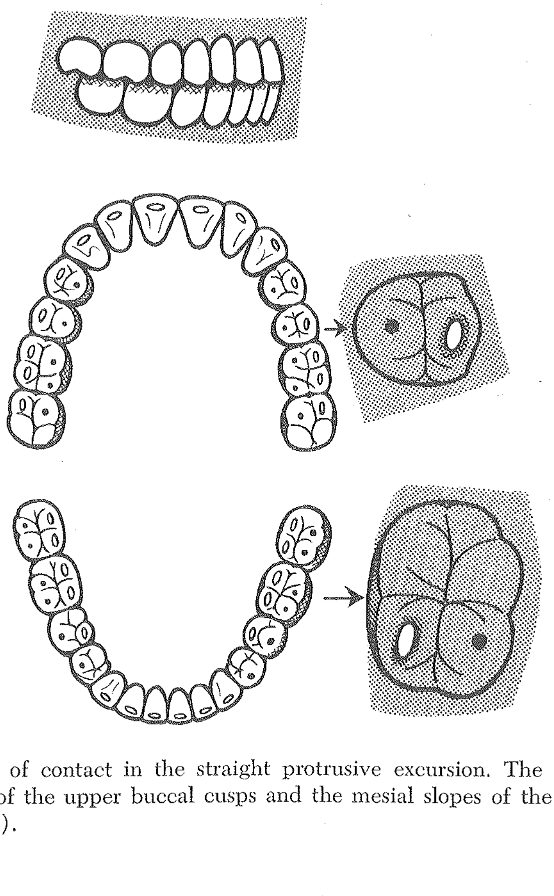


Fig. 605. The areas of contact in the straight protrusive excursion. The adjustment is made on the distal slopes of the upper buccal cusps and the mesial slopes of the lower lingual cusps (balanced appliance).

Adjustment of working and balancing excursions

The next step is to adjust the working and balancing excursions, which is done simultaneously—the working occlusion on one side and the balancing on the other side, and vice versa.

Again apply a thin coating of alcohol and whiting and allow it to dry. Move the articulator to the working position of one side, which automatically puts the other side into the balancing position. Be sure to use the full Bennett movement by riding against the Bennett guide, always applying muscle power (with the fingers) in the direction toward which the articulator is being moved.

The occlusal surfaces are now examined for interferences—the areas where the whiting is rubbed away. The markings on the working side will be on the mesial and distal slopes of the upper buccal cusps and on the outer aspect of the distal and mesial slopes of the lower buccal cusps. The mesial slopes of the upper buccal cusps are adjusted to the distal slants of the lower buccal cusps.

Since the linguodistal slopes of the *upper* buccal cusps were corrected for the protrusive excursion, the correction, if any, is confined to the outer aspect of

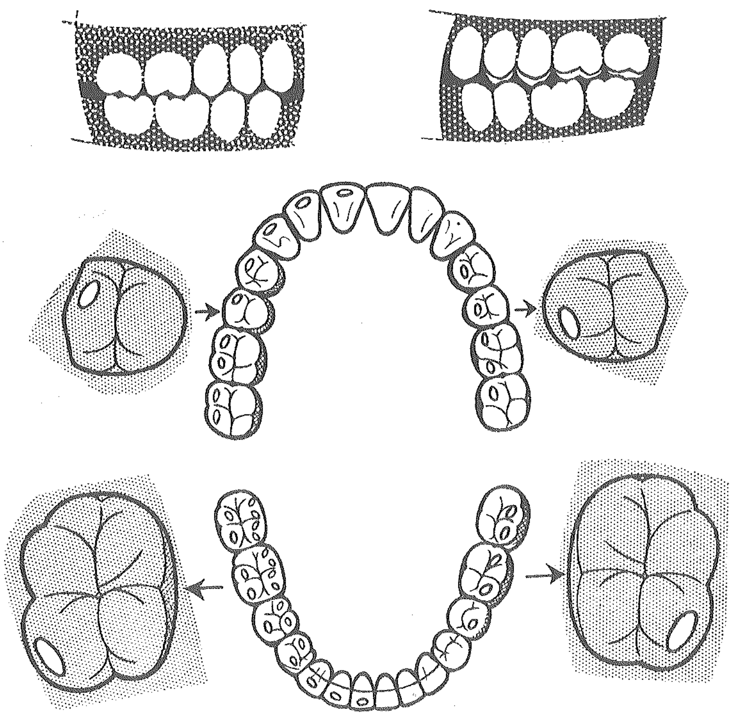


Fig. 606. The areas of adjustment on the working side are confined to the mesial slopes of the upper buccal cusps and the mesial slopes of the lower buccal cusps. On the balancing side, the areas of adjustment are on the mesiolingual surfaces of the lower buccal cusps (balanced appliance; see text).

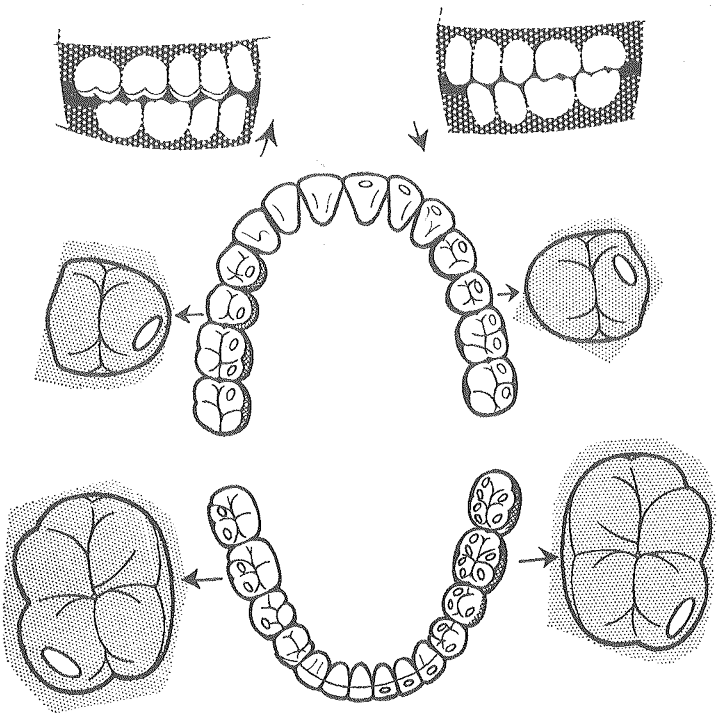


Fig. 607. The working and balancing contacts of the opposite excursion of the appliance shown in Fig. 606 (balanced appliance).

the mesial slopes of the lower buccal cusps (Fig. 606). Be careful to restrict the grinding to these areas without disturbing the tips of the upper cusps and the tips of the lower cusps. Also take care not to disturb the distolingual aspects of the upper buccal cusps because these are the areas on which the tips of the lower cusps travel in the protrusive excursion.

There may also be markings on the mesial and distal buccal slopes of the lower lingual cusps on the working side. These are relieved, but not the marks on the upper lingual cusps which contacted these areas.

On the balancing side, the marks will be on the buccal (or outer) aspect of the distal surfaces of the upper lingual cusps and on the linguomesial surfaces of the lower buccal cusps (Fig. 606). Confine the adjustment to these surfaces. The tips of the lower buccal cusps were developed previously and must maintain the cusp height. The tips of the upper lingual cusps were adjusted to these and must be maintained. The correction is made on the mesiolingual surfaces of the lower buccal cusps to permit the balancing cusps to have uninterrupted access to their centric position.

Repeat this procedure in the opposite excursion, adjusting both the working and balancing positions (Fig. 607).

Adjustment of centric relation

The final and most important adjustment is the centric relation correction. For this, remove all the whiting which may have accumulated in the previous procedures and apply a new thin coat of alcohol and whiting, which is permitted to dry. Gently open and close the articulator, taking care not to bounce it in closing. There will be areas of contact (Fig. 608), all of which should be removed, except the ones on the tips of the cusps. It may be necessary to change some of the slopes slightly so that the tips of the cusps can easily reach their centric seat without deviation of the articulator from its normal closing arc. In other words, if the centric relation-holding contacts are not marked or do not hold strips of 1/1,000 cellophane (which is a test for contact), alter the slopes of the cusps until the condition is corrected. It may be necessary to retrace some of the adjustment steps in order to achieve a better centric contact.

The centric position is the position in which the patient has the greatest amount of vertical closure—the position in which the jaws are closest together. The jaws must arrive at this position, stopped by the occlusal surfaces, without any deviation whatsoever of the masticatory mechanism. The patient must be able to get his teeth together without having to steer himself into a position. It must be automatic, without the guidance of the cuspal inclines.

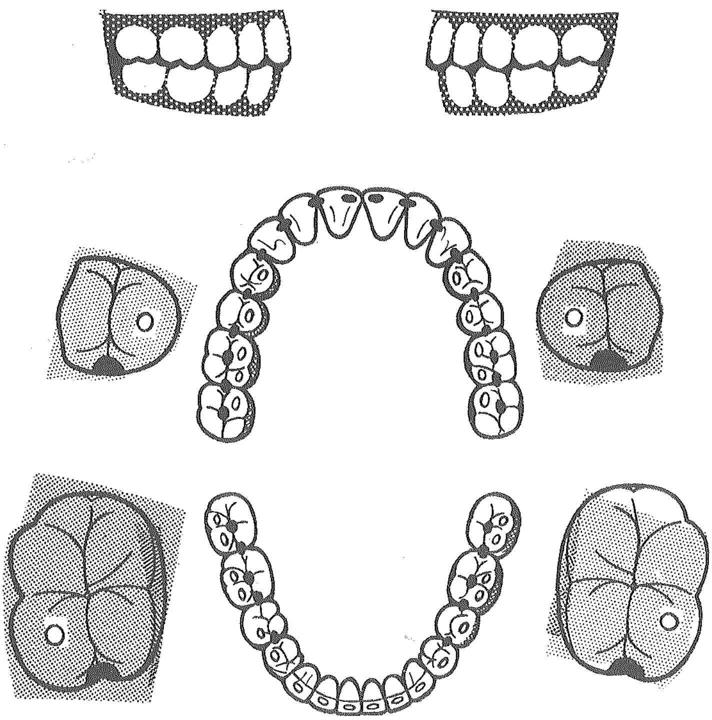


Fig. 608. The centric relation contacts in a perfectly adjusted ideal balanced prothesis. If any of these contacts are heavier than the others, the fossa is relieved, never the cusp tip.

ESTABLISHING THE SECONDARY CARVINGS

By the time that the restorations have been refined to proper function, much of the primary carving will have been destroyed. The restorations are now cleaned with soap and water, and the carvings are re-established.

Be extremely careful in the carving not to cut any holes through the occlusal surfaces! This can be avoided if a meticulous examination of the restorations is made and all suspiciously thin areas are measured with a pair of sensitive calipers. As far as primary and secondary grooves are concerned, it is better to leave an area uncarved than to have a hole in the restoration.

Re-establish the primary carvings in the restorations and make them more efficient and more beautiful by artistically placing secondary grooves to accentuate the details of the cuspal form. After all these years, I still keep in front of me casts of a set of good natural teeth which serve as a model when I do my final carving of secondary grooves. They are hard to improve upon! The carvings are made with burs of one's choice, but I prefer No.'s 557, 701, and 35 to re-establish the carvings of the grooves and sulci.

Any sharp edges that may have been created lingually by the machining of these grooves and sulci are removed with a rubber wheel. The entire occlusal surface is gone over with a brass wire wheel. This produces a nice, dull appearance without altering any of the laboriously established surfaces.

The margins of the restorations are *not* finally thinned to knife-edge sharpness until the appliance has been worn, remounted, worn again, and found to be satisfactory. Only then, just prior to final cementation, is this done.

If it is carefully executed, the procedure just described will produce a beautifully balanced articulation.

REFINING A MUTUALLY PROTECTED ARTICULATION

In the refinement of a mutually protected articulation at the remount stage, the steps are similar to those followed in establishing the articulation in wax, with certain obvious differences. In the finished castings, the process is primarily one of removing prematurely contacting surfaces or of adjusting contacting surfaces to make them simultaneous, whereas in the development of the articulation in wax, the process is one of carefully building surfaces into accurate contact. Moreover, in the adjustment process, several steps are of necessity combined, and the right and left sides must be coordinated simultaneously.

The important thing is to keep in mind constantly what the finished product must be like—where the contacts are and where the areas of clearance are located.

Protrusive and lateral protrusive excursions

The first positions or excursions to be examined are the protrusive and lateral protrusive. In these excursions, the anterior teeth are in function or contact, and the posterior teeth are out of contact (Fig. 609). This statement requires some

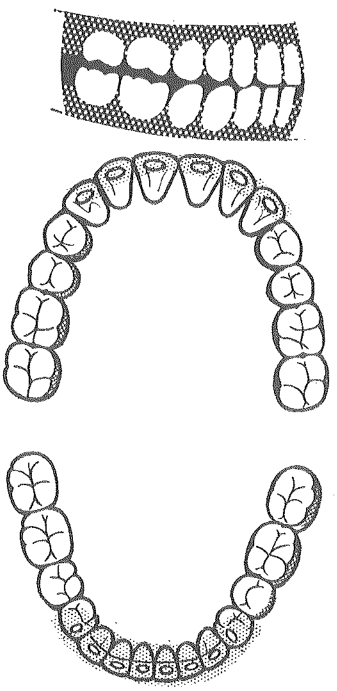


Fig. 609. The contacts in a mutually protected articulation are only on the anterior teeth in the protrusive and lateral protrusive excursions.

clarification. The six anterior teeth function as a unit. They simultaneously make contact as the patient goes into a protrusive position. Whenever possible, the distal aspect of the upper cuspids also maintains contact with the mesial marginal ridge of the lower first bicuspid in the protrusive excursion. All the other cusps are out of contact. The amount of clearance is minimum and depends upon all the factors of articulation described in another chapter. In other words, the clearance could be considerable, but if this is permitted, then the cusp elements which are necessary for the all-important centric relation contacts will not be available.

In the lateral protrusive position, the anterior contact is on the central and lateral teeth and cuspids whenever possible. The rest of the teeth are out of contact—again, not a great deal but definitely not in contact.

Working and balancing positions

In the working and balancing positions, the contact again is on the anterior teeth, particularly the cuspids. The central and lateral teeth share this contact wherever possible in their respective excursions. All the posterior cuspal elements are out of contact in the working and balancing excursions (Fig. 610) although, again, this lack of contact is slight and not so great as it could be. For this reason, precise registrations are necessary to permit an accurate duplication of the move-

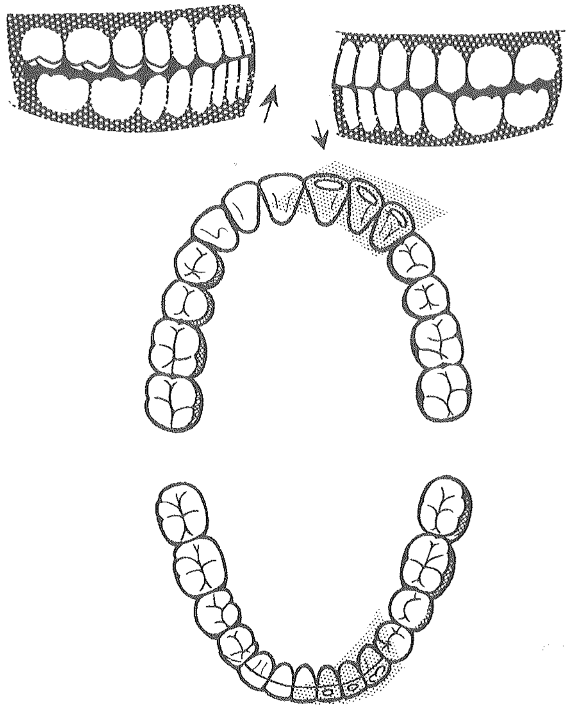


Fig. 610. All the posterior cuspal elements are out of contact in the working and balancing excursions (mutually protected articulation).

ments on an articulator so that these misses are kept to a minimum without any interferences.

Adjustment of contacts in centric relation

Having adjusted the appliance for the various excursions, we are now ready to examine it for centric relation contacts. These are the most important contacting surfaces of all and must be carefully adjusted.

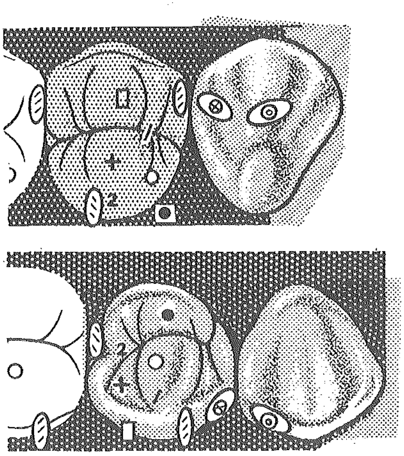
Up to this point, the location of the areas to be cleared have been marked with carbon paper. The centric *contact* areas, however, should be marked in a more accurate manner, for they must be very carefully equalized to balance the teeth in the centric closure. Whiting dissolved in alcohol will permit a more accurate marking of the areas to be adjusted.

In making the corrections in centric relation, there are no definite rules to follow, and so we must be guided by good judgment based on a knowledge of what the end result should be. The elimination of any premature contact can usually be accomplished by grinding either the upper or lower tooth surface. The surface selected (usually both surfaces are slightly reduced) is determined by the end product of the reduction process. For instance, to ameliorate a premature contact between a transverse ridge of an upper tooth and a marginal ridge of a lower tooth, one would not want to grind the lower marginal ridge, leaving a notch in it. Therefore, the transverse ridge is reduced. This is an example of what is meant by good judgment based on a knowledge of what the end result should be. This knowledge was gained in the establishment of the articulation in wax. This procedure is in contrast to the refinement of the articulation in gold when full balance is desired. In the adjustment of the balanced restoration, there are certain prescribed steps to follow and particular areas to adjust in a definite sequence.

Contacting areas in centric relation. The best way to attempt to point out where the contact areas are located in a mutually protected articulation is to describe each upper and lower tooth relationship on one side. If the situation is normal, the other side will be similar. The accompanying line drawings will be helpful in clarification of the location of the minute contacting areas of this type of articulation.

Cuspid (Fig. 611). (1) The mesiolingual surface of the upper cuspid contacts the distobuccal surface of the lower cuspid. (2) The distolingual surface of the upper cuspid contacts the mesiobuccal surface of the mesiobuccal marginal ridge of the lower first bicuspid.

First bicuspid (Fig. 612). (1) The buccal triangular ridge of the upper first biscuspid crosses and makes contact on the buccal surface of the distal slope of the buccal marginal ridge of the lower first bicuspid. (2) The lingual triangular ridge of the upper first bicuspid contacts the inner aspect of the distobuccal marginal ridge of the lower first bicuspid. (3) The buccal triangular ridge of the lower first bicuspid contacts the inner aspect of the mesiolingual marginal ridge of the upper first bicuspid. (4) The lingual triangular ridge of the lower first



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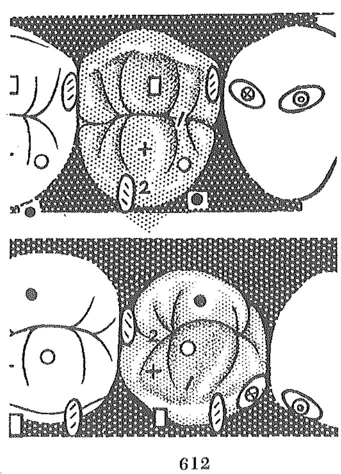

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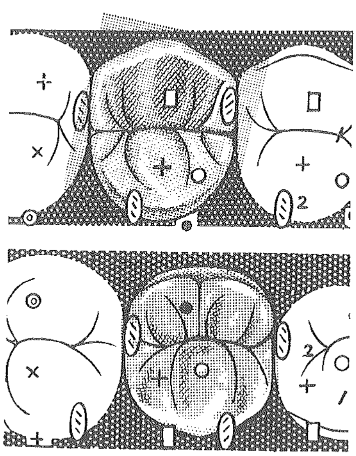
Fig. 611. The centric relation contacting areas of the upper cuspid after proper adjustment (mutually protected articulation).

Fig. 612. The centric relation contacting areas of the upper and lower first bicuspids after proper adjustment (mutually protected articulation).

bicuspid contacts the lingual side of the mesiolingual marginal ridge of the upper first bicuspid. (5) The mesial marginal ridge of the upper first bicuspid crosses and contacts the mesiobuccal marginal ridge of the lower first bicuspid. (6) The distal marginal ridge of the lower first bicuspid crosses and contacts the distal portion of the lingual marginal ridge of the upper first bicuspid.

Second bicuspid (Fig. 613). (1) The buccal triangular ridge of the upper second bicuspid crosses and makes contact with the buccal aspect of the distal slope of the buccal marginal ridge of the lower second bicuspid. (2) The lingual triangular ridge of the upper second bicuspid contacts the inner aspect of the distobuccal marginal ridge of the lower second bicuspid. (3) The buccal triangular ridge of the lower second bicuspid contacts the inner portion of the mesial slope of the lingual marginal ridge of the upper second bicuspid. (4) The lingual triangular ridge of the lower second bicuspid contacts the lingual side of the mesial portion of the lingual marginal ridge of the upper second bicuspid. When there are two lingual cusps on the lower second bicuspid, the contact is made between the triangular ridge of the distolingual cusp and the lingual side of the mesial portion of the lingual marginal ridge of the upper second bicuspid. (5) The mesial marginal ridge of the upper second bicuspid crosses and contacts the mesial portion of the buccal marginal ridge of the lower second bicuspid. (6) The distal marginal ridge of the lower second bicuspid crosses and contacts the distal portion of the lingual marginal ridge of the upper second bicuspid.

First molar (Fig. 614). (1) The triangular ridge of the mesiobuccal cusp of the upper first molar crosses and contacts the distal slope of the marginal ridge of the mesiobuccal cusp of the lower first molar. (2) The triangular ridge of the



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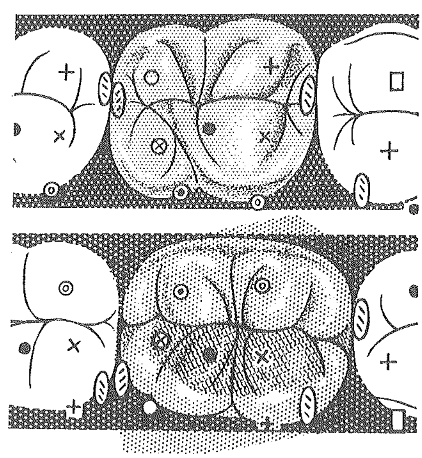

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Fig. 613. The centric relation contacting areas of the upper and lower second bicuspids after proper adjustment (mutually protected articulation).
Fig. 614. The centric relation contacting areas of the upper and lower first molars (mutually protected articulation).

mesiolingual cusp of the upper first molar crosses and contacts the triangular ridge of the mesiobuccal cusp of the lower first molar. (3) The oblique ridge of the upper first molar runs from the distobuccal cusp to the mesiolingual cusp and is divided by the mesiodistal central groove. The buccal portion (on the distobuccal cusp) contacts the groove between the buccal and distobuccal cusps of the lower first molar. (4) The lingual portion (on the mesiolingual cusp of the upper first molar) crosses and contacts the triangular ridge of the buccal cusp of the lower first molar. (5) The triangular ridge of the distolingual cusp of the upper first molar crosses and contacts the triangular ridge of the distobuccal cusp of the lower first molar. (6) The mesial marginal ridge of the upper first molar crosses and contacts the mesial slope of the marginal ridge of the mesiobuccal cusp of the lower first molar. (7) The distal marginal ridge of the upper first molar crosses and contacts the distal slope of the marginal ridge of the distobuccal cusp of the lower first molar. (8) The triangular ridge of the mesiolingual cusp of the lower first molar contacts the mesial portion of the lingual surface of the lingual marginal ridge of the mesiolingual cusp of the upper first molar (actually the cusp of Carabelli). (9) The triangular ridge of the distolingual cusp of the lower first molar crosses and contacts the lingual surface of the lingual marginal ridge of the upper first molar as the marginal ridge dips from the mesiolingual cusp to the distolingual cusp.

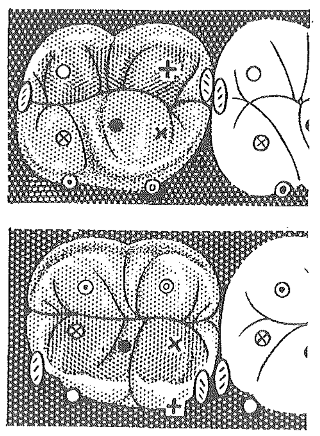

Fig. 615. The centric relation contacting areas of the upper and lower second molars (mutually protected articulation).

Second molar (Fig. 615). The contacting surfaces of the upper and lower second molars are the same as those of the first molars. (1) The triangular ridge of the mesiobuccal cusp of the upper second molar crosses and contacts the distal slope of the marginal ridge of the mesiobuccal cusp of the lower second molar. (2) The triangular ridge of the mesiolingual cusp of the upper second molar crosses and contacts the triangular ridge of the mesiobuccal cusp of the lower second molar. (3) The oblique ridge of the upper second molar runs from the distobuccal cusp to the mesiolingual cusp and is divided by the mesiodistal central groove. The buccal portion (on the distobuccal cusp) contacts the groove between the buccal and distobuccal cusps of the lower second molar. (4) The lingual portion on the mesiolingual cusp of the upper second molar crosses and contacts the triangular ridge of the buccal cusp of the lower second molar. (5) The triangular ridge of the distolingual cusp of the upper second molar crosses and contacts the triangular ridge of the distobuccal cusp of the lower second molar. (6) The mesial marginal ridge of the upper second molar crosses and contacts the mesial slope of the marginal ridge of the mesiobuccal cusp of the lower second molar. (7) The distal marginal ridge of the upper second molar crosses and contacts the distal slope of the marginal ridge of the distobuccal cusp of the lower second molar. (8) The triangular ridge of the mesiolingual cusp of the lower second molar contacts the mesial portion of the lingual surface of the lingual marginal ridge of the mesiolingual cusp of the upper second molar. (9) The triangular ridge of the distolingual cusp of the lower second molar crosses and contacts the lingual portion of the lingual marginal ridge of the upper second molar as the marginal ridge dips from the mesiolingual cusp to the distolingual cusp.

ADJUSTMENT OF ANTERIOR TEETH

The adjustment of the anterior teeth is determined by the particular appliance on hand and how it is to be completed.

If six upper anterior veneer crowns are involved, they are easily remounted with the posterior restorations and can then be adjusted on the articulator.

When pin-ledges are involved, they, too, can be remounted with the posterior restorations, but their handling is a little more delicate because of their size and shape. With care, however, they can be remounted and adjusted on the articulator.

Porcelain jackets can be remounted, also, but there is a risk of breakage in their handling. A safer procedure is either to remount the biscuit jackets—and then repair them if there is any chipping—or to adjust the biscuit jackets directly in the mouth after the posterior restorations have been adjusted and temporarily inserted in the mouth.

Another possible condition is one requiring no anterior restorations. These rare occurrences can sometimes be successfully completed by a slight reshaping of the anterior teeth. This can be done on the remount casts as the posterior restorations are refined for completion of the appliance. A notation is made of the areas reshaped on the casts; after which, the natural teeth are reshaped in the mouth in accord with the notation.

Whatever the situation concerning the anterior teeth may be, the end result of the adjustments should be the same.

For a fully balanced appliance, there should be slight or no contact in centric relation.

In the lateral protrusive and protrusive excursions, the upper and lower anterior teeth should be in continuous contact—simultaneous with the posterior tooth contacts. When the posterior teeth are at the peak of the lateral protrusive or protrusive excursion, the anterior teeth should also be edge to edge or tip to tip. This, of course, is the ideal arrangement. In practice, many compromises have to be made. Sometimes the relationship of the anterior teeth is such that it is impossible to have this ideal arrangement. Splinting is occasionally resorted to in order to maintain the position of the anterior teeth. This is usually done when the relationship is such that the lingual surfaces of the upper anterior teeth cannot possibly be built out enough to establish an ideal contact.

In the working occlusion, the cuspid, lateral, and central teeth should be in continuous contact simultaneously with the posterior teeth.

ADJUSTMENT OF ANTERIOR TEETH IN A MUTUALLY PROTECTED ARRANGEMENT

In centric relation, we strive wherever possible to have the anterior teeth in slightly lighter contact than the posterior teeth. In other words, if the posterior restorations will hold a strip of cellophane of 1/1,000 thickness, one should be able to pull this cellophane from between the anterior teeth with only a little resistance.

In some patients, the anterior teeth are so positioned that it is impossible to arrive at this arangement.

From centric relation to the other excursions, the anterior teeth take on the guidance. The posterior teeth are out of contact shortly after the patient leaves centric relation. This would hold true if the patient were to make a test glide or if the appliance were being examined either on the articulator or in the mouth.

Many times, this arrangement is possible only in the cuspid region. Whenever possible, the cuspid should always be well restored so that, as the patient leaves centric relation, the posterior teeth are disengaged—disengaged by the patient's opening component of jaw movement—guided by the proprioception of the cuspid. The cuspid does not cause ramping apart of the jaw but, rather, is the feeler that governs the opening component of the jaws.

Because there is no accurate means of recording or determining this inclination, it is frequently necessary to adjust this cuspid contact in the mouth. This is not unlike the determination of the anterior guidance when an appliance is built to full balance. Actually, when an appliance is built to full balance, the posterior articulation is built first, and then the anterior teeth are harmonized with the posterior teeth. But, before a suitable posterior articulation can be built, an anterior guidance that will dictate physiological cusps must be established. Thus, in effect, we are selecting an anterior tooth relationship. We are making a careful guess based on experience and the factors of the particular case.

CHAPTER 21

Cementation

After the restorations have been adjusted and worn satisfactorily and the periodontal tissues have responded to treatment or the joint disturbance cleared up, the restorations are cemented permanently. Before undertaking this procedure, one should be satisfied beyond a doubt that he has succeeded in what he started out to accomplish. It is far better to wait and be sure than to rush and regret. It is much easier to carry out an extra remount procedure than to attempt to make a correction after the restorations have been permanently cemented.

The cementation procedure is extremely important. A perfectly good appliance can be ruined if each detail is not carefully executed.

PREPARATION OF RESTORATIONS FOR CEMENTATION

The restorations are removed from the teeth, and the removal knobs, if present, are ground away. The margins, which up to this point have been left thick, are now thinned.

If inlays or onlays are involved, it is advisable at this time to spin the margins. Suitably mounted stones lubricated with petrolatum are used for this purpose. The restorations must be accurately held in position during this procedure. A very useful inlay pressure applicator made by Medart* permits the restoration to be properly seated while the margins are being spun and prevents it from being vibrated from its seat.

The proximal surfaces are carefully polished, but the occlusal surfaces are only cleaned with a brass scratch brush. If veneers are present, they are given a careful final polish.

Any temporary cement is removed from the inside of the restorations. Heating them in Jel-Sol† is an easy and convenient way to accomplish this. The inside is then wiped with a pellet of cotton immersed in benzene, and the surface is dried.

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*Gus H. Medart, Burbank, Calif.

†J. F. Jelenko & Co., Inc., New York, N. Y.

PREPARATION OF TEETH FOR CEMENTATION

The teeth are cleaned of any temporary cement. At this point, they should be tested for vitality because it is easier to institute endodontia now than after the restorations are cemented. The preparations should also be checked for sensitivity. Usually at this stage the teeth are not sensitive by reason of the length of time in which the temporary cement has been used. However, if they are, it is necessary to use anesthesia; otherwise the patient will not bite the restorations to place, and the appliance will be ruined. The comfort of the patient will facilitate the successful seating of the restorations, and this cannot be overemphasized.

To keep the teeth dry, the mouth is packed with Fiber-Lint* and cotton rolls, and a saliva ejector or aspirator is used while the cement is being mixed. The preparations are cleaned with a pellet of cotton immersed in benzene to remove any trace of temporary cement or other debris that may be present. The benzene is allowed to evaporate.

Any gingival seepage must be controlled. Adrenalin chloride 1% or zinc chloride solution 20% is recommended for this purpose. If there is considerable seepage, it may be necessary to use Gingi-Pak† or Racord.‡

In all deep preparations and almost routinely, now apply a small amount of Meticortelone dissolved in a bit of MCP.§ This is applied on the cleansed tooth with a tiny wire loop applicator.

A very thin mix of zinc oxide and eugenol is prepared. When the permanent cement has been mixed (as about to be described), a minimal amount of the thin zinc oxide and eugenol is applied to the preparation. The restoration and permanent cement are then quickly placed in position.

MIXING AND APPLYING CEMENT

For best results, a crown and bridge cement of good quality should be used. It must be a slow-setting material because normally a quadrant of restorations is cemented at a time. Furthermore, sufficient mixing time is needed to reduce the acidity and thereby prevent damage to the pulps.

A glass slab is cooled in a refrigerator or cold water for 30 minutes and then thoroughly dried. About 10 drops of cement are placed at one end of the slab and a small amount of cement powder at the other end. A small portion of the powder is brought over to the liquid, and the spatulation is begun. As the powder is incorporated into the liquid, the mix is spatulated over a large area of the slab. This ensures adequate mixing with a cooling effect from the slab. More powder

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*S. S. White Dental Manufacturing Co., Philadelphia, Pa.

†Surgident, Ltd., Los Angeles, Calif.

‡Pascal Co., Inc., Seattle, Wash.

§Camphorated parachlorophenol with metacresyl acetate root canal dressing, supplied by Sultan Chemists, Jersey City, N. J. (see Fry, A. E., Watkins, R. F., and Phatak, N. M.: Topical Use of Corticosteroids for the Relief of Pain Sensitivity of Dentine and Pulp, Oral Surg. 13:594, 1960).

is introduced into the mix until the consistency is creamy. This mixture will be easy to handle, its working time will be sufficient to allow careful seating of the restorations, it will set to insoluble crystals, and it will not be injurious to the pulps.

Place this creamy mix of cement in the clean, dry restorations, being sure to apply an ample amount to each and trying not to trap air in the mix. The preparations are dried—not desiccated—with a warm blast of air, and the restorations are placed in position. An automatic mallet is used to vibrate the castings to place, and their seat is ensured by having the patient bite on an orangewood stick. When the restorations are all the way home, cover them and the teeth with Dry-Foil* to prevent the saliva from attacking the unset cement. Then have the patient bite firmly on a cotton roll and hold it for several minutes. If a patient objects to biting on cotton, the roll may be wrapped in cellophane. If the patient's muscles tire, the operator should help to maintain pressure on the cotton roll by supporting the lower jaw with his hands. When the cement has completely set, remove the cotton roll, Fiber-Lint, and Dry-Foil and clean away the excess cement.

Usually half of the restorations, i.e., two quadrants, are cemented at one sitting. It is preferable to cement either all the lower teeth or all the upper teeth at a sitting. Thus, should there be a slight discrepancy in the thickness of the permanent cement as compared with the temporary, it will not cause temporary intolerance of the appliance. This possibility is minimized if, in the last remount, the restorations were temporarily cemented with a thin mix of temporary cement.

The inside surfaces of the full-crown restorations have been machined (or deplated) to allow a sufficient thickness of cement for insulation and to facilitate the seating of the restorations. Some men advocate escape holes in the restorations to ensure proper seating, but it is my opinion that they are not necessary if the cementing procedures are carefully executed. Moreover, the task of patching the restorations before they are hardly completed is thus eliminated.

SPECIAL CONSIDERATIONS IN CEMENTATION

Removable appliances

When a removable prosthesis is involved, an additional slight precaution is necessary. When the abutment teeth are in position, the excess cement on the attachment side of the abutments is wiped off, and a little petrolatum is applied to the male attachments of the removable appliance before insertion. After the appliance is inserted, the abutment teeth and the partial denture are covered with Dry-Foil, and the patient bites to place with cotton rolls.

This procedure prevents any possible difficulty in removing the prosthesis if excess cement sets between the abutment teeth and the attachment. Should there be a problem in removing the appliance after the cement has set, it may be

*J. F. Jelenko & Co., Inc., New York, N. Y.

advisable to clean off the cement as much as possible and have the patient return the next day. Any prying at this time could disturb the newly formed cement crystals. However, if the preceding steps have been carried out properly, this difficulty will not be encountered, and the success of the prosthesis will be ensured.

Fixed bridges or splints

When a fixed bridge or any units that are splinted together are cemented, removal of the set cement can be facilitated by a little trick demonstrated by Dr. L. A. Cohn of New York City. Simply place a small amount of counter wax or any other very soft wax in the proximal areas of the bridge or splint, taking care not to have it near the margins. This soft wax will prevent any cement from getting into these areas. When the cement has set, the wax is easily cleaned away, and there is no problem of removing hard cement from the narrow proximal areas.

Imperfectly seated restorations

Occasionally, even with the best of care, a restoration will not be perfectly seated. This situation is usually detected in the final remount study casts. Careful impressions are taken of the completely cemented appliance, and the casts are mounted on the articulator by means of a face-bow transfer and a centric inter-occlusal record. Any discrepancy will be discernible on these casts and, if slight, can generally be corrected by the use of a small abrasive wheel. No other adjustment to the articulation should be necessary.

Porcelain jackets

Special care is required in cementing porcelain jackets in order to avoid breakage. As a rule, they are not cemented temporarily because they could very easily be damaged in removal. It will be recalled that these restorations were constructed after complete adjustment of the posterior restorations—as a matter of fact, usually after permanent cementation of the posterior restorations. If the jackets were tried in at the biscuit stage, very little adjustment, if any, should be required now.

The jackets are tested for fit and proper contact, and the articulation is checked. If they pass inspection, they are ready to be permanently cemented.

Prior to permanent cementation of porcelain jackets, it is advisable to test the effect of the shade of the cement about to be used, for it can have a tremendous effect on the shade of the restorations. It is a very simple procedure to mix a little water or glycerin with some of the cement powder, place the mixture in the jackets, and position them on the teeth. The exact shade will now be evident. It is common to use a slightly darker or more yellow cement for the cuspids. Usually when six anterior jackets are made simultaneously, they are "shaded in the set," the cuspids having a deeper hue than the central and lateral teeth.

Before the jackets are finally cemented, cement powder of varying shades should be tested in water mixtures to determine which will produce the desired effect.

It is possible to cement six porcelain jackets at one time. However, if one is hesitant about handling that many at one time, there are certain precautions to observe.

Jackets that are not to be cemented in the first mix should be placed on their respective teeth. This ensures proper seating of the jackets which are being cemented, for the adjacent jackets serve as contact points. In addition, this prevents any excess cement from getting on an adjacent preparation and spares us the task of removing it.

Another precaution is to fill the jacket completely with cement to prevent the entrapping of air. Trapped air will not easily be expelled and can cause breakage.

In seating the jacket to place, use a vibrating motion and then apply pressure with the fingers or a cotton roll. In no instance should an automatic mallet or an orangewood stick be used, as was advocated for the gold restorations. After the jacket or jackets are seated, they are covered with Dry-Foil and held to place with a cotton roll and vertical seating pressure applied by the fingers. A patient should never be trusted to bite them to place because invariably he will displace them labially.

If the operator chooses to cement three of six jackets at one time, he must wait until the first batch of cement is completely set before cementing the remaining three. Any slight pressure will disturb newly set cement crystals.

Pin-ledges

Special care is required when pin-ledges or any restorations that may have auxiliary retentions of fine caliber are cemented. The cement must be placed in the holes very carefully to ensure its reaching the bottom of the holes. A slightly thinner mix is advocated here, and it should be applied with a root canal plugger small enough in size to permit the cement to be wiped on the walls of the holes. Here again, care should be taken not to entrap any air.

These restorations should be vibrated to place with an automatic mallet and then bitten to place by the orangewood stick procedure. Then cover them with Dry-Foil and have the patient bite on a cotton roll while the cement sets thoroughly.

Small restorations

When any small restoration is being cemented, it is advisable to place cement in the preparation, not on the restoration. It is easier to handle a restoration if it is not covered with cement. This is true of Class V, pin-ledge, small MO or DO, and occlusal restorations. In the case of large MOD restorations and crowns, however, it is usually convenient to fill the restorations with cement and carry them to place.

CHAPTER 22

Grinding the articulation of natural teeth

Promiscuous grinding of the occlusal surfaces of natural teeth is often criminal. Many mouths have been ruined by so-called preventive equilibration. Improper or careless grinding has aggravated periodontal conditions and actually made joint disturbances acute.

PREMATURITY—DEFINITION

Since the term "prematurity" will occur frequently throughout this chapter, let us at the outset establish its meaning.

A prematurity is any tooth contact (1) that prevents the normal hingelike closure of the mandible in any position within tooth contact, (2) that is not in harmony with the temporomandibular joint and causes its abnormal function, and (3) that causes undue stress to be transmitted to the periodontal tissues and nullifies the objective of equal stress distribution.

GRINDING—INDICATIONS AND CONTRAINDICATIONS

If a three-unit bridge is to be constructed for a mouth with some premature contacts, should the prematurities be eliminated? This question is frequently asked, but the answer will depend upon the findings of a complete diagnosis. Can we correlate the prematurities to any clinical or radiographic evidence of pathological disorder? Are there any joint symptoms?

If the answer to these questions is "No," then we had better avoid grinding. On the other hand, if the answer is "Yes," some good can perhaps be accomplished by intelligent equilibration. I would consider spaced anterior teeth that are directly due to a prematurity a reason for attempting correction of the condition.

Let me explain my attitude toward tooth grinding.

Prematurities without pathological involvement

If there are prematurities without a pathological condition, it is because the patient has developed a protective proprioceptive reflex which has been sufficient, with the patient's resistance, to prevent the development of pathosis. Now if these prematurities should be ground away, what could happen? The premature forces on the tissues would be removed or changed. The teeth would then receive stresses for which the patient has not developed a protective proprioceptive reflex. When treatment is instituted, it is very possible that the age and resistance of the patient would prevent him from withstanding the stresses with the same facility as when the prematurities first developed. Moreover, it is quite likely that the patient developed the prematurities over a long period of time, and here we would be suddenly changing the condition. As a consequence, a pathological condition could readily develop. It would be much safer, therefore, to allow the prematurities to remain as they are. In these patients, as when a diagnosis for full-mouth rehabilitation is made, the philosophy is to institute treatment only when there is a good and definite reason for so doing.

The same sequence could create a joint disturbance. Here again, a certain combination of conditions may not appear normal. Yet, unless definite symptoms are present, my advice is to leave the malfunction alone. To do otherwise might precipitate the very thing we hope to prevent. Without interference, it may never develop.

In my opinion, the grinding of occlusal surfaces is never indicated unless there is a definite pathological condition that may be improved by intelligent equilibration. It should never be instituted as a preventive measure.

Prematurities with pathological involvement

It follows, then, that there are conditions which may be improved by intelligent equilibration. In patients in whom there is definite pathological involvement of the periodontal tissues, it may be instituted as an adjunct to periodontal treatment although, of course, it can never take the place of full-mouth rehabilitation. It is conceivable, however, that a particular set of circumstances might justify intelligent equilibration. If there is only slight pathological involvement which is confined to a small segment of the mouth or an isolated area, equilibration might then well be part of the periodontal treatment. This would be particularly true if the hard tissues (the teeth) were free of cavities and if none of the teeth needed replacement. Likewise, if a joint disturbance existed and it were possible to ascertain the cusp or cusps causing the malfunction, we would be justified in grinding the offending cusps in the hope of correcting the condition.

Occasionally one may encounter a patient with extensive pathological disorder and corresponding malfunction of the teeth. The situation definitely calls for full-mouth rehabilitation, but the patient cannot afford it. Would intelligent equilibration be helpful here? Yes, it would, but the degree of success will be directly proportional to the shortcomings inherent in the procedure. Sometimes these shortcomings are so great as to render the procedure useless. Until tooth structures can be created where they are needed, the degree of success will be limited.

From this reasoning, it might be concluded that it is possible to combine intelligent equilibration with some tooth building by restoration. My experience indicates that this is not practical. What happens is that the operator will have done more work than would have been required for a complete rehabilitation—only to achieve an inferior result.

One condition which can be improved by grinding is spaced anterior teeth when the spacing is due to the rebound contact after the lower jaw skids off a posterior prematurity. For purposes of classification, the spacing in such cases may be considered pathological.

Grinding as a retaining procedure in postorthodontic patients

Intelligent equilibration can be of great help to orthodontic or, rather, postorthodontic patients.

Why is this so?

In these patients, it is frequently not possible to achieve perfect articulation by tooth movement. Prematurities very often exist in the articulation at the conclusion of orthodontic treatment. The teeth are newly positioned. The bone around them is in a state of flux, for some destruction has occurred and some healing is taking place. The patient has not had time to develop a protective proprioceptive reflex. Before this can be developed, the teeth may be driven out of position. These are the patients who can be helped by intelligent equilibration—the situations in which preventive grinding is a useful adjunct to treatment. It may even be advantageous in such patients to resort to the placement of several restorations, if needed. A full rehabilitation is not recommended in the majority of these patients—first, because the discrepancy in the articulation is usually not too great and, second, because most postorthodontic patients are quite young and extensive reconstruction procedures are contraindicated.

All newly completed orthodontic prostheses should be very critically evaluated as to function in order that the orthodontic result be maintained. If we conclude that a patient can be helped by intelligent equilibration, how do we proceed?

The first requisite is to obtain accurate study casts and to mount them on an articulator so that they are on the same axis as the teeth of the patient. Full registrations would more than compensate for the time required to take them, but axis-mounted casts will suffice. With the latter, a careful correlation has to be made of the eccentric contacts between the prematurities discernible on the mounted casts and those seen in the mouth. Full registrations would make this an easy task.

After the prematurities are located, the biggest job is ahead—that of deciding how to relieve them. The simplest part of the procedure is the actual removal of the prematurities. Thirty minutes may be spent deciding where to grind for one second! The grinding, remember, is *final* and for all time.

The decision on where to grind should be based on the procedures of establishing an articulation, as described earlier in the text. A clear understanding of these procedures will reveal the shortcomings of grinding as a treatment and prevent grinding away the wrong surfaces.

GENERAL RULES FOR GRINDING NATURAL TEETH

From the chapters dealing with the development of an articulation in wax and the refinement of an articulation after remounting, certain rules can be formulated.

1. Centric relation-holding cusps (the lingual cusps of the upper teeth and the buccal cusps of the lower teeth) should never be ground unless they are also high (premature) in some other excursion. Even then, they should be ground only enough to correct the centric prematurity. If they are still premature in the other excursions, the adjustment must be made on the other surfaces because these cusps must remain in contact in the centric position. Further reduction would destroy centric relation and be disastrous.
2. In the correction of any prematurity, two surfaces are always involved—an upper and a lower. Grinding either surface will correct the particular prematurity. The important thing, however, is to decide which surface is to be ground. The decision is made after a careful examination in all the excursions to determine whether the upper or lower surface is also premature in some other excursion. If the upper surface is premature in more than one excursion, it follows then that it should be reduced until it is correct in all excursions. Frequently, the grinding will correct the other excursions and leave the original prematurity improved, but still high. The correction is then completed by reducing the lower surface. The advantage of this method is that several improvements can be made with a minimum of grinding.
3. Wherever possible, efforts in grinding should be directed so that the stresses of function will fall as nearly as possible within the long axes of the teeth. This is emphasized by the importance of the centric relation-holding cusps.
4. Always use small cutting instruments to make the reductions. Grinding seldom entails the removal of a great deal of tissue, but rather reshaping of the surfaces. Large stone or diamonds cannot accomplish this.
5. In grinding, never leave a flat plane or surface. All articulating surfaces are rounded (parabolic) because all jaw movements are rotary. Equal contact can be maintained, therefore, only by rounded surfaces.
6. When tooth grinding has been instituted, careful follow-up of the patient is necessary. When the forces of function are changed on a tooth, that tooth is quite likely to change its position in the arch. Thus, it may need further adjustment several times before it finally becomes stabilized.
7. It is important to make new study casts at frequent intervals as the grinding proceeds and as the teeth settle into their new positions.

SELECTION OF AREAS FOR GRINDING

Perhaps the best way to describe where to grind is to present several common situations and explain why a particular area is selected for grinding. I shall attempt to cover every possible situation.

All the conditions which shall be described will be between the upper first bicuspid and the lower second bicuspid. By the use of common sense, these relations can be applied to conditions in any part of the mouth.

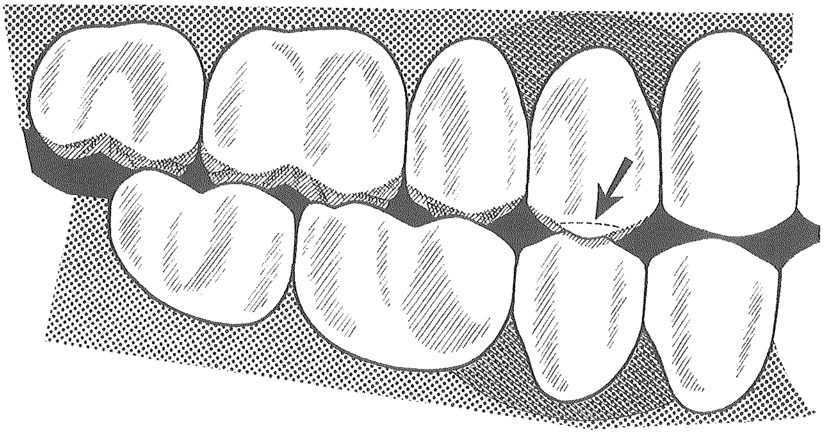

Fig. 616. Premature in the lateral protrusive excursion only, between the buccal cusp of the upper first bicuspid and the buccal cusp of the lower second bicuspid.

Case 1 (Fig. 616)

Description. Prematurity in the *lateral protrusive* excursion only, between the tip of the buccal cusp of the upper first bicuspid and the tip of the buccal cusp of the lower second bicuspid.

Treatment. Grind the tip of the upper first bicuspid because it does not contact in any other position.

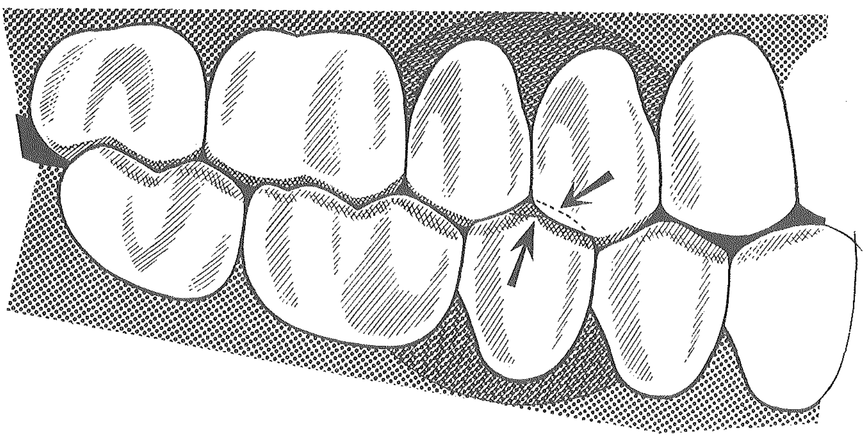

Fig. 617. Prematurity in centric relation, between the tip of the buccal cusp of the lower second bicuspid and the marginal ridges between the upper first and second bicuspids.

Case 2

Description. Prematurity in *centric relation* between the tip of the buccal cusp of the lower second bicuspid and the marginal ridges between the upper first and second bicuspids (Fig. 617); in the *lateral protrusive* excursion, between the tip of the buccal cusp of the lower second bicuspid and the tip of the buccal cusp of the upper first bicuspid (Fig. 618); and in the *protrusive* excursion (Fig. 619), between the tip of the buccal cusp of the lower second bicuspid and the crest of the buccal cusp of the upper first bicuspid, extending to the mesiodistal contours of the distal half of the buccal cusp of the upper first bicuspid (Fig. 620).

Treatment. First adjust for the correct centric relation contact by reducing the tip of the buccal cusp of the lower second bicuspid (Fig. 620).

Check for protrusive contact and adjust by grinding the crest of the buccal cusp of the upper first bicuspid (Fig. 620).

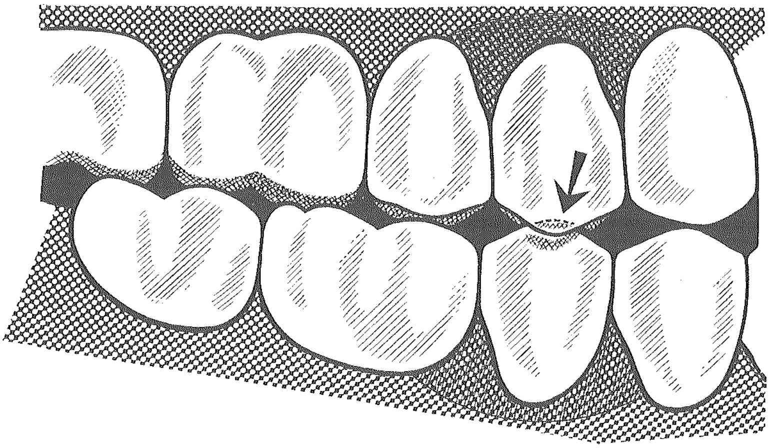

Fig. 618. Case shown in Fig. 617. The tip of the buccal cusp of the lower second bicuspid is also in premature contact in the lateral protrusive excursion with the tip of the buccal cusp of the upper first bicuspid.

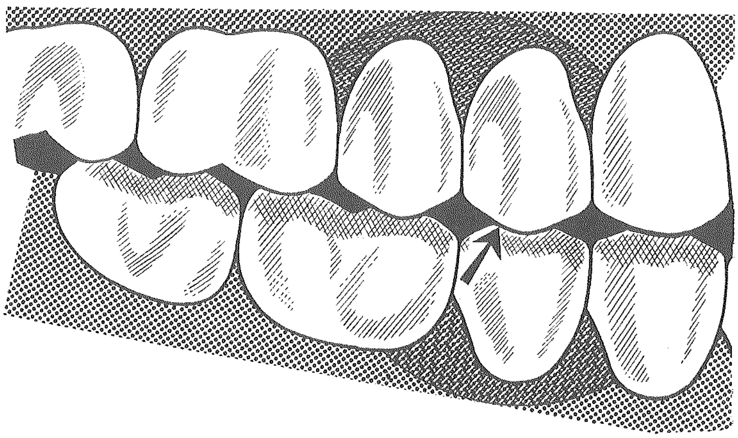

Fig. 619. Case shown in Fig. 617. The tip of the buccal cusp of the lower second bicuspid is in premature contact in the protrusive excursion with the crest of the buccal cusp of the upper first bicuspid.

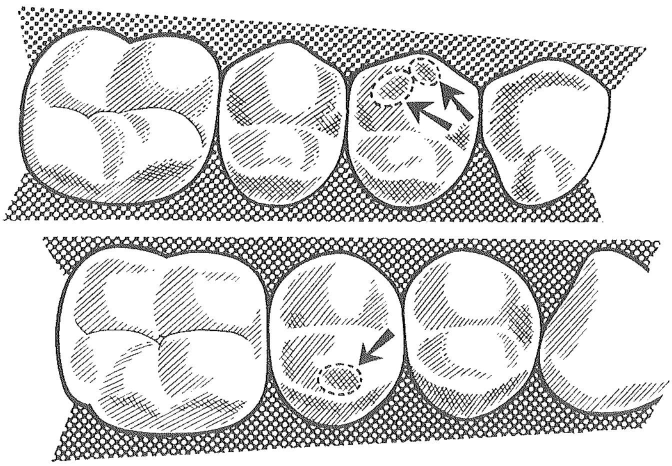

Fig. 620. Correction of the case shown in Fig. 617. Grind the tip of the buccal cusp of th lower second bicuspid. If necessary, grind the crest of the buccal cusp of the upper first bi cuspid. Finally, if it is still high in the lateral protrusive excursion, grind the tip of the bucca cusp of the upper first bicuspid.

Reduce the mesiodistal contour of the distal half of the buccal cusp of the upper firs bicuspid. If it is still high in the lateral protrusive excursion, reduce the tip of the bucca cusp of the upper first bicuspid (Fig. 620).

Case 3

Description. Prematurity in the *centric* contact only, between the tip of the buccal cusp o the lower second bicuspid and the marginal ridges of the upper first and second bicuspids (Fig 621); no contact of the tip of the buccal cusp of the lower second bicuspid or any other cusp in the eccentric positions.

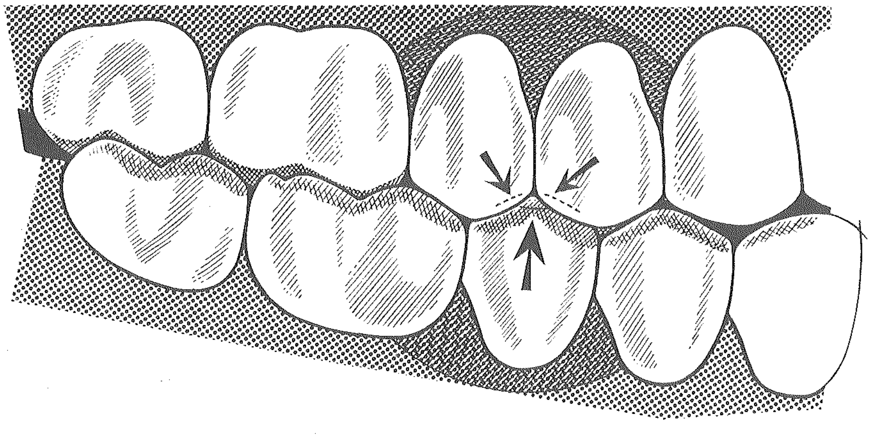

Fig. 621. Prematurity in centric contact only, between the tip of the buccal cusp of the lowe second bicuspid and the marginal ridges of the upper first and second bicuspids.

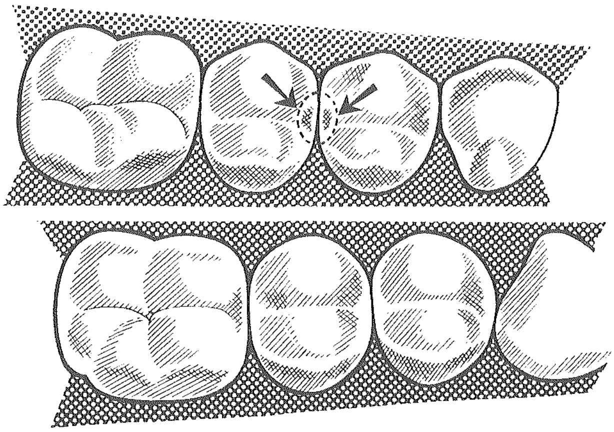

Fig. 622. Correction of the case shown in Fig. 621. Reduce the marginal ridges of the upper first and second bicuspids.

Treatment. Grind the marginal ridges of the upper first and second bicuspids (Fig. 622) because the height of the cusp is already short in the other excursions.

Case 4

Description. Prematurity between the mesial slope of the buccal cusp of the lower second bicuspid and the distal slope of the buccal cusp of the upper first bicuspid, in the *working* occlusion (Fig. 623).

Treatment. First check to see whether there is clearance in the lateral protrusive excursion. If there is, grind the mesial slope of the buccal cusp of the lower second bicuspid (Fig. 624).

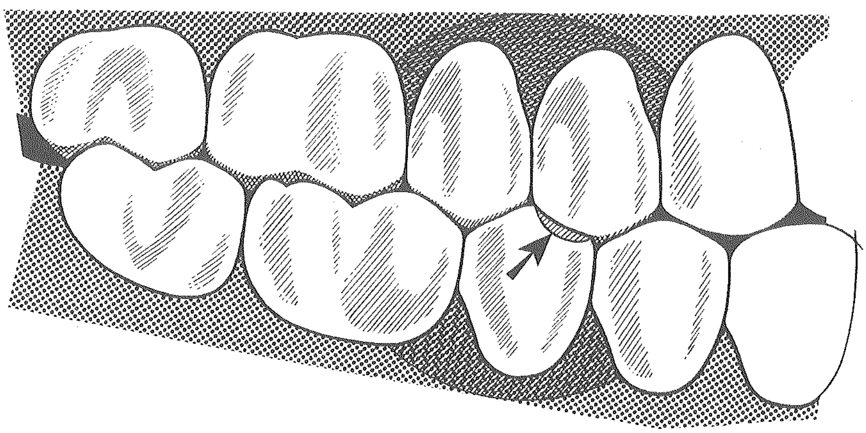

Fig. 623. Prematurity between the mesial slope of the buccal cusp of the lower second bicuspid and the distal slope of the buccal cusp of the upper first bicuspid in the working occlusion.

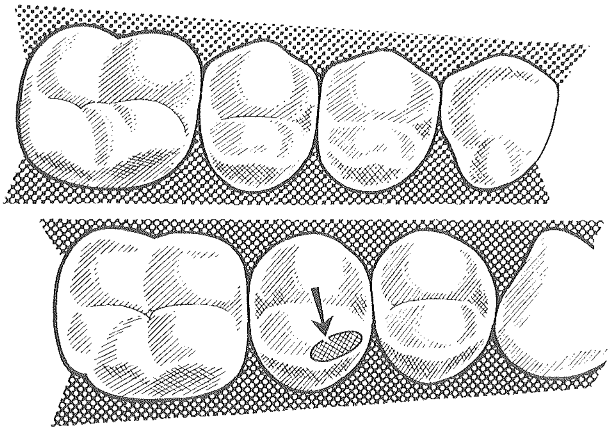

Fig. 624. After checking the prematurity shown in Fig. 623 for clearance in the lateral protrusive excursion, correct the condition by grinding the mesial slope of the buccal cusp of the lower second bicuspid, as shown.

Case 5

Description. Prematurity between the tip of the lingual cusp of the upper first bicuspid and the tip of the buccal cusp of the lower second bicuspid, in the *balancing* position only (Fig. 625).

Treatment. If the lingual cusp of the upper first bicuspid is satisfactory in centric relation, relieve the tip of the buccal cusp of the lower second bicuspid. Check the contact between the tip of the lingual cusp of the upper first bicuspid as it travels on the mesial inner aspect of the buccal cusp of the lower second bicuspid in the balancing relation. If it interferes, reduce the mesial inner aspect of the buccal cusp of the lower second bicuspid (Fig. 626).

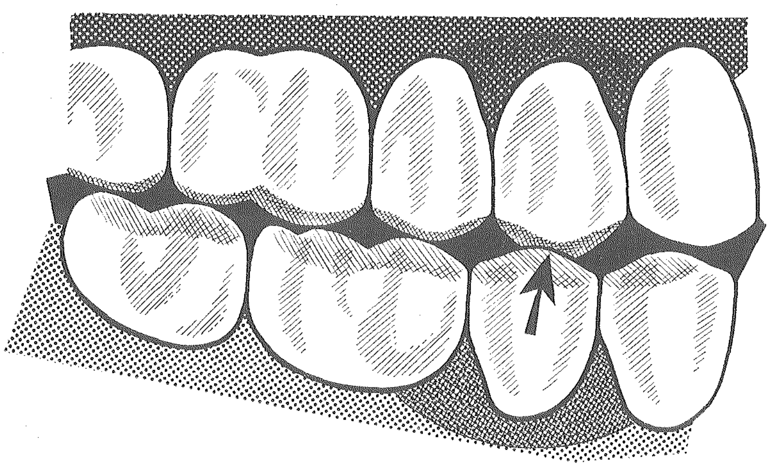

Fig. 625. Prematurity between the tip of the lingual cusp of the upper first bicuspid and the tip of the buccal cusp of the lower second bicuspid in the balancing position only.

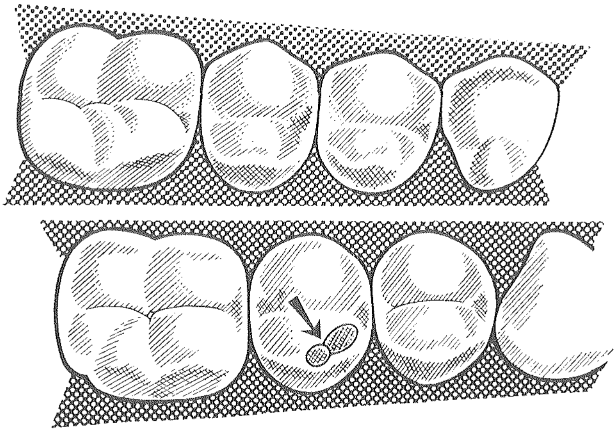

Fig. 626. Correction of the case shown in Fig. 625. If the centric relation is all right, relieve the tip of the buccal cusp of the lower second bicuspid. Also correct the mesial inner aspect of the buccal cusp of the lower second bicuspid.

Case 6

Description. Prematurity between the mesial inner slope of the buccal cusp of the upper first bicuspid and the distal slant of the buccal cusp of the lower first bicuspid, in the *working* occlusion (Fig. 627).

Treatment. First check to see whether the distal *slant* of the buccal cusp of the lower first bicuspid ends where the next mesial slope begins. If this is so, grind the mesial inner slope of the buccal cusp of the upper first bicuspid (Fig. 628).

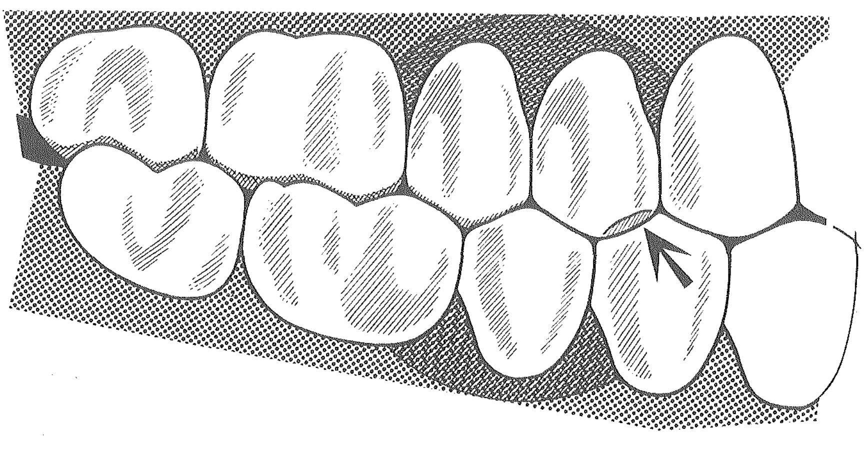

Fig. 627. Working occlusion prematurity between the mesial inner slope of the buccal cusp of the upper first bicuspid and the distal slant of the buccal cusp of the lower first bicuspid.

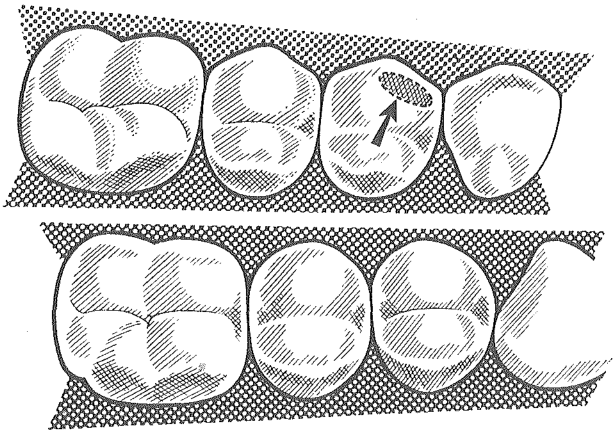

Fig. 628. To correct the condition shown in Fig. 627, grind the mesial inner slope of the buccal cusp of the upper first bicuspid if the distal slant of the buccal cusp of the lower first bicuspid ends where the next mesial slope begins, as shown.

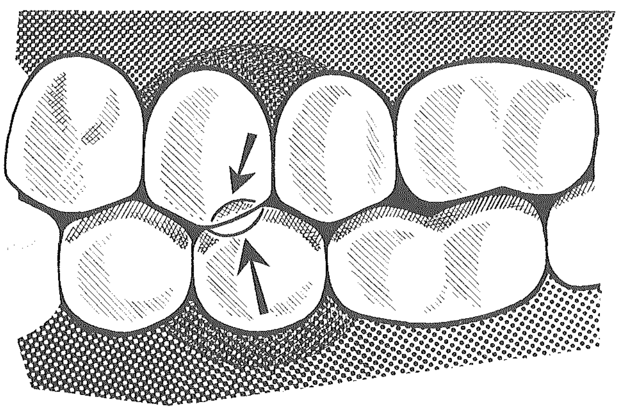

Fig. 629. Prematurity between the lingual cusp of the upper first bicuspid and the lingual cusp of the lower second bicuspid in the working and protrusive excursions.

Case 7

Description. Prematurity between the lingual cusp of the upper first bicuspid and the lingual cusp of the lower second bicuspid in the *working* and *protrusive* excursions (Fig. 629).

Treatment. First check to see whether the lingual cusp of the upper first bicuspid is all right in centric relation and in the other excursions. If it is, reduce the lingual cusp of the lower second bicuspid (Fig. 630).

If the lingual cusp of the upper first bicuspid is also premature in centric relation and in the balancing position, adjust this by grinding the upper lingual cusp to obtain the correct centric and balancing contacts (Fig. 630).

If the lingual cusp of the lower second bicuspid is still in prematurity after the reduction of the upper lingual cusp, complete the adjustment by grinding the lingual cusp of the lower second bicuspid (Fig. 630).

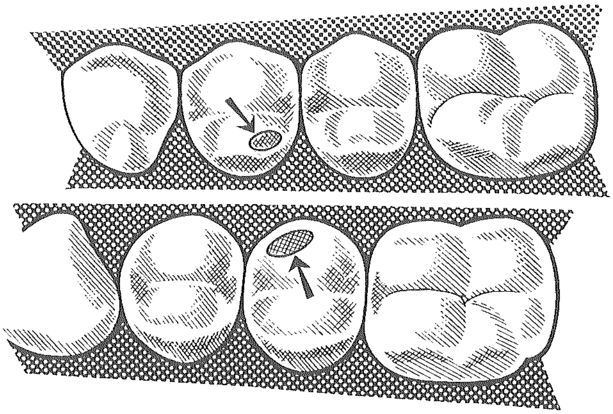

Fig. 630. Correction of the condition shown in Fig. 629. Reduce the lingual cusp of the lower second bicuspid if the upper lingual cusp is satisfactory in centric relation and in the balancing excursion. If the lingual cusp of the upper first bicuspid is premature in the centric and balancing positions, then reduce the upper lingual cusp.

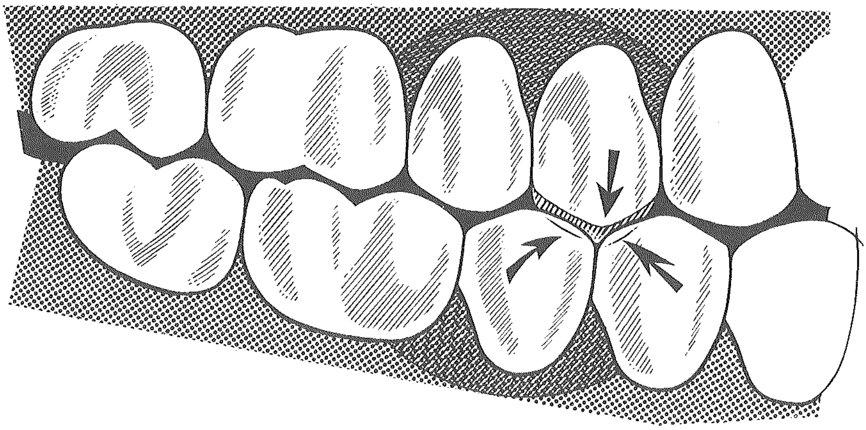

Fig. 631. Prematurity between the lingual cusp of the upper first bicuspid and the marginal ridges of the lower first and second bicuspids in centric relation.

Case 8

Description. Prematurity in *centric relation,* between the lingual cusp of the upper first bicuspid and the marginal ridges of the lower first and second bicuspids (Fig. 631).

Treatment. This prematurity can be corrected either by grinding the lingual cusp of the upper first bicuspid or by deepening the marginal ridges of the lower first and second bicuspids.

In order to grind intelligently, one must first decide whether the length of the lingual cusp of the upper first bicuspid is needed in the other excursions. If it is in premature contact in the balancing excursion and also in the protrusive, then the lingual cusp of the upper first bicuspid (Fig. 632) may be reduced. We must effect the reduction very carefully, removing a small amount at a time and

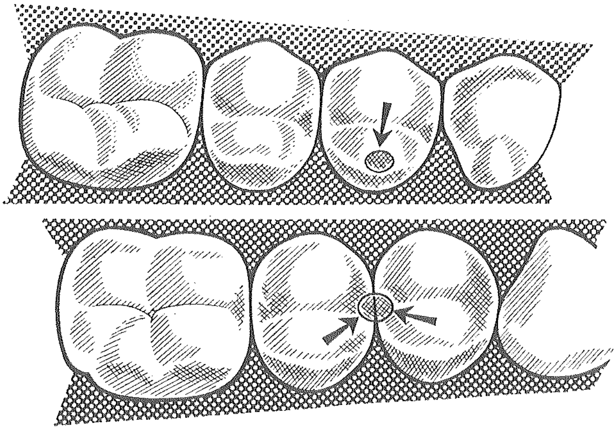

Fig. 632. Adjustment of the condition shown in Fig. 631 after checking to see whether the lingual cusp of the upper first bicuspid is needed in the other excursions. If it is premature in the balancing and protrusive excursions, then reduce the upper lingual cusp. If, after reduction of the upper lingual cusp to be in harmony in the lateral excursions, it still is high in centric relation, reduce the marginal ridges of the lower first and second bicuspids.

always checking back to centric relation. The centric contact is the most important and the one that must be preserved. As much of the lingual cusp of the upper first bicuspid may be removed as is necessary to correct the other excursions, but only as long as this cusp remains in centric contact. If there is still some prematurity in centric relation when the other excursions are cleared, complete the adjustment by reducing the marginal ridges of the lower first and second bicuspids (Fig. 632).

If during testing the lingual cusp of the upper first bicuspid is satisfactory in the other excursions, correction must then be confined to the reduction of the marginal ridges of the lower first and second bicuspids because the length of the lingual cusp of the upper first bicuspid is needed for the other excursions.

SPACED ANTERIOR TEETH

Special consideration should be given to the type of condition referred to earlier in the chapter in which the anterior teeth are spaced because of a posterior prematurity.

Description

If the patient's teeth are examined in *centric occlusion,* it will be noticed that the upper and lower anterior teeth are in tight contact (Fig. 633). There is usually some wear on the lingual surface of the upper teeth and the labial surface of the lower teeth. Upon critical examination, however, if the patient closes the jaws in the terminal hinge position and stops the closure as soon as he has a tooth contact, it will be seen that the anterior teeth are quite far apart (Fig. 634). Now

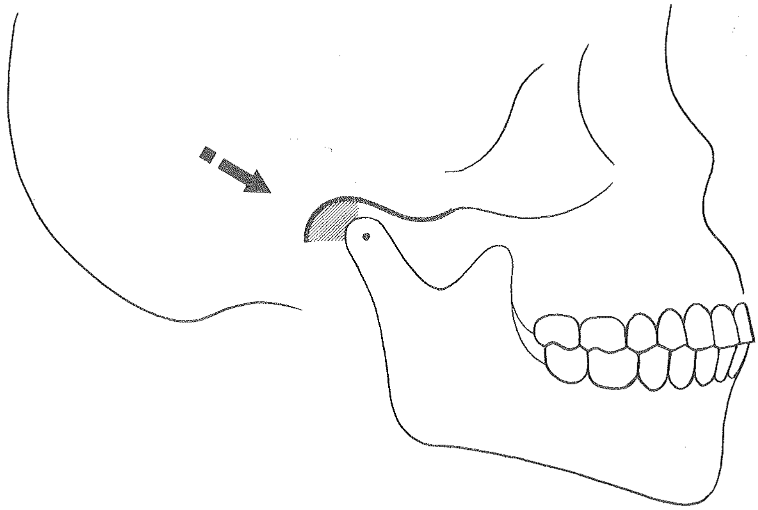

Fig. 633. The upper and lower anterior teeth are in contact when the patient is in centric *occlusion.*

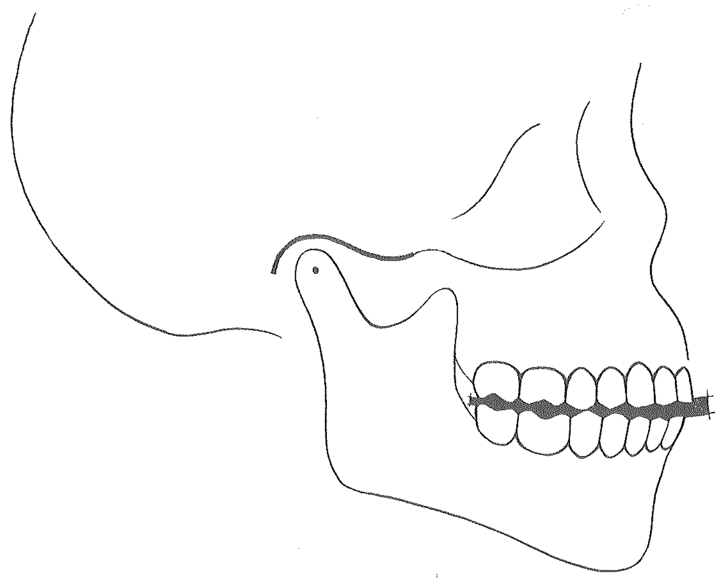

Fig. 634. When the patient is in the terminal hinge position, a posterior prematurity causes considerable separation of the anterior teeth.

if the patient closes the jaws all the way, there will be a slide or skid as the patient gets his teeth into centric occlusion. The anterior teeth will come together tightly (Fig. 635). If the patient is permitted to do this on his own while the operator holds a finger on the anterior teeth, a jarring will be felt every time the teeth come together.

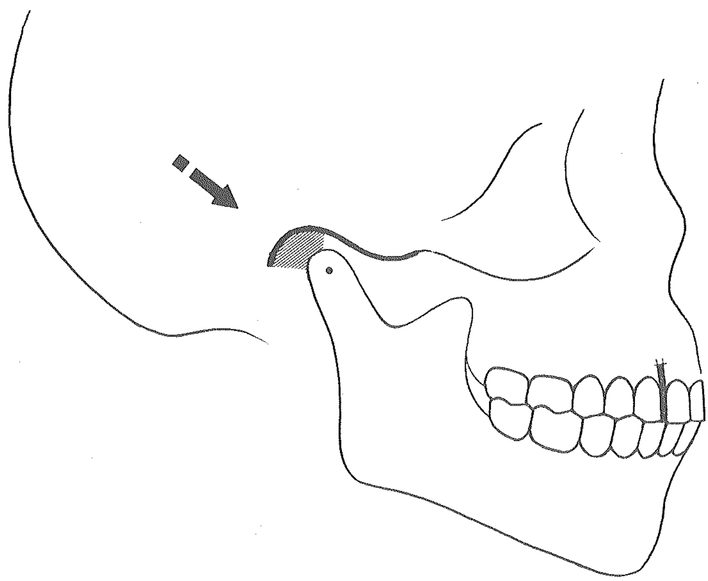

Fig. 635. After the patient slides off the prematurity, the teeth assume centric *occlusion* again, with the anterior teeth in tight contact.

The amazing thing is that, after the prematurity is removed and the patient is permitted to close the jaws on the terminal hinge arc, there is considerable space between the anterior teeth in the full closed position. It is as though we have opened the bite by grinding the teeth!

Actually what has happened is that the lower jaw has been allowed to assume its correct position in relation to the upper jaw by removal of the interference that prevented this position. The lower jaw (condyle) has been permitted to travel back and up, thus creating a space anteriorly. Once this space has been created, the teeth may very well return to their original position by the action of the lip. If the condition is of long standing, the use of a simple Hawley retainer for a few weeks is all that is needed.

Should any anterior restorations be required, they can easily be placed without excessive tooth destruction or without overbuilding the labial aspect of the anterior teeth, which may already be too protrusive. Pin-ledges are ideal for these situations.

Locating the prematurity

The first point of contact is very easily located on axis-mounted casts. The next step is to decide how to remove the prematurity in order to permit a smooth hinge closure without any tooth interference. The contact may be on a cusp slope, which necessitates its removal. It must be determined which area has to be reduced so that, with a minimum of grinding, the interference will be removed and still sufficient tooth structure maintained for centric relation. Sometimes the prematurity is directly on top of another cusp. This is more difficult to correct. It may be necessary to hollow out one of the cusps to provide a nest for the opposing cusp. This condition, if present on several teeth, may be impossible to correct by grinding.

After the area to be corrected is located on the mounted casts, it must be correlated in the mouth. This procedure requires great care. Carbon paper is the poorest material to use for this purpose—it marks everything and is self-defeating. Typewriter ribbon as used by Lauritzen* is excellent, provided that it is handled properly. The holding of the ribbon by the contacting teeth is as helpful as the actual mark. Thin plastic sheets, such as are used for test-packing dentures, are likewise practical for this procedure. Pulling the sheet held by the contacting teeth will serve to point out the premature contact like an arrow.

I prefer to use 30-gauge green casting wax cut into strips wide enough to cover the teeth. A wax strip is placed on the upper or lower teeth after it is determined from the mounted casts where the correction is needed. The patient is guided in the closure until the wax is thinned or penetrated. The point of penetration is easily located with an explorer. While the wax is still in position, a mark is made through the point of penetration with an indelible pencil. When the wax is removed, the area of contact is clearly visible.

When certain beyond a doubt that the exact area has been located, grind the area very carefully, using a small inverted cone stone or diamond point. The corresponding area on the casts can be removed.

Now the next area of adjustment is located. After four or five such adjustments on the casts, it will be necessary to take new impressions and a new centric relation record. The new casts are again carefully studied for new areas of premature contact, and the entire procedure is repeated until the amount of correction desired is achieved.

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CHAPTER 23

*Mucostatics**

Current prosthetic views regarding soft tissue treatment in impression procedure fall into two schools of thought.

Stress type versus mucostatic type of impression

There are those who believe that the mucosa will yield and change its outline form when force is applied on the denture. Consequently, they feel that so-called tissue positioning should be anticipated and incorporated in the impression. Such an impression is generally classified as the stress type.

Proponents of the opposite view, namely, that soft tissue will not give, adhere to the philosophy of the mucostatic principle, which demands that the impression and denture base be accurate negatives of the soft tissue in its normal passive form. An impression which fulfills this requirement is known as the mucostatic type.

The question is naturally raised, "How is it possible for diametrically opposed concepts to achieve objective results?" It is only through a study of the histological and physiological characteristics of the parts involved and the applied physical laws that this apparent enigma can be understood.

Since tissue is composed of liquids and solids, it may be said that, for prosthetic purposes, it cannot be compressed but may be displaced in its free state. The terms "compression" and "displacement" provide the initial clues for explaining the seeming results of both types of impressions.

Application of Pascal's law and corollary

Compression may be defined as the act of reducing the volume of matter. Displacement applies to a change of position. Since there is no reduction in the volume of tissue with either type of impression, the fundamental difference lies in the effect created by soft tissue displacement. Obviously, any tissue position will produce a stable impression, for Pascal's law and its corollary apply to an

*Prepared with the assistance of Dr. William R. Dykins, Nanticoke, Pa.

enclosed liquid or semifluid, regardless of position. The stabilization point occurs whenever there is an intimacy of contact between the impression and the mucosa. The same phenomenon is witnessed in an accurate base.

In order to choose the type of impression which is compatible with biological realities, we must examine the histological factors. Tissue, being predominantly liquid, is elastic. Consequently, it tends to return to its normal form once the distorting stresses are removed. Herein lies the explanation of the rebounding movement observed under the stress type of impression or base. This movement is what prosthodontists have chosen to term the resiliency factor of soft tissue.

It has already been pointed out that any tissue position will suffice to obtain the stabilization point. Therefore, in order to avoid this rebounding characteristic, it is sensible to try to capture nature's own tissue position in the impression. It is also sound biological practice not to disturb the cells.

With the knowledge that Pascal's law and its corollary do apply to soft tissue and that potential soft tissue movement can only be parallel to its bony support unless it is intimately confined, our attention is directed to what importance can be ascribed to the flange area.

The critical problem of all impression base procedures is not to prevent vertical displacement of soft tissue, but how best to resist lateral movement of tissue to bone, with its consequent loosening of the base. Mechanical resistance to this movement is dependent upon the shape of the basal coverage, to what degree the flanges can be employed, and the angle of the applied force. One can readily see that since the shape of the part is unalterable—and thus the usable flanges are limited—control of the applied force by sound articulation offers the greatest potential in coping with this problem.

INTERFACIAL SURFACE TENSION

The retention of a mucostatic appliance is predicated on the phenomenon of interfacial surface tension. This may be defined as that bonding force which is exhibited when two glass slabs are moistened and pressed together. The glass slabs are not easily pulled apart, but one can slide on the other with great ease. The thinner the fluid film, the greater will be the surface tension. This is why an accurate fit is so necessary. The more accurate the fit, the thinner the fluid film, and consequently the greater the retention—". . .capillary forces are the principal physical forces involved in denture retention."[1] Because the greatest surface tension force is exhibited at right angles to the surfaces, it is important to use all the horizontal area possible. Since the weakest force is manifested when the pull approaches parallelism to the long axis of the liquid film, it is necessary to take advantage of irregularities in the surface. The flanges of a denture counteract this lateral force of displacement. Dykins has compared the lingual flange of a lower denture to the flange on a railroad car. The latter prevents the car from sliding sideways but does not support any of the load.

The film layer forms a meniscus at the edges of the contacting surfaces. Two glass slabs can be readily separated by running water on their edges. This destroys the meniscus, and the fluid layer thickens, with a resultant reduction of surface tension. The same phenomenon occurs when an impression is flooded by a stream of water to facilitate its removal. It is because of this phenomenon that the edges of a denture base are kept to a minimal bulk. This type of edge reduces the accumulation of saliva at the periphery and thus prevents the destruction of the meniscus and the resultant loss of surface tension.

OUTLINE OF BASE AREA

To obtain the maximum retention of a base, certain points must be observed. We should utilize as much horizontal area as possible without encroaching on muscle tissues. If the muscle tissues are distorted, they will in turn displace the tissues on the ridge areas, and the accurate fit will be lost. We should take advantage of any irregularities or use a flange to counteract the sliding of the base horizontally (the direction in which the least surface tension is exhibited). We should have the most accurate counterpart of the ridge areas as possible so that the fluid film will be thin. To protect the integrity of the fluid film meniscus, we should form thin, dull edges on the appliance.

By extending the base outline to the proximity of the muscle attachment, it is possible to obtain some retention from the muscle action. This is not to imply that it is necessary to obtain a so-called peripheral seal because this would be impossible without some distortion of the adjacent tissues. It simply means that patients learn to use their muscles to help retain an appliance in place. Therefore, the idea is to design the outline so that the patient can reach the base edges by muscle contraction if he so desires.

To understand how the mucostatic principle operates, let us review the tissue characteristics which make this possible.

Tissue is elastic. This means that when tissue is pressed, it resists deformation. As soon as the pressure is removed, it returns to its original shape and position. Because of this characteristic, it is extremely important to secure an impression of tissue without distorting it. When tissue is distorted, it seeks constantly to regain its normal position. An impression which is pushed to place displaces tissue of necessity. The displaced tissue, because of its elastic property, tends to return to its normal position and, in so doing, moves the impression. The same thing occurs if a base is made from the distorting impression. It will be lifted from its original position. It is the minimizing of this phenomenon that distinguishes the mucostatic from the stress type of impression. The constant movement of a base made from a distorting impression not only precludes the possibility of establishing an accurate articulation, but is also responsible for the rapid necrobiosis so frequently seen when this type of impression is used.

Tissue is composed of solids and liquids. For all practical purposes it cannot be compressed. Soft tissue contains a great deal of water. According to Pascal's law, when a liquid is confined, any pressure transmitted to that liquid is equally and instantly transmitted in all directions. Tissue is made up of cells. Each cell encloses fluid. The cells are attached together and normally cannot be separated. If the tissue is accurately contained in a base on one side and in immovable bone on the other, for all practical purposes it is wholly contained. Therefore, Pascal's law and its corollary do apply. When pressure is applied to the confined tissue, either all of it moves or nothing moves. It will not move in part. The tissue assumes the rigidity of the container, regardless of how mobile it may be when not contained. It cannot be compressed, only distorted or displaced. Thus, a mucostatic base is as firm on soft tissue as it is on solid bone when vertical force is applied.

Because of the anatomy of the lower ridge area, it is much easier to construct a lower mucostatic base. The lingual anatomy permits the placing of a flange which prevents the base from skidding.

On the upper mucostatic base, all the flanges are so placed that they cannot prevent the forward skid produced by the action of the mandible against the base. Occasionally there is a favorable ruga area that tends to counteract this horizontal movement. In addition, the dissipation of the articulating forces should tend to position the base vertically into a more intimate contact with the tissue.

Practical experience dictates that a compromise must sometimes be made. This is frequently the case in the construction of an upper mucostatic base, where it may become necessary to place a slight bead in the postdam area. Although this is a violation of the strict mucostatic principle, the bead in no way resembles the so-called postdam usually seen. Actually it is a finishing line that slightly displaces the tissue—primarily to prevent the saliva from pumping under the upper base and increasing the thickness of the fluid film. When to employ this postdam effect is determined when the impression is tested for forward horizontal stability.

TISSUE BASE CONSTANT

What is the importance of a mucostatic base?

The mucostatic base has made it possible for us to arrive at a condition which Dykins has termed the "tissue base constant." In other words, the mucostatic principle permits the construction of a base that maintains a constant relation to the supporting tissues. This is what enables us to attempt to solve the articulation problem in both full and partial dentures.

The tissue base constant is most evident in the precision attachment removable appliance. Here, if one actually tries to construct a prosthesis that will contribute to the articulation and not just fill in the spaces, the importance of mucostatics is demonstrated most vividly. A mucostatic base will maintain its relationship to the natural teeth during construction and afterward during function. As a matter of fact, this is borne out even more dramatically by the many mucostatic appliances that have been constructed without natural tooth retainers of any kind. These claspless partial dentures continue to maintain a tissue base constant, so that even after years of service a piece of testing cellophane can be held with equal tension between the occlusal surfaces of the removable prosthesis and the occlusal surfaces of the adjacent natural teeth.

The tissue base constant is the link between the temporomandibular joint and the occlusal surfaces of edentulous restorations. "The tissue base constant originates in the impression, is delivered by the base and is perpetuated by the articulation."[2]

The importance of proper articulation was forcefully demonstrated when mucostatic bases were introduced into dentistry. The nonyielding bases demanded a proper relationship of the two members and an accurate alignment of the occlusal surfaces. When improper articulation was attempted on them, these passive-type bases became violent! Before teeth were placed on them, they had been most comfortable and had withstood all possible testing pressures without causing the least distress. This was as it should be, for if bases are constructed to duplicate the nondisplacing impressions, there is no reason for them to be uncomfortable. But when improperly articulated teeth were placed on the bases, the patients could not tolerate them! Why? Because the passive relation of the bases to the tissue had been disturbed. The result was either the complete separation of the bases from the tissue or soreness of the soft tissues.

The tissue base constant emphasized the importance of articulation and initiated a way of establishing it.

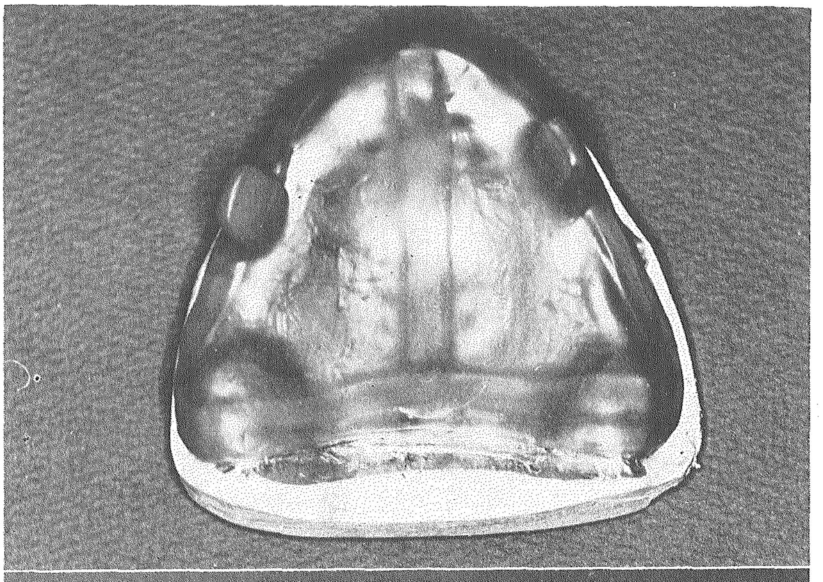
If one understands the principles involved in mucostatics, it is not too difficult to arrive at a technique for carrying them out. Let us briefly review the various approaches to the realization of these principles and point out the advantages and disadvantages of certain techniques.

TRAYS

It is essential to have an appropriate means of carrying the impression material to the mouth. Custom-made trays are well worth the time and effort involved in their construction. Less desirable are stock trays of any kind, for it is rarely possible to select one that will be adequate for the job.

The tray is constructed on a preliminary cast which should be obtained with a minimum of tissue distortion. This can be accomplished with either alginate or hydrocolloid. Two layers of Tenax* baseplate wax are adapted to the cast over the area intended to be covered with the base. (For partial dentures, a single layer of Tenax will provide ample spacing because usually there are anterior teeth for guidance in seating the tray.) A sheet of 1/1,000 tin foil is burnished over this wax spacer. After lubricating the tin foil with some petrolatum, adapt a sheet of Tenax wax to form the tray (Fig. 636). Place a small handle in the anterior vault area of the upper tray and two short handles on each side

*S. S. White Dental Manufacturing Co., Philadelphia, Pa.



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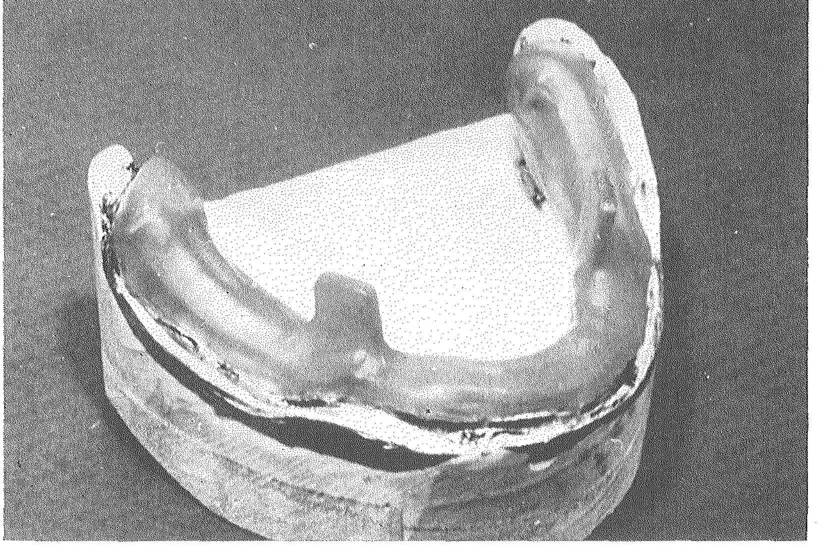

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Fig. 636. Wax pattern for an upper tray.
Fig. 637. Wax pattern for a lower tray.

in the bicuspid area of the lower tray (Fig. 637). These wax patterns are then invested in a casting investment, burned out, and cast in aluminum (Fig. 638).* Although they take a little time, trays thus constructed are most practical because they are light, thin, and strong. Moreover, if an impression has to be retaken, this

*Refer to Chapter 4 for the procedure for casting clutches.

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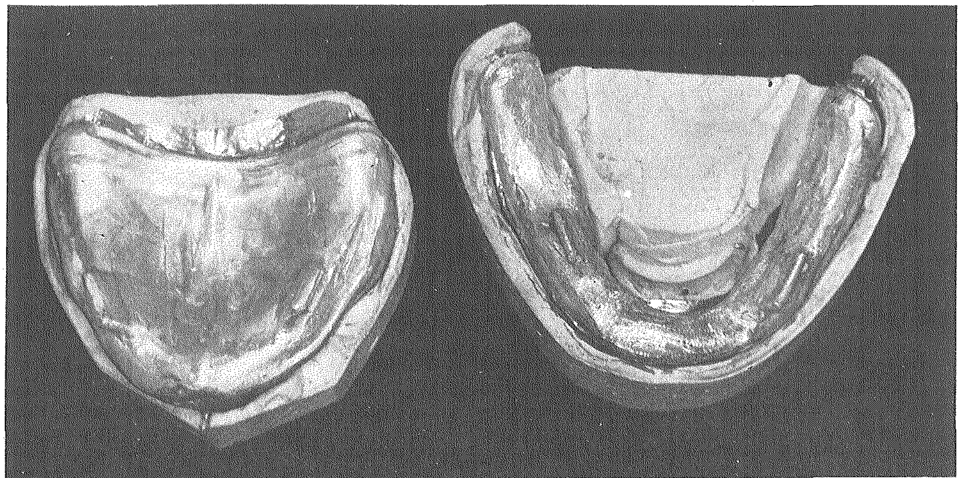

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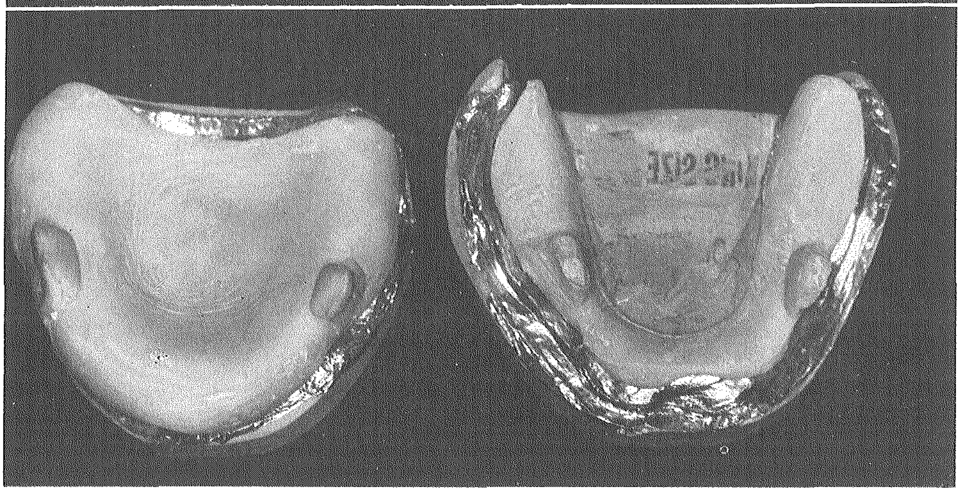

Fig. 638. Completed aluminum trays.
Fig. 639. Trays made from quick-curing acrylic.

type of tray can easily be cleaned by immersion in warm water (160° F.) for a few minutes.

A custom tray can also be fabricated with one of the self-curing acrylic resins. Ontray* and Formatray† have been used successfully for this purpose. The material is mixed in a glass jar and allowed to polymerize for a short time until it can be handled as a dough. It is then pressed between two glass slabs to form a sheet and adapted to the relieved cast and trimmed to the desired outline. Handles can be conveniently attached in the areas previously mentioned (Fig. 639).

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*William Getz Corp., Chicago, Ill.
†Kerr Manufacturing Co., Detroit, Mich.

MATERIALS USED FOR MUCOSTATIC IMPRESSIONS

Zinc oxide and eugenol material

The most suitable material for a mucostatic impression is a zinc oxide and eugenol cement, such as Ackerman's,* because of the following characteristics:

1. It is softer than the softest tissue that might be encountered.
2. The setting time can be controlled because it has a fast and a slow setting liquid which may be mixed to suit the locality (temperature and humidity affect the setting time).
3. It sets to a hard, brittle impression, which can be trimmed and returned to the mouth for stability confirmation. Further, no separating medium is needed when the cast is poured.
4. Being a zinc oxide and eugenol material, it absorbs a slight amount of moisture from the tissues, thus affording the thinnest possible space between the impression and the tissue (the thinner the fluid film, the greater the interfacial surface tension).

In addition to Ackerman's, there are several other zinc oxide and eugenol materials which are suitable for a mucostatic impression. One should make sure, however, that the material selected has the properties just enumerated.

Alginate material

Some men have successfully used alginate material for mucostatic impressions. Properly handled, it can produce very satisfactory results. The same trays are necessary, but the material is easier to mix and use. It has another advantage in that it makes it possible for one to run an investment cast and thus avoid the duplicating procedure which is time consuming and which may introduce some inaccuracies. The one disadvantage with alginate material is that the impression cannot be returned to the mouth for a stability test.

Rubber base material

Rubber material is likewise being used for mucostatic impressions, and here, too, custom trays are required. The medium-thick material offers about the right consistency for a mucostatic result. This material is not so difficult to handle as the zinc oxide and eugenol—although, of the three, the alginate is the simplest to control. With rubber material, the investment cast can be run directly into the impression. Moreover, several casts may be obtained from the same impression. A disadvantage is that a rubber base impression cannot be satisfactorily returned to the mouth for testing.

A possible objection to the use of this material is the fact that the mouth must be absolutely dry. The material does not absorb moisture, and slight inaccuracies may develop if any moisture is present. On an upper impression,

*Ackerman Dental Co., Santa Monica, Calif.

tiny bubbles will be seen in the posterior palatal area where the glands have secreted some saliva before the impression material has completely set. To eliminate the saliva factor, the patient should be premedicated with atropine sulfate or Banthine bromide. Especially recommended is Banthine with phenobarbital*; each tablet contains 50 mg. of Banthine and 15 mg. of phenobarbital. One tablet an hour before appointment time and one tablet as the patient is seated in the chair will produce a dry mouth and relax the patient to a degree.

MIXING IMPRESSION MATERIAL

The mixing of the impression material may require some practice. All batches have slight variations, and therefore a test mix should be made before a new batch is used for practical appliances. Since only one test mix is necessary per batch, it is economical to buy the large-sized package.

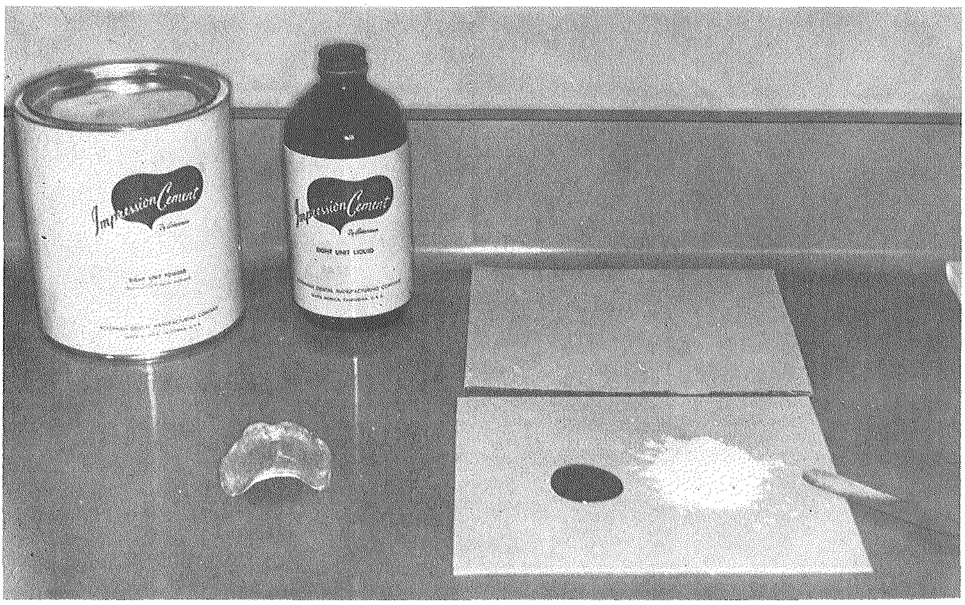


Fig. 640. Ackerman's impression material on a slab ready to be mixed.

The proportion of powder to liquid is about three to one. On a large, wax-free mixing pad, place about four scoops of the powder (Fig. 640). (A scoop is furnished with the material.) Alongside this loosely piled mound, pour enough liquid to cover roughly an area about the size of the base of the powder mound. Another pad—this one empty—should be within easy reach.

With a relatively stiff spatula, bring approximately three fourths of the powder to the liquid and begin to mix them together. When the powder has begun

*G. D. Searle & Co., Skokie, Ill.

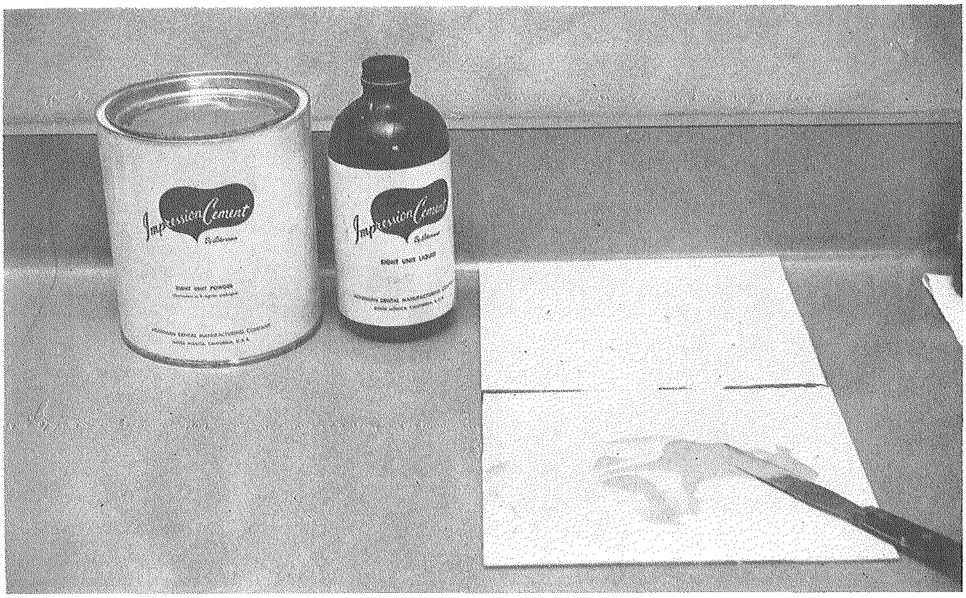


Fig. 641. Excess powder is removed from the mixing pad and dumped on a second empty pad.

to wet down, commence the spatulation. Here one can judge whether enough powder has been incorporated into the mix. If more powder is needed, quickly bring some of the remaining one fourth into the mix. When it appears that the proper consistency has been reached, the unincorporated powder is dumped onto the empty pad, leaving an unencumbered area on which to spatulate (Fig. 641). Spatulate the mix until it is smooth and then load the tray.

The discarded powder must not be returned to its original container although it may be stored in another can and used for clutch cementation. There is always the possibility that small particles of it may have come into contact with the liquid, and these would make the powder lumpy for the next use. Although this would be all right for clutch cementation, it would be disastrous for impression-taking.

TAKING THE IMPRESSIONS

The patient needs to be instructed as to his behavior while the impressions are being taken. He must remain still; he must keep his tongue and cheeks perfectly relaxed.

Lower impression

The patient's mouth is packed with 6 × 6 gauze squares which have been formed into rolls. The ends of the gauze are tucked into the roll to prevent any loose fibers from remaining in the mouth when the roll is removed. A roll is placed on each side of the ridge in the cheek area and brought to the anterior

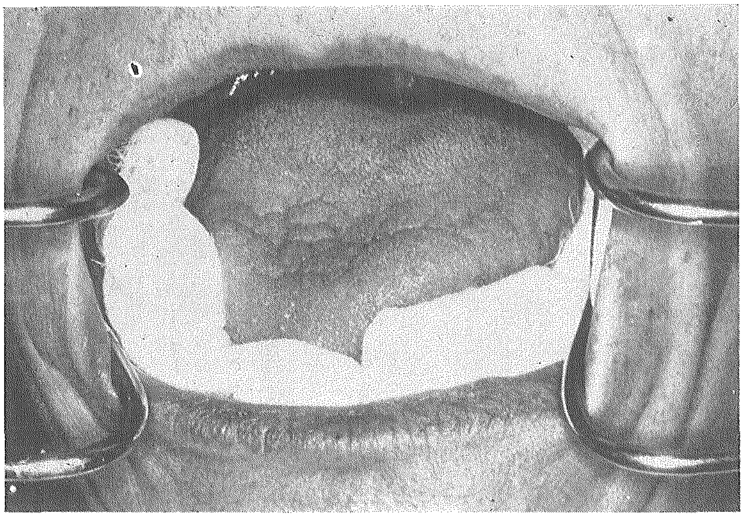


Fig. 642. Gauze wipes, 6 × 6 inches, used to keep the mouth dry while the impression paste is mixed.

buccal fold. A third roll is placed on the lingual area and held in place with a saliva ejector (Fig. 642).

As soon as the tray is loaded, the assistant quickly removes the saliva ejector and the gauze rolls. The loaded tray is placed in position, and the patient is told to extend his tongue and then relax it. At the same time, with the index fingers push the cheeks outward, then remove the fingers, and instruct the patient to sit perfectly still and to keep his cheeks and tongue still.

The extending of the tongue pulls out any lingual tissue that may have become trapped under the tray. It also centers the tray. The same thing is done buccally when the fingers push the cheeks outward.

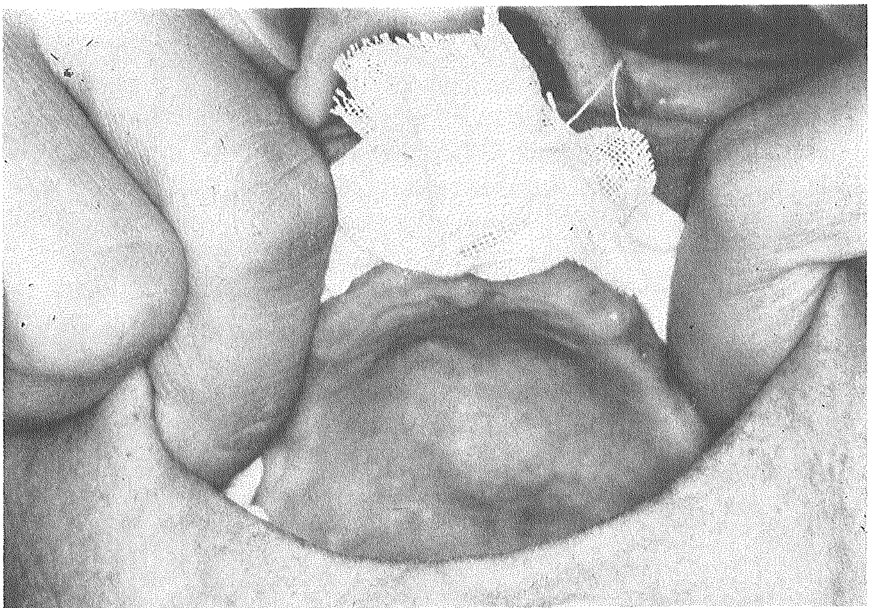
After a few seconds, it is permissible to replace the saliva ejector in the mouth, but it must be held away from the tray until the material has had its initial set and cannot be distorted.

When the material is completely set, help to loosen the impression from the ridge by flushing it with cold water. Then lift it out and examine, trim, and test it for stability. The stability test is made by "walking" the fingers around the impression. There should be no give in any area.

Upper impression

Gauze is packed around the buccal surface of the upper ridge (Fig. 643). The saliva ejector is put in place, and the palate is wiped with another piece of gauze.

Now load the upper tray, piling more material in the center of the vault. In order to keep the material properly piled in this position (assuming a correct consistency), we must keep the tray in motion, i.e., turning it over as we move



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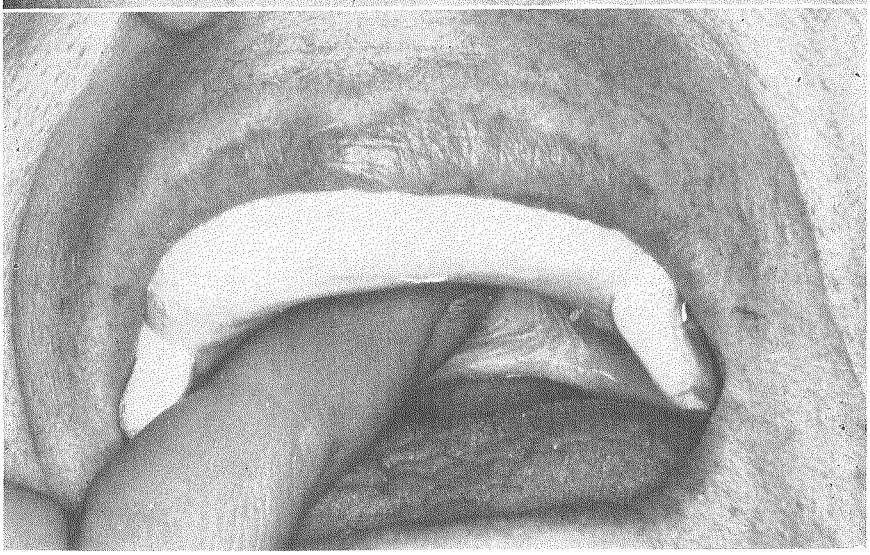

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Fig. 643. Gauze wipes, 6 × 6 inches, used to keep the upper areas dry.
Fig. 644. Gentle support of the upper tray until the initial set takes place.

it toward the mouth. The assistant removes the gauze packs and may wipe a small amount of the impression material on the center of the vault. This is important if the vault is deep. Now quickly place the tray in the mouth, tease it to place with a slight vibrating motion, and then release the finger pressure. Again, the cheeks are snapped apart to prevent their being trapped between the tray and the ridge area. To prevent the tray from dropping down, gently support it until the initial set has taken place (Fig. 644).

After the material has set, examine the buccal flanges. Because the upper tray has a very short flange, it sometimes happens that a thin layer of material will crawl to the desired height but will be too thin to remove. If this is the case, prepare a somewhat heavier mix and apply it under the lips and in the cheeks with a wipe of a cement spatula. When this hardens, flood the impression with some cold water and remove, trim, and test it for stability.

POURING THE CAST

It is advisable to pour the cast as soon as possible, regardless of the impression material used. Some are less critical than others, but none of them improves with age.

The impression is poured in an investment of choice, depending upon the material to be used for casting. This eliminates the errors that might occur during any duplicating process. We are aware that a miscast will mean a new impression, but this calculated risk is worth while.

The peripheries of zinc oxide and eugenol impressions do not have to be supported, but it is better to box them (Fig. 645). The investment is carefully mixed and vibrated into the impression. The impression is not inverted, for the weight of the unset stone would pull it away from an inverted impression. This is true of any impression.

The peripheries of alginate and rubber impressions must be supported. This is accomplished by applying a very thin mix of stone around the outside edges of the peripheries. When the periphery-supporting stone has set, a suitable separating medium is carefully applied to the stone. Now the impression is

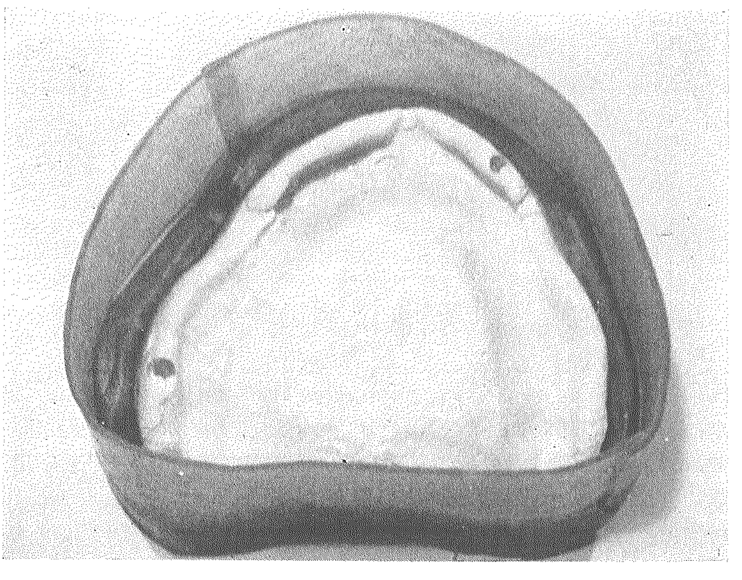

Fig. 645. A boxed impression makes a better cast.

poured in an investment of choice. If the base is to be cast out of aluminum or gold, use model Cristobalite.* If it is to be a nonprecious metal casting such as Ticonium, then Ticonium's special refractory material† must be used.

When the investment cast is completely set, it is carefully separated from the impression. The zinc oxide and eugenol impression must be handled with special care to avoid damaging the surface of the investment cast. The impression material should be thoroughly softened before any attempt is made to remove it. The cast and investment are placed in warm water (about 180° F.) and kept there for 3 or 4 minutes. Then they are separated. If the water is warmer than 180° F., the impression material will stick to the cast, and it will be impossible to completely remove it without causing damage to the surface of the investment cast. The rubber and alginate materials, however, will separate with ease, and this is one of their desirable qualities.

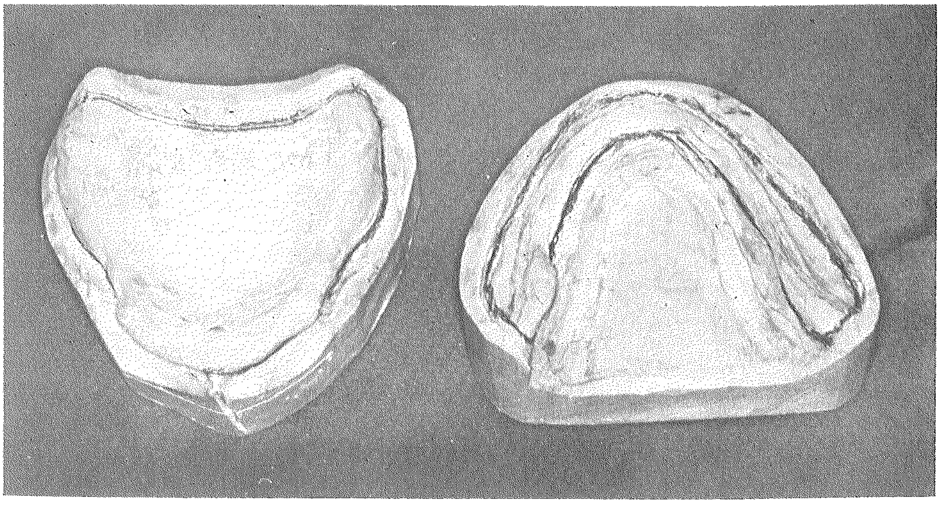

Fig. 646. Outline of the base areas to be included in the dentures.

OUTLINE OF THE BASE

When the investment cast has thoroughly dried, determine the outline to be used. To outline the denture-bearing areas properly requires some thought and experience. The general rule is to cover as much of the horizontal bearing area as possible *without* impinging on any muscle attachments (Fig. 646). Remember that the periphery of the casting is to be made thin. Thus, impingement on any muscle attachment will not be tolerated. Even more important is the fact that impingement is a violation of the mucostatic principle which holds that tissue must remain in its passive form.

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*Kerr Manufacturing Co., Detroit, Mich.

†Ticonium, Division of Consolidated Metal Products Corp., Albany, N. Y.

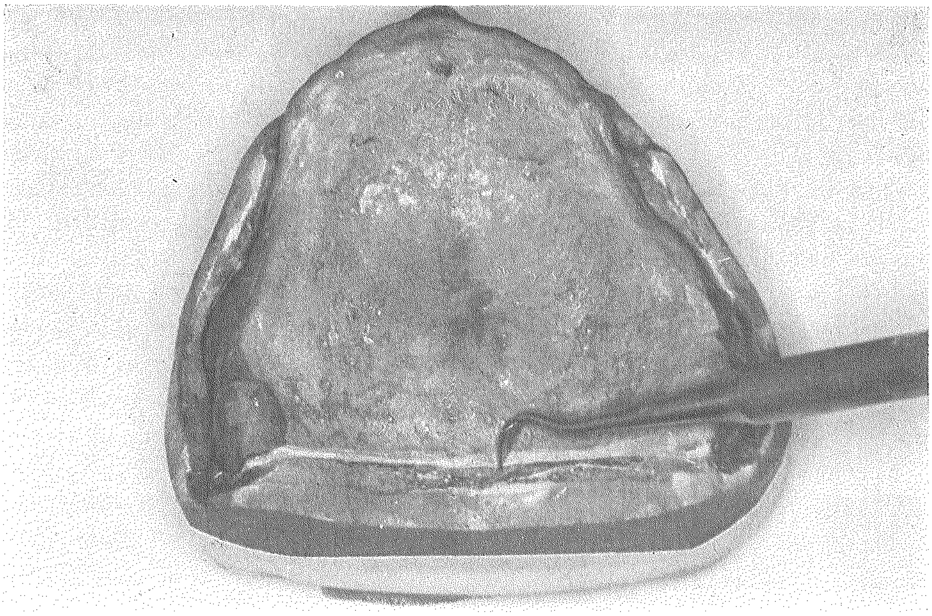

Fig. 647. The instrument used to establish a *slight* posterior bead.

The lingual flange of the lower base does not have to be too long. We have found, though, that patients are more aware of the lingual edge of the denture if it is too short. Again, muscle freedom is of greatest importance.

The same principle applies to the buccal and labial outlines of the upper base. Posteriorly, the usual posterior limits are observed although here they are not so critical as the postdam advocates claim. Take advantage of the distal slopes of the tuberosites if they are present. The distal limit in the midline should be anterior to the foveae, for these are openings of salivary glands, and the saliva would tend to thicken the fluid film and destroy the retention.

It is at this time that the small bead for the posterior border of the upper base which we mentioned earlier is established. It should be extremely *slight!* If it is too heavy, it will only have to be removed later because it will not be tolerated. To form this bead, take a spearheaded amalgam carver and gently scrape a very thin line—not more than .25 mm. in width and depth—across the posterior border (Fig. 647).

The casts are now ready to be waxed for the casting pattern.

WAXING AND CASTING THE BASE

Lower wax pattern

The type and thickness of the wax used to form the pattern will depend upon the material to be used in the base. When the base is to be made of gold, the lower pattern is made of 26-gauge casting wax.

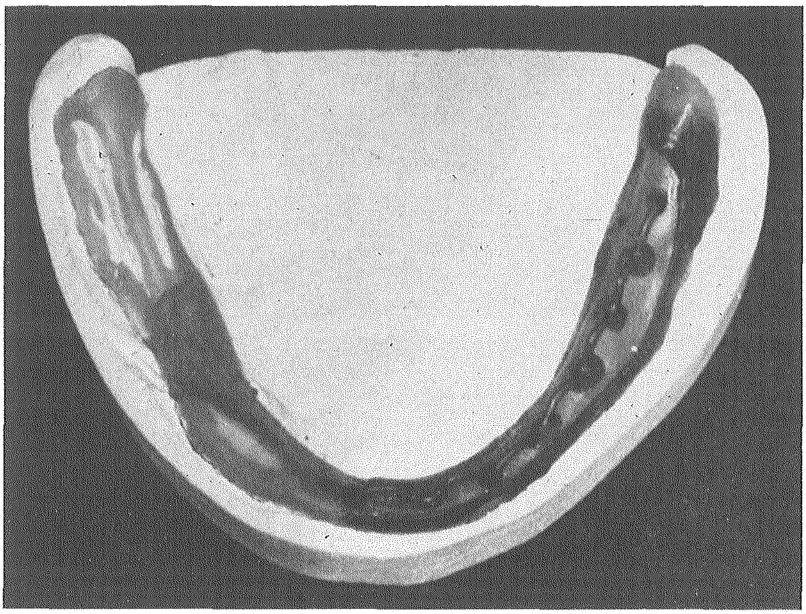

Fig. 648. Combined waxing steps for a lower base.

Caution must be exercised in adapting the wax so that it does not become thinned out as it is applied to the cast. Sprue forms of 18-gauge wax may be used at the periphery to apply a finishing line. These are tacked to place and then gently flattened out with a *warm* (not hot) spatula, care being taken to maintain the undercut for the retention of the acrylic. Additional retention is established over the wax pattern with plastic retention forms or by the placement of small wax mushrooms (Fig. 648). Some men prefer to omit the peripheral finishing line, the idea being to reduce the amount of finishing necessary on the casting. This is an important consideration because any finishing is likely to cause some inaccuracy in the base. For this reason, it should be kept to a minimum and even then should be carried out with considerable care.

The lower pattern is best sprued from the anterior ridge area. Additional sprues may be run from the main sprue to each heel. Distal vents may also be employed if desired.

The wax pattern and investment cast are invested in model Cristobalite in a long, oval ring with an asbestos liner. The flask is *slowly* burned out and soaked for 45 minutes at 1200° F.; after which, it is cast in an end-over-end centrifugal casting machine.

Upper wax pattern

The upper wax pattern is made of 28-gauge casting wax when gold is to be used. Care must be taken to avoid thin spots when the wax is being adapted to

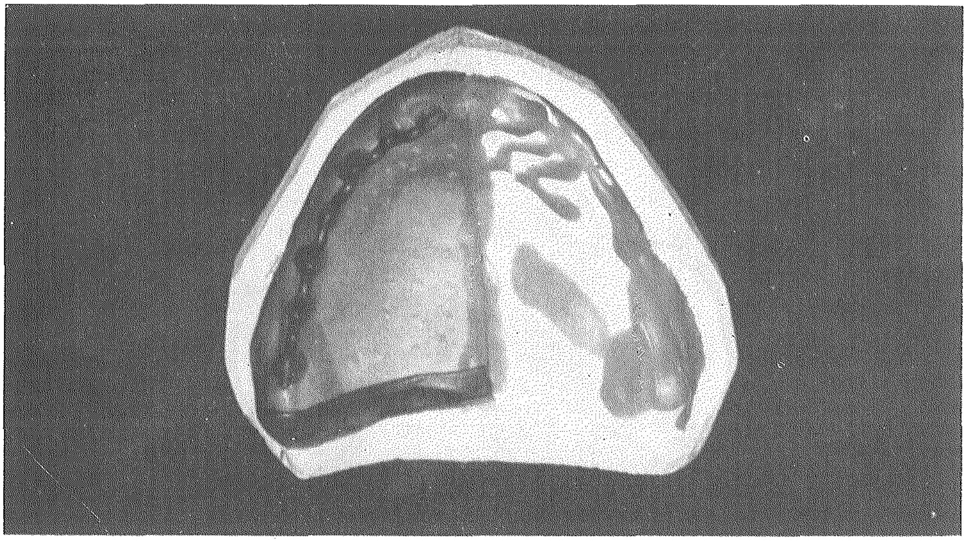

Fig. 649. Combined waxing steps for an upper base.

the upper investment cast. It may be advisable to place a very thin layer of sticky casting wax in the protruding areas of the rugae. If it is desired, one may wax over the 28-gauge sheet to re-emphasize the rugae.

A posterior finishing line is always used. The rest of the upper periphery may or may not have a finishing line. Here again, retention is established with plastic retention forms or with small wax mushrooms (Fig. 649). It is preferable to cover the entire palatal area with plastic to minimize the machining of the casting. However, if the palatal area is to be in metal, it must be polished in the wax to reduce the amount of machining necessary. The machining and polishing must be done with extreme care to avoid warping the base.

If the casting is to be made of aluminum,* the same waxing technique is followed, but the pattern must be thicker. Tenax baseplate wax provides a suitable thickness. The lower base should be reinforced in the anterior arch region for additional rigidity.

Handling an aluminum base

The casting of an aluminum base requires greater care than the making of an aluminum clutch or tray. The burn-out should be a slow and thorough procedure. The burned-out flask is allowed to cool to about 200° F. and is then cast with *new* metal. If cast at any higher temperature, the casting may have holes in it.

The removal of sprues and any machining and polishing must, of course, be

*The aluminum used is called D214 and is a special alloy manufactured by the Aluminum Company of America.

done very carefully. This is true for any metal casting. One method of controlling warpage is to grind and polish under water. This prevents any heat from developing during the process.

If the casting is to be of Ticonium, it is advisable to send the investment cast (made of a special Ticonium investment) to a reliable Ticonium laboratory—but one which is thoroughly familiar with mucostatic castings—for they require special handling.

After many years of experience with the three types of castings—gold, aluminum, and Ticonium, we have found that Ticonium cast bases produce the finest results over a long period of time.

Construction of remount platform

As soon as the castings are ready to be tried in the mouth, remount casts are made for each base. They serve two purposes. They are used to relate the casting to the articulator, and they will act as a check to determine whether any changes have taken place in the castings. Metal bases can become so badly warped by careless processing and polishing of the acrylic as to render them useless.

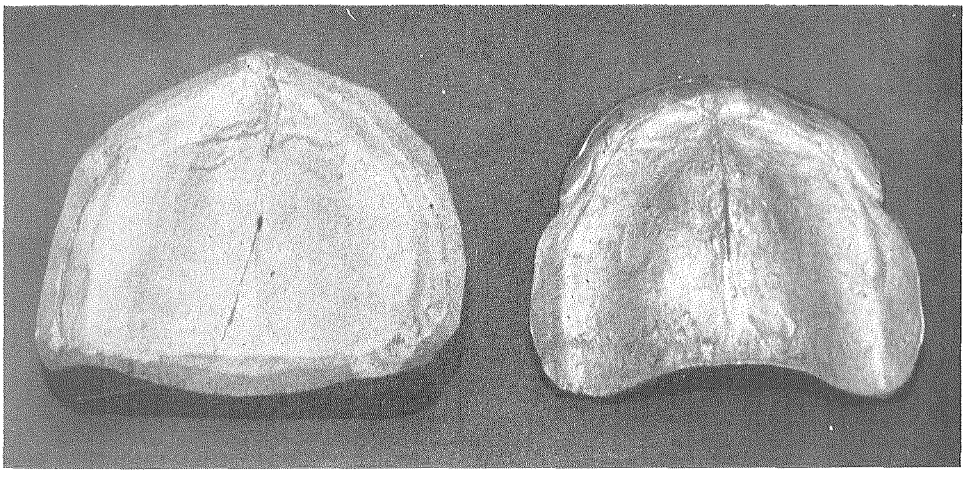

Fig. 650. A remount platform for an upper base.

If the remount platform is to be accurate, it must be carefully constructed. Any sharp undercuts should be relieved with water-soluble molding clay or wet pumice. However, in order that there be as much contact as possible with the stone, only the severe undercuts should be relieved. All the peripheries should be in accurate contact with the cast (Fig. 650).

CONCLUSION

If the foregoing principles and precautions are observed, it should be possible to produce a base that is stable, retentive, and comfortable. There is no reason why a base per se should cause any discomfort. It is the dissipation of the masticating forces that will determine whether a base is going to be comfortable. It is the teeth that are placed upon the base and how they are placed which will be responsible for the future status of the base. So, it should be obvious that any soreness which develops after the prothesis is completed must be caused by the articulation of the teeth.

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CHAPTER 24

*Full dentures**

Role of gnathology in full-denture construction

The construction of full upper and full lower dentures calls for the same care and skill employed in the treatment of natural teeth and involves the same principles. Gnathological procedures are just as important in edentulous patients as in dentulous ones because, regardless of the presence or absence of teeth, the patient's jaw movements—his masticating cycle—are identical.

Nevertheless, since these principles are difficult to incorporate in treatment, too often they are set aside as impractical and unnecessary. As a result, compromises are made and all sorts of procedures are substituted, and the patient has to attempt to wear restorations that are absolutely foreign to his requirements. The amazing fact that patients will doggedly wear such appliances perhaps serves to encourage or justify their construction. The resultant destruction of the alveolar ridges is accepted as inevitable.

Yet, just as the loss of natural teeth can now be prevented by carrying out gnathological procedures, so too can the destruction of alveolar ridges be prevented or minimized.

Requisites for gnathological treatment of patients with full dentures

The first requisite for physiological dentures is the construction of a suitable base, one which must be in a constant relationship to the tissues upon which it functions. Dykins[†] terms this the "tissue base constant," and it is developed by adherence to the mucostatic principles described in Chapter 23. Upon this type of base must be fabricated a physiological articulation, fulfilling all gnathological principles.

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*This chapter is by no means intended to cover the construction of full dentures. An entire book would be required for that. The intention here is only to apply the principles of gnathology to the denture field. Mere mention will be made of the many details of full-denture construction, but the gnathological procedures will be fully treated.

†Dr. William R. Dykins, Nanticoke, Pa.

The principles of articulation are exactly the same for dentures as for natural teeth. Some discrepancies can be tolerated with dentures, however, for here the teeth are all on one base. Further, more freedom in establishing the articulation is permitted because the mutable factors of articulation are more easily altered. The anterior guidance may be changed as one sees fit, esthetic considerations being the only limitation. Likewise, one may alter the plane of occlusion and the curve of Spee to enhance the function of the prosthesis. With edentulous patients we are not hampered by malpositioned teeth and limiting pulp locations.

In order to establish a proper articulation, we must follow the same procedures employed with a dentulous patient. The hinge axis must be located and recorded, and the path of the centers of rotation must be faithfully reproduced. These procedures are more troublesome in an edentulous patient, for it is difficult to fasten the required apparatus securely to the patient. Special clamps are needed to attach the apparatus to the lower jaw, and additional equipment is required to stabilize the recording apparatus to the upper jaw. It is difficult to use the pantograph equipment on an edentulous patient, but it can be done. Dr. Don Myers of Los Angeles and San Bernardino, California, is now experimenting with a procedure whereby clutches are actually attached to edentulous jaws with gold screws. The pantograph tracings are thus as accurate as dentulous writings.

STUDY CASTS, IMPRESSION TRAYS, AND FINAL IMPRESSIONS

The first step in the construction of dentures is to obtain a set of study casts. These casts are made from impressions taken in hydrocolloid or alginate with stock trays, each impression covering as much area as possible with minimum tissue displacement.

Fig. 651. Outline on study casts for tray construction.

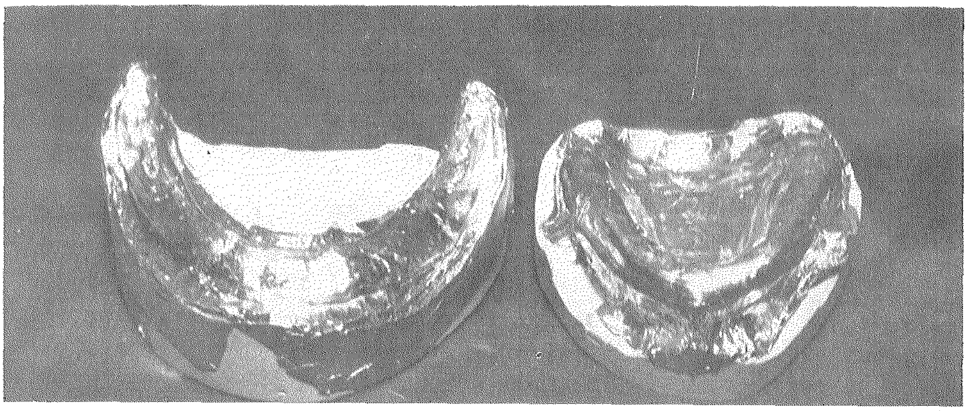

Fig. 652. Two layers of Tenax wax and one layer of tin foil are used as a relief.

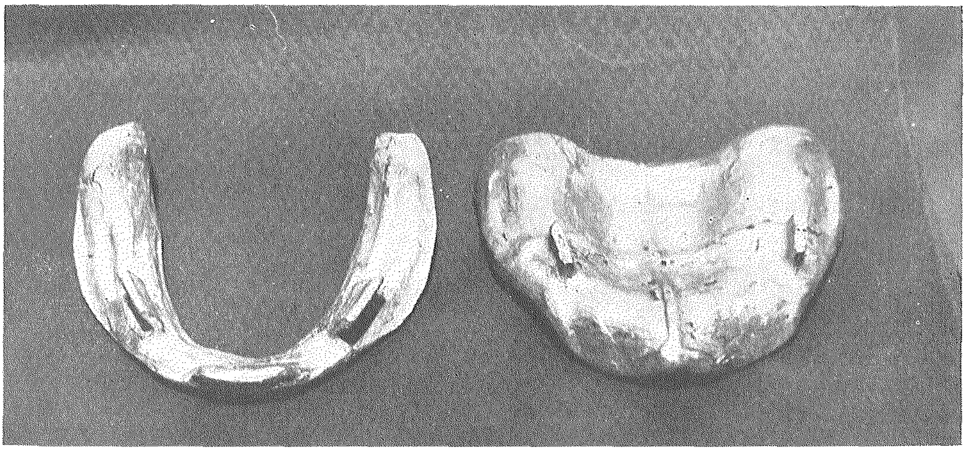

Fig. 653. Reinforcement and handles are added to aluminum trays.

The appliance is outlined on the casts (Fig. 651), and cast aluminum trays for taking the final impressions are constructed. The trays are made a little short of the outline and oversized to permit free exit of excess impression material. Usually two layers of Tenax* baseplate wax are placed over the study casts to provide adequate relief for the trays. Tin foil 1/1,000 inch is adapted over this wax relief (Fig. 652). A layer of Tenax wax is then adapted over the tin foil covering the relief and trimmed to the established outline. Reinforcement is added where needed for sturdiness, and for ease of manipulation handles are attached where there can be no interference with the tongue or other tissues (Fig. 653).

Although metal (aluminum) is the material of choice, it is possible to construct

*S. S. White Dental Manufacturing Co., Philadelphia, Pa.

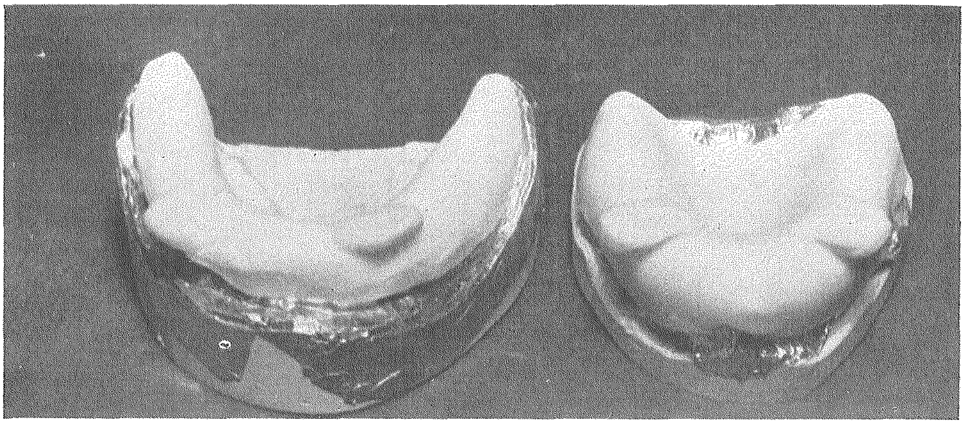

Fig. 654. Plastic trays.

these trays with self-curing plastic (Fig. 654). In either case, the final impressions are taken as described in Chapter 23.

If the denture base is made of plastic, the material must be handled in a very special manner in an attempt to simulate the accuracy of a cast metal base. This is not always possible. More often the result is a compromise which is reflected in the finished appliance.

LOCATION OF HINGE AXIS

The next step is to locate the hinge axis.

By means of a special tray (Fig. 655) and a chin clamp, a crossbar is stabilized to the lower jaw. Side arms with their styli are fastened to the crossbar, one on each side of the patient's face.

Skin movement can be concealed with graph paper fastened to a head cap or some band device which will hold the paper firmly against the patient's face. If a good upper ridge is present, an upper tray may be cemented to the ridge, and a crossbar and flags may be attached to the tray, as in the procedure for a dentulous patient.

It is advisable to have some sort of intraoral stop so that, as the patient opens and closes the jaws in the location of the axis, he will have a position against which to light. This can be devised by luting a flat piece of metal to the upper tray or upper base (Fig. 656). The lower tray, in turn, should have a bearing point which will act as the contact between the upper and lower bases (Fig. 657).

Now locate the centers of vertical rotation by moving the stylus tip to the location where it spins without arcing. After this has been done on both sides, the next step is to transfer the marks permanently to the patient's skin. A third point on the side of the nose is selected to establish the axis-orbital plane.

By means of a transfer bow, the upper base is related to the axis of the articula-

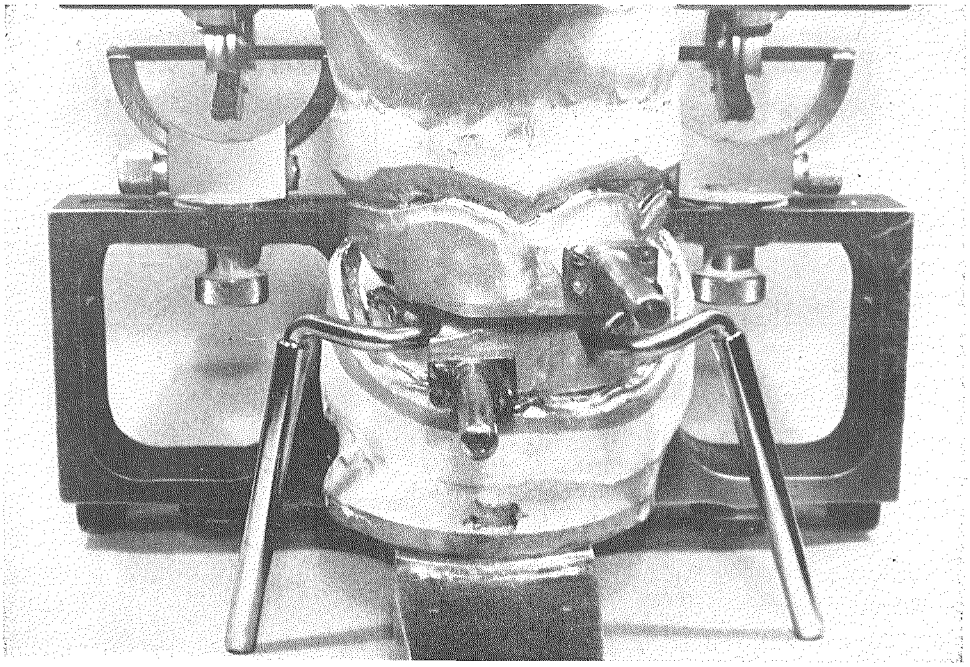

Fig. 655. Special lower tray with stud for crossbar attachment.

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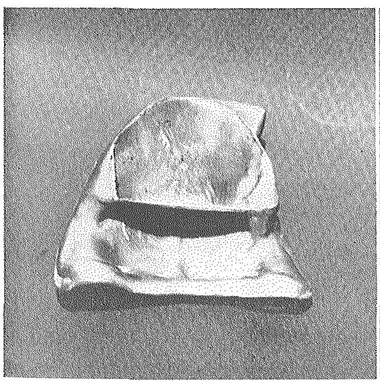

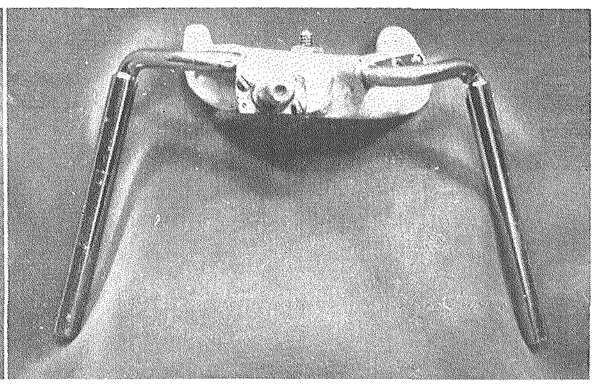

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Fig. 656. Upper tray with bearing plate and stud attachment.
Fig. 657. Bearing screw on the lower tray contacts the upper bearing plate in closure.

tor. By means of a centric interocclusal record, the lower base is located in proper relationship to the upper base.

REGISTRATION

Taking a jaw-writing of an edentulous patient is a difficult procedure and probably should be undertaken only by the really ambitious dentist. Nevertheless, good writings are essential for good dentures; therefore, a technique for taking registrations of edentulous patients will be described.

The procedure is best accomplished in two stages: one session devoted to locating the axis with the equipment just described and a subsequent session concerned with taking the writings. To attempt to accomplish this in one appointment is not recommended. For one thing, it may tire the patient unduly. Moreover, in the process of locating the axis, the apparatus may become loose on the patient, with the result that—before the writings are completed—it will have become so loose as to be useless.

Special trays are constructed to attach the writing apparatus to the maxillae and mandible.

The tray for the maxillae is overextended with a built-up anterior surface for a stud attachment. A bearing plate is placed in the palate (Fig. 656).

The lower tray, in addition to having a surface to which a stud can be attached, must be so constructed that the bent arms which will clamp the tray in position can be fastened thereto. This is accomplished by building a ridge in the molar area when waxing up the tray. This ridge can be drilled and tapped to permit attactment of the bent arms. The lower tray must also have a small plate for carrying a bearing point that will work against the plate on the upper tray (Fig. 658).

The trays with their attachments—the studs on the upper and lower trays and the bent arms on the lower tray—are lined with heavy rubber base impression material and positioned on the respective jaws. Light biting pressure is used to hold the trays in position while the rubber material sets (Fig. 659). (Zinc

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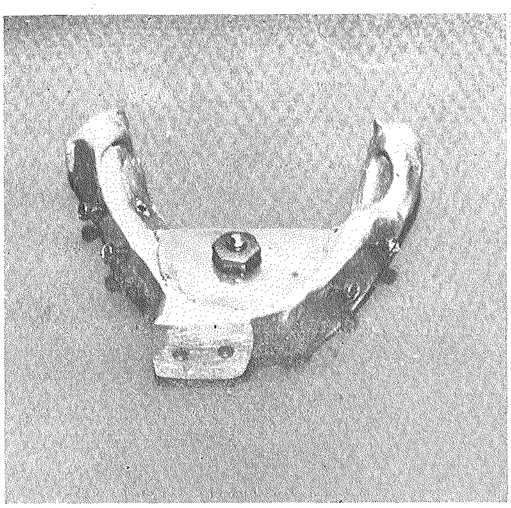
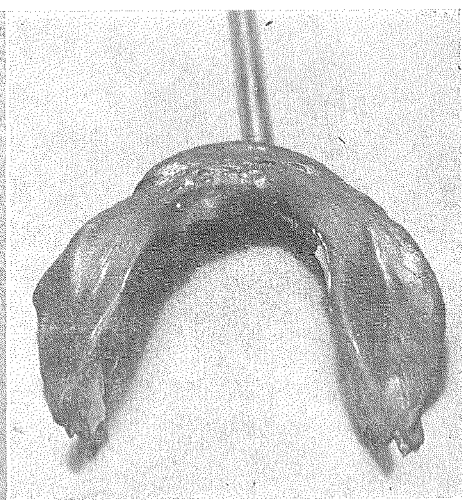
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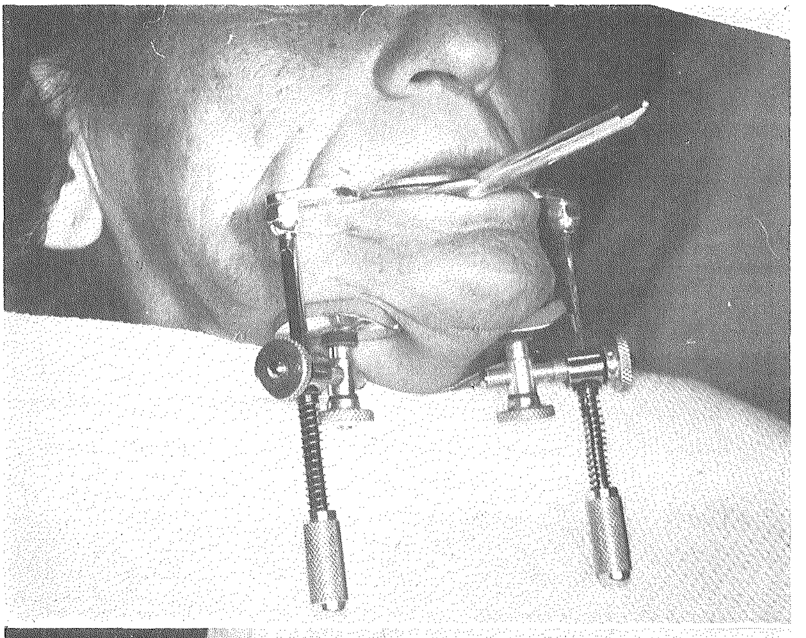
Fig. 658. Special lower tray with ridges for attachment of the bent stabilizing arms.
Fig. 659. Heavy rubber material used as a lining in the special trays.



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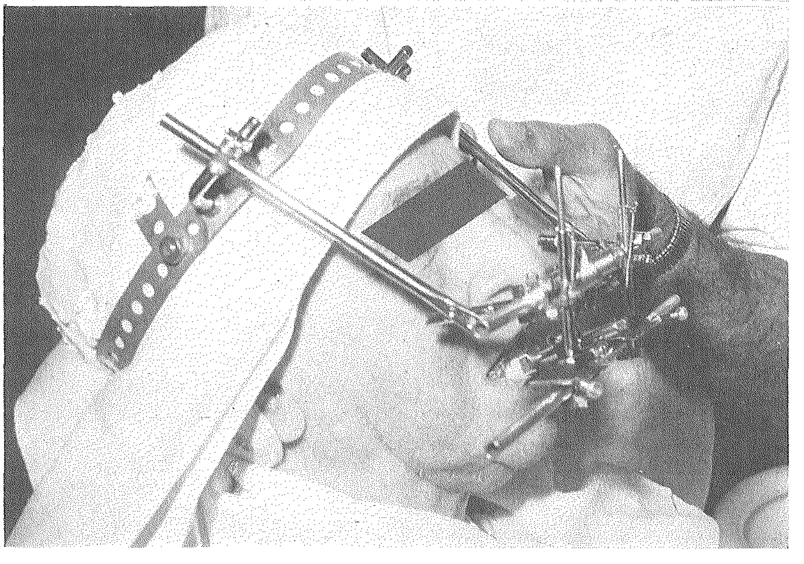

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Fig. 660. The Lauritzen chin clamp in place.
Fig. 661. Plaster head cap for stabilizing the upper tray and recording apparatus.

oxide and eugenol paste may also be used as a liner, but patients seem to find the rubber material more comfortable.)

When the rubber material has set, the clamps are attached to the bent arms with universal toggles and adjusted to the area between the chin and the angle of the mandible on each side. The toggles are then locked, and the take-up screws are turned up until the clamp cups are snug against the mandible. Both sides should be turned up simultaneously to ensure equal pressure on the mandible.

Lauritzen* has designed a ready-made clamp for the edentulous lower jaw (Fig. 660), which provides the easiest and the best way of stabilizing a lower tray or denture for recording purposes.

To stabilize the upper tray, McCollum† has recommended the use of a custom-made plaster head cap (Fig. 661). A bar is attached from each side of the cap to the crossbar fastened to the stud of the upper tray. This device holds the tray in place and permits the side arms to be fastened to the supported crossbar in an immobile relationship.

The procedure for taking the registrations after the apparatus has been stabilized is the same as that for a dentulous patient and is described in detail in Chapter 5.

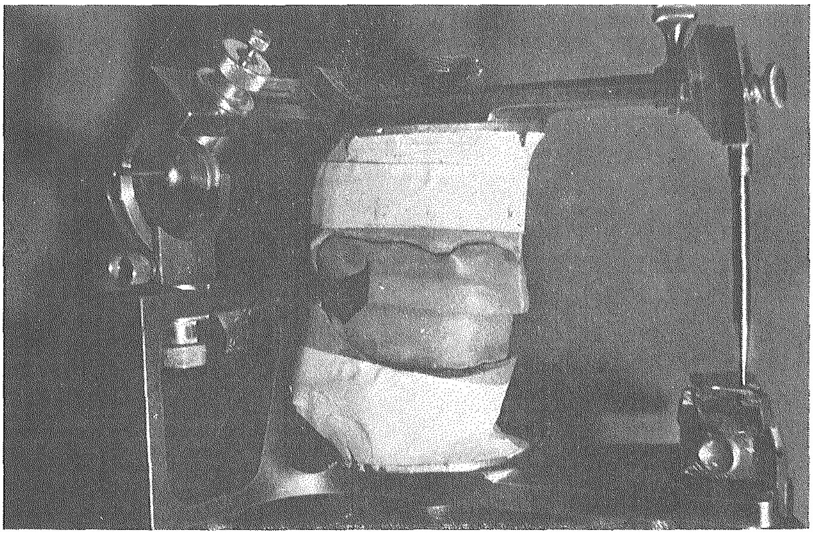

Fig. 662. Blueprint wax rims may be used as a guide in making the trial setup.

ESTABLISHING THE ARTICULATION

After adequate registrations are secured and the denture bases are accurately mounted on an articulator, we must now furnish the articulation for the patient. A wax blueprint (Fig. 662) may be used as a guide in making the trial setup.

The same factors of articulation which influenced the carving of the wax occlusal surfaces for a full-mouth rehabilitation will determine the arrangement of the teeth for full dentures. However, because more latitude in dealing with

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*Dr. Arne G. Lauritzen, Seattle, Wash.
†Dr. B. B. McCollum, Sepulveda, Calif.

the alterable factors is permitted, there is somewhat more freedom in producing an articulation. Changes in the anterior guidance are possible, being limited only by the esthetic requirements of the appliance, and anterior teeth do not have to be prepared for pin-ledges or veneer crowns in order that these changes can be made. The occlusal plane may also be readily altered as to both position and curvature, thus enabling the articulation to be enhanced quickly without having to worry about the proximity of the pulps in tooth preparation.

On the other hand, the placement of the cusps is sometimes more difficult. When an articulation is carved in wax, a cusp can be readily built up, moved, or reduced. When this is done in porcelain, however, careful grinding is required. If a cusp requires more height, it can be raised in the wax setup by moving the tooth. However, to raise a single cusp on a tooth may necessitate grinding away the rest of the porcelain. Fossae and sulci have to be deepened, and this takes time and care. Small mounted stones are employed for this purpose, and they should be used with adequate water lubrication to facilitate the grinding and protect the porcelain from chipping.

Centric relation and esthetics

The teeth are arranged for esthetics and for a centric closure. The selection of the anterior teeth is a matter of esthetics, and the dentist will be guided by that consideration alone. The selection of posterior teeth, however, should be limited to Pilkington-Turner teeth,* for these are the only posterior teeth that are properly proportioned. Less grinding will be required if the teeth are correctly proportioned for articulation.

Before any grinding is attempted on the posterior teeth, one must be sure of the centric relationship. The bases are placed in the mouth and tested for centric relation. If it is not perfect, the lower appliance will have to be remounted. The new centric interocclusal record may be taken with very soft wax or with quick-setting stone. The patient must be in the terminal hinge position, and the bases must be properly seated on the tissues. After remounting the lower base, reset the teeth to the correct centric relation and again try the appliance in the patient's mouth.

When the correct centric relation has been established, the esthetics of the anterior teeth is determined. It is impossible to properly establish the esthetics of a prosthesis unless it is in correct centric relation because the muscles will not react naturally if they are in a strained relationship or if they have to hold a base in position

In determining the esthetics of an appliance, check the vertical dimension for clarity of speech. Check the size, shape, and shade of the anterior teeth and check the profile for proper lip support. This is determined by the position of the upper anterior teeth. Check the high and low lip lines and also check the

*The Dentists' Supply Co. of New York, York, Pa.

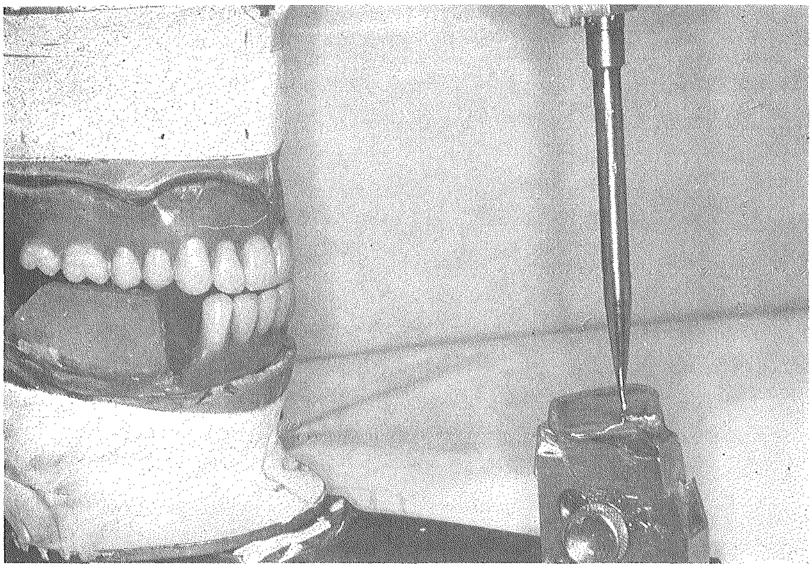

Fig. 663. Anterior guide set.

anterior guidance—the vertical overlap and the overjet. This factor will influence the articulation of the posterior teeth.

When all these factors have been satisfactorily established, the bases are returned to the articulator where the anterior guide is carefully set to reproduce the relationship of the anterior teeth and to prevent their displacement (Fig. 663). It is desirable to maintain this anterior tooth arrangement since it was selected for the esthetic requirements of the appliance. Sometimes the anterior arrangement is copied from a pre-extraction photograph or cast. In immediate denture patients, it is extremely important to maintain the original anterior relationship.

Positioning and grinding of posterior teeth

It is advisable to remove all the lower posterior teeth and begin the setting and grinding of one tooth at a time (Fig. 664). This will prevent the other teeth from interfering with the movements of the articulator and will better enable the operator to see and move the tooth as he works. The lower anterior teeth might also be removed to permit a clearer view of the lingual aspect of the posterior teeth as they are articulated. Since the incisal guide has already been set, there will be no problem about properly resetting these anterior teeth.

Meanwhile, of course, the mechanical principles of maximum stability must be observed. After some experience it is possible to visualize where the teeth are going to fall. It will suffice to say that the lower posterior teeth should be set with the anteroposterior groove directly over the crest of the lower ridge. The upper teeth normally occlude with the lingual cusps in this groove. However, if

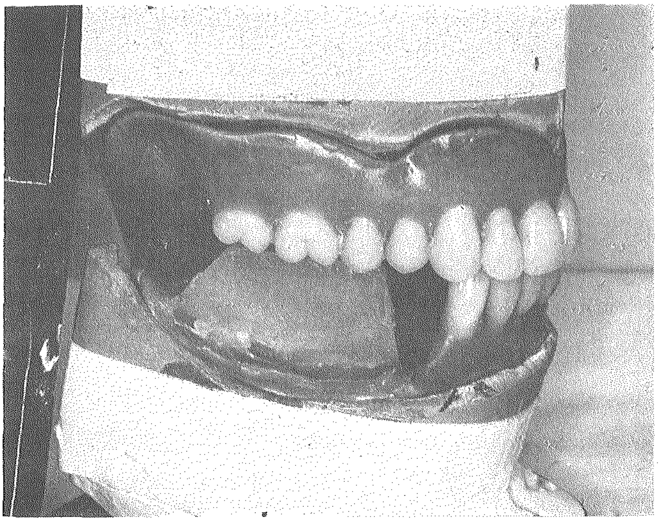

Fig. 664. All the lower posterior teeth are removed.

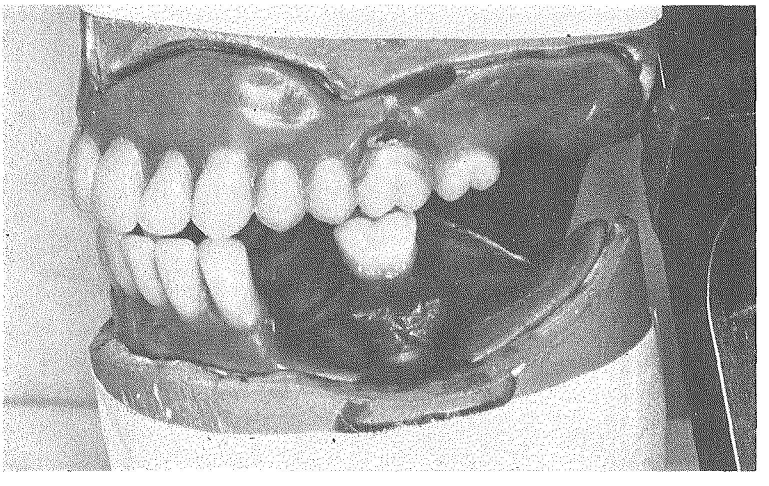

Fig. 665. Placement of the lower first molar.

in this position the teeth are too buccal to the crest of the upper ridge, we may have to resort to a cross-bite relationship. For all practical purposes, this constitutes an upside-down situation, with the lower teeth functioning like upper teeth and the upper teeth functioning like the lower teeth. There is a slight difference in the positioning of the various cusps.

The upper teeth are all in position.

Articulation of lower first molar. The first lower tooth to be positioned and ground is the first molar (Fig. 665). This is because of its importance in the articulation. It is the key tooth in any arrangement of teeth. In setting the lower first molar, there should be absolutely no compromise in its relations.

Dentsply Setup Wax* is used for the positioning procedure. This has the properties of a sticky wax and offers a minimum of shrinkage with a maximum of strength to hold the teeth in position during both the development of the articulation and the checking of the articulation in the mouth.

Begin by positioning the lower first molar in centric relation. Before the wax completely sets, move the articulator to the various positions and examine the relationship of the cusps. Such changes as will have to be made in the stock teeth to harmonize them for the particular appliance will depend on the various factors of articulation and their influence on cusp height and placement, as described in Chapter 12. After the different tipped positions of the lower first molar are tried, decide how it must be tailored in order to fulfill the requirement of equal distribution of contact in the various excursions.

Lateral protrusive and balancing excursions. Just as in the wax carving, the first position to be examined is the lateral protrusive. Make the tip of the buccal cusp of the upper second bicuspid contact the tip of the mesiobuccal cusp of the lower first molar and the tip of the mesiobuccal cusp of the upper first molar contact the tip of the distobuccal cusp of the lower first molar in the lateral protrusive position. These tips can usually be brought into position by tilting the upper and lower teeth.

In moving the upper teeth, be careful not to change the plane of occlusion too much, for this was checked for esthetics during the try-in. If any grinding is necessary to effect the approximation of these cusps, it should be done now. Great care should be taken in returning the articulator to centric position lest we destroy what has just been accomplished. In order to see how the cusp tips are going to meet, carefully move the instrument to the various positions. Check to determine whether the lingual cusp of the upper second bicuspid and the mesiolingual cusp of the upper first molar contact the respective cusp tips of the lower teeth in the balancing position (Fig. 666). The lingual cusp of the upper second bicuspid should contact the tip of the mesiobuccal cusp of the lower first molar. The mesiolingual cusp of the upper first molar should pass between the buccal cusp and the distobuccal or fifth cusp of the lower first molar. If one of these upper lingual cusps is too short, then it must be lengthened either by tipping in the tooth at the neck or by grinding the other cusps so that the lingual cusp will become longer when the tooth is brought down.

To lengthen a cusp that is too short, one must grind the other cusps and bring the tooth down bodily. In other words, by shortening the tips of the buccal cusps of the upper teeth, one can bring the upper tooth down bodily until the buccal tips again contact the tips of the lower buccal cusps. In so doing, the lingual cusps of the upper teeth have been lengthened.

Centric relation contact. Having established the tips of the buccal and lingual cusps of the upper teeth and the tips of the buccal cusps of the lower teeth, we

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*The Dentists' Supply Co. of New York, York, Pa.

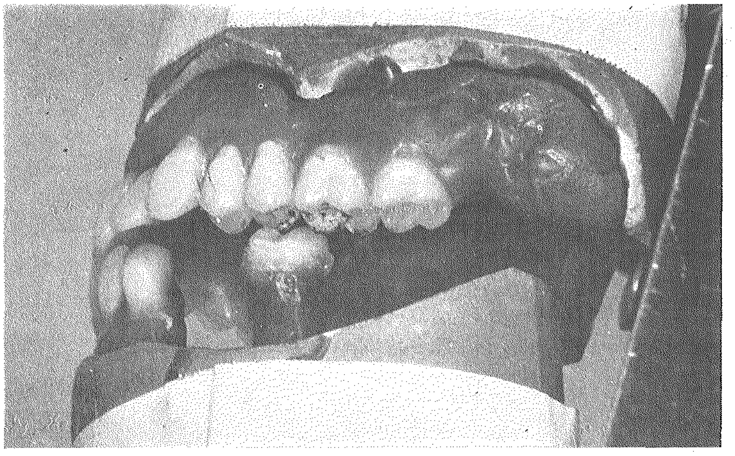


Fig. 666. Balancing position contacts.

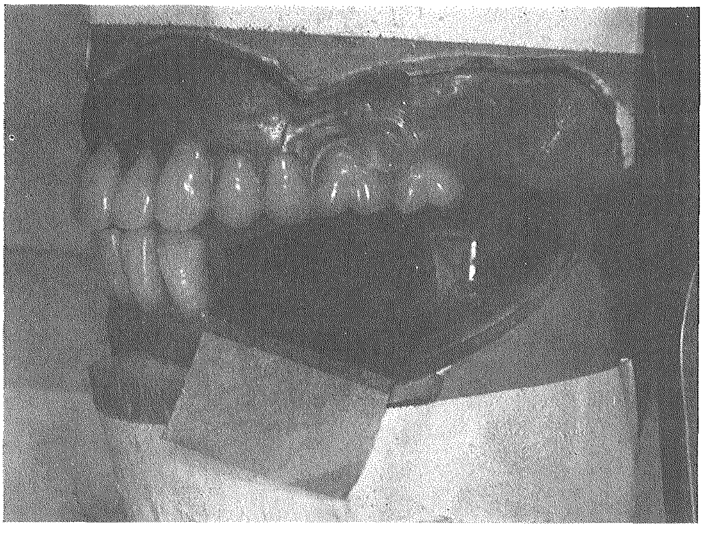


Fig. 667. Carbon paper for testing centric relation contacts.

next have to see how the tips of the upper lingual cusps are going to contact the fossae of the lower teeth in centric relation. At the same time, examine how the tips of the lower buccal cusps are going to fit into the respective fossae of the upper teeth in centric relation. Do this carefully, using thin, hard carbon paper to mark any premature contact (Fig. 667). If these centric relation-holding cusps are premature, simply deepen the respective fossae. *The cusp tips must not be ground* because these were established to their proper length in the lateral protrusive and balancing excursions.

It could be that there is *no contact* in centric relation between these cusps and fossae, in which case the problem is somewhat more complicated. It would be simple if the fossae (or marginal ridges) could be filled in, but this is not possible with porcelain teeth. Thus, the centric cusp must be made longer, or the entire opposing tooth must be brought into closer contact in centric relation. Either of these procedures would correct the discrepancy but would also make the previously established cusp tips too high in the lateral protrusive and balancing excursions. Therefore, we must decide which maneuver will accomplish the objective with the least trouble.

In a sense, we have to work backwards. If the lower teeth are raised until the fossa makes contact in centric relation, very likely the lingual cusp of the upper tooth will be in a premature contact in the balancing position. The lingual cusp of the upper tooth cannot be shortened because the lower tooth has just been lifted to meet the lingual cusp of the upper tooth in centric relation. Therefore, the tip of the buccal cusp of the lower tooth must be shortened. This is simple, but in so doing we must be careful not to destroy the tip-to-tip contact of the upper buccal cusps with the lower buccal cusps in the lateral protrusive position. Also, we must be concerned with the relationship of the tips of the lower buccal cusps in their centric contact with the fossae of the upper teeth.

So, it can be seen how very complicated the problem can become. It may be necessary to combine tooth tipping with cusp and fossa grinding in order to achieve the objective. One can appreciate the wisdom of dealing with one tooth at a time.

Working and protrusive positions. There now remain the details of perfecting the working occlusion contacts and the lower lingual cusps (Fig. 668). The straight protrusive contacts must also be adjusted or perfected (Fig. 669).

The lower lingual cusps are easily adjusted because they contact only in the working and protrusive positions. If they are too high, they merely have to be

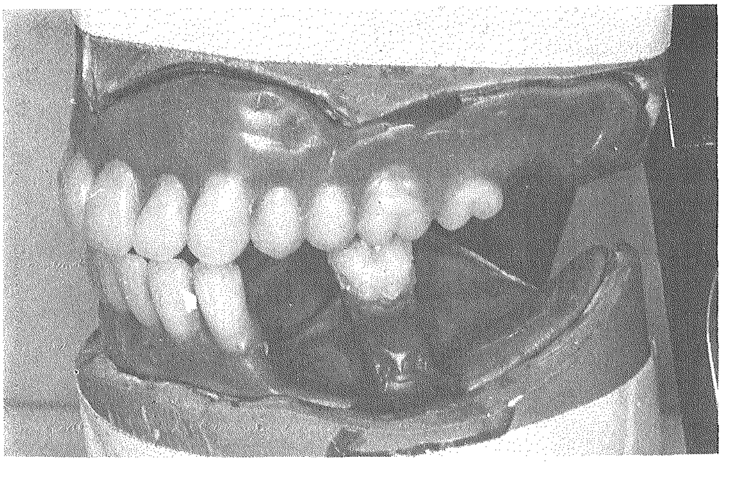


Fig. 668. Adjustment of the working position contacts.

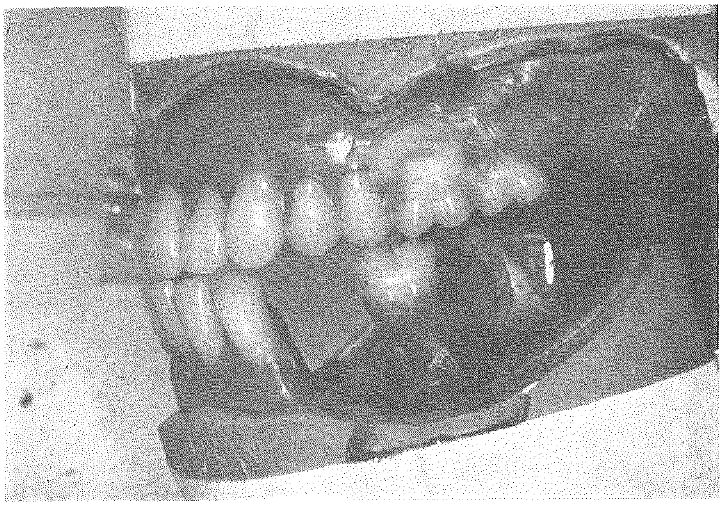


Fig. 669. Examination of the protrusive contacts.

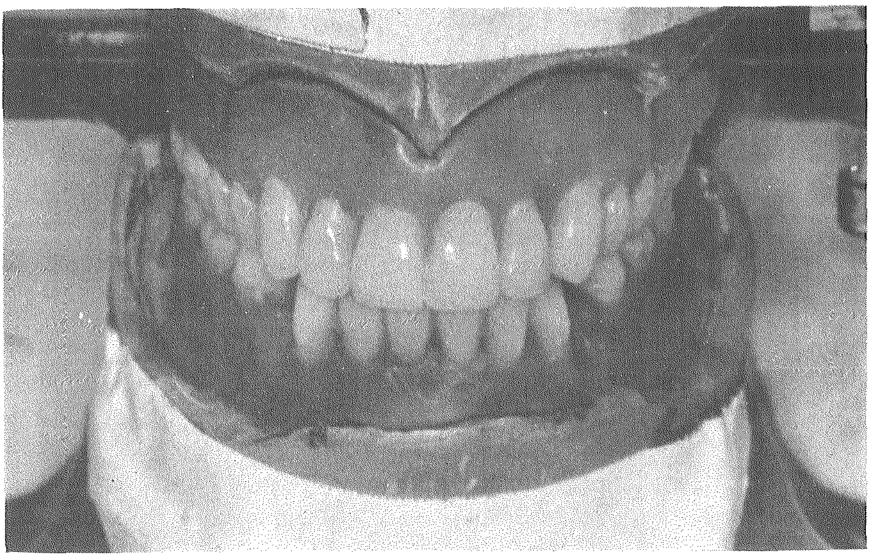


Fig. 670. All the posterior teeth are in place except the lower first bicuspids.

shortened. If they are a little too short, the problem is not serious. McCollum, as a matter of fact, advocates a lack of contact for the lower lingual cusps. The important thing is that they not be in premature contact.

Completing the setup. The same general principles apply to the remaining posterior teeth. One by one, they should be positioned and adjusted—the lower second molar and the lower second bicuspid—on both sides (Fig. 670). The next step is to return the lower anterior teeth to the position they occupied at the beginning of the setup.

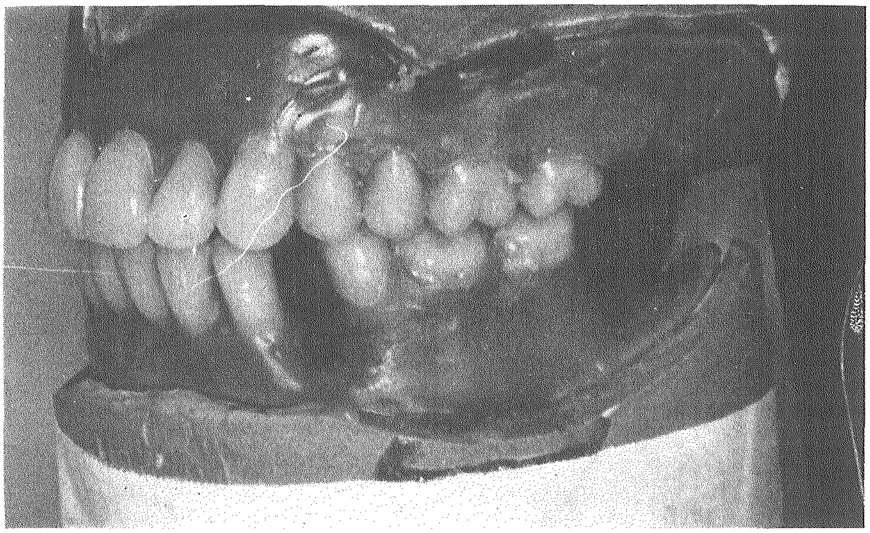


Fig. 671. Space for the lower first bicuspid.

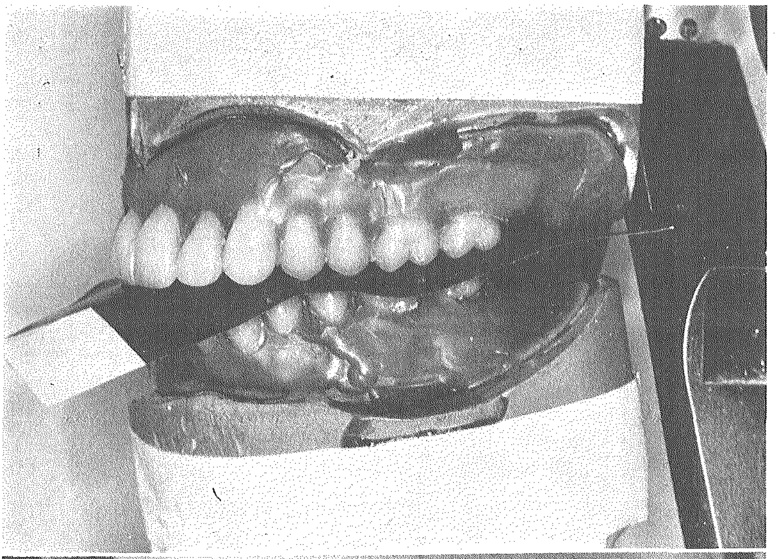
The last tooth to be set is the lower first bicuspid (Fig. 671). There is a twofold reason for this. It is the least important tooth for articulation, and if any compromise is required, it may be made here. Furthermore, it is in the least conspicuous area of the mouth. Depending upon the relation of the upper and lower jaws and teeth, it may be necessary to reduce this tooth mesiodistally. Sometimes it may even be necessary to leave this tooth out altogether.

When all the teeth are securely waxed to position, it is advisable to further perfect the articulation. The adjustments now will be minor and will not necessitate the movement of any teeth. It is for the most part a removal process, much like the procedure of adjusting restorations for natural teeth after remounting (Fig. 672).

The various steps of articulation should be checked in sequence and adjusted accordingly—first, the lateral protrusive, next, the straight protrusive, and then the balancing and working positions. Finally, complete the adjustment by paying strict attention to the centric relation contacts. These are the most important. Here there can be no compromise. Sacrifice anything else, but be sure the centric contacts are perfect!

After the prosthesis is processed, it should be returned to the articulator and again be examined for any changes that might have taken place during processing (Fig. 673). When all final adjustments are completed, the porcelain surfaces must be carefully polished. This is accomplished by using abrasive rubber wheels and points and following with wet pumice on a rag wheel. Last, use powdered porcelain (Trupolish*) to give the teeth a final polish. If this is done properly,

*The Dentists' Supply Co. of New York, York, Pa.



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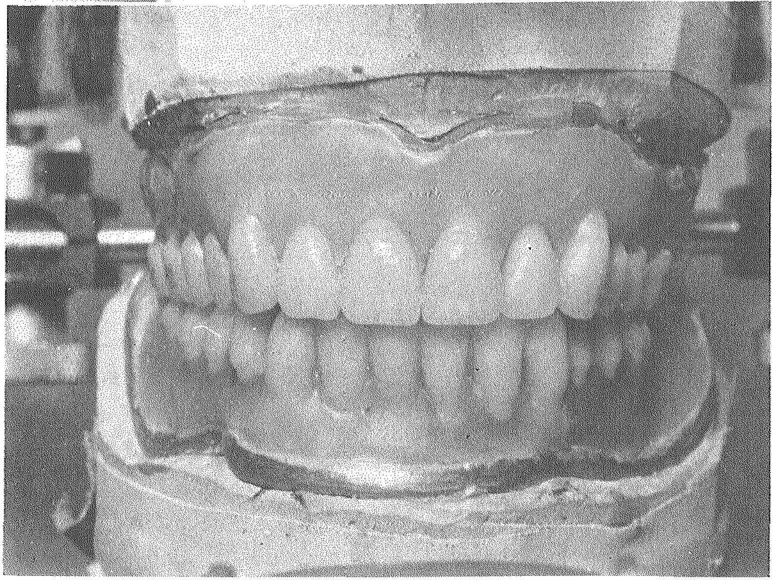

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Fig. 672. Adjusting the completed setup.
Fig. 673. The processed appliance returned to the articulator by means of a split-cast arrangement.

there will actually be a glaze on the ground surfaces. Careless use of the abrasive rubber wheels, however, can alter the carefully established cusp relationships; therefore extreme caution should be exercised. As a matter of fact, when Lauritzen finishes adjusting a set of porcelain teeth, he uses some petrolatum and then mills them on the articulator so that the porcelain polishes itself. With this polishing procedure, no changes can be introduced into the articulation.

CHAPTER 25

Removable partial dentures

Wherever there is a choice, the fixed prosthesis is always the restoration preferred. Unfortunately, however, there are many patients whose mouths cannot possibly be restored to proper function by fixed appliances. In these instances it becomes necessary to construct a removable appliance that will best enhance the masticatory mechanism and actually contribute to its health. Frequently the decision is for a small cantilever rather than a removable bridge. Occasionally a "fourteen-tooth" fixed appliance will be made in preference to a removable arrangement. Each situation, of course, must be carefully analyzed and all factors weighed before an intelligent final decision can be reached. And there are exceptions to every situation. By and large, though, the general rule is to use a fixed appliance wherever possible instead of a removable one.

When a removable prosthesis is indicated, certain fundamental principles must be observed if it is going to be a physiological restoration.

MUCOSTATIC BASE

A mucostatic base is the first requisite of a physiological prosthesis. By this is meant a base that exhibits the properties of a tissue base constant. In other words, the base must function on the tissues without movement. It must be in a passive state under all circumstances. It must neither displace tissue in function nor bound back (or up) when function ceases. Normal muscle activity must not cause its displacement. These are rigid requirements, but they must be met if the removable appliance is to contribute to the normal nondestructive function of the oral mechanism.

How is such a base obtained?

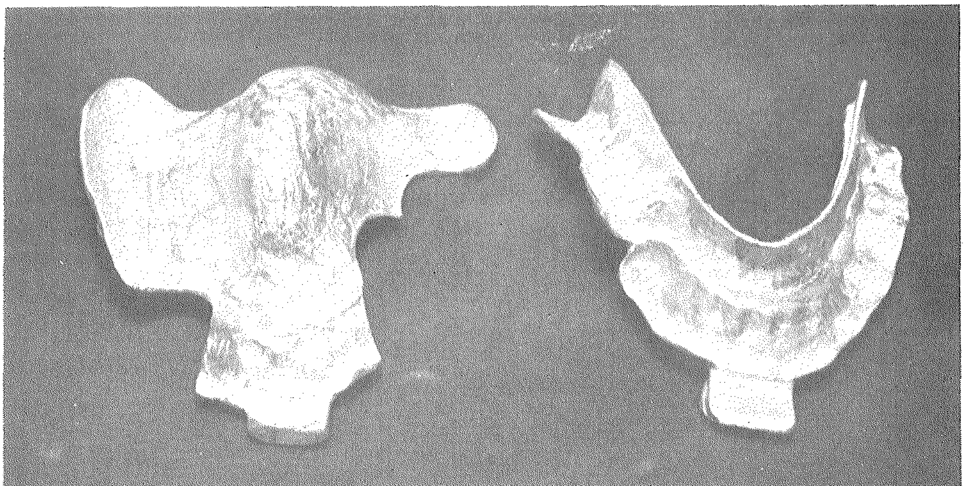
Mucostatic impression

The first step is to secure a mucostatic impression of the base area. This means an accurate imprint of the tissues in a passive state. An impression should be taken of the tissues in a relatively normal, healthy condition. In other words, we do not want an impression that is taken immediately after an ill-fitting appliance has been removed, nor do we want an impression of swollen or abraded tissues.

If any irritations are present, wait until they are healed before proceeding with the impression. A good rule is for the patient not to wear any restorations for at least 72 hours. During this period, frequent warm saline rinses will help to restore the tissues to normalcy.

Custom-made aluminum tray

A custom-made aluminum tray is an aid in securing a good mucostatic impression. Although plastic tray materials may be used, they leave something to be desired because, in order to be rigid, they must be bulky, and a bulky tray is liable to cause difficulty. The tray has to be a loose-fitting approximation of the base



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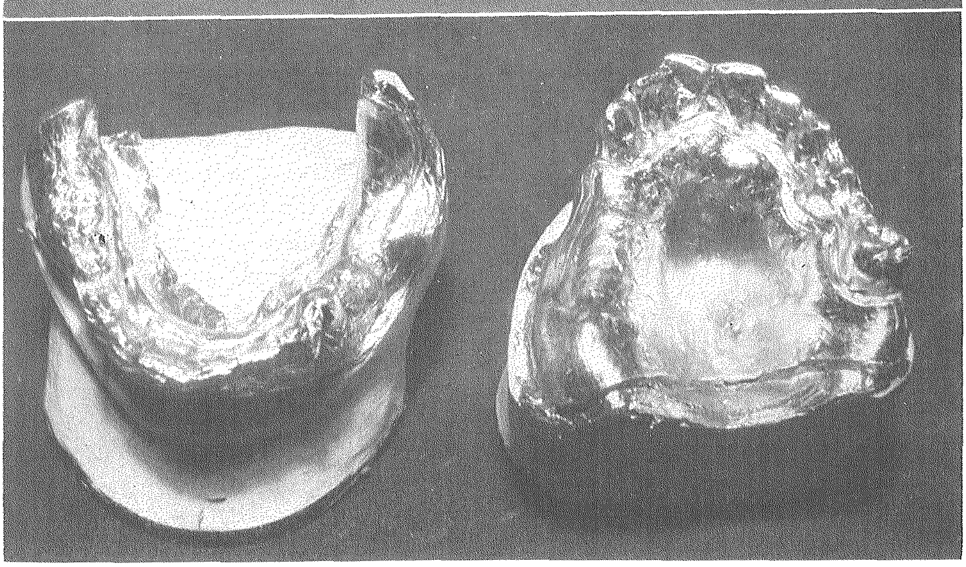

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Fig. 674. Aluminum partial denture trays.
Fig. 675. The relieved casts on which the partial denture trays were constructed.

area. Its periphery must be short of the anticipated outline. Its weight must be such that it will literally float in the impression material. It must be rigid enough to withstand distortion during removal and subsequent handling. These partial denture trays are usually designed with a combination natural tooth rest and handle that will not interfere with any of the oral tissues (Fig. 674).

In making an impression tray for a removable appliance, use one layer of Tenax* baseplate wax as a spacer over the base area on the cast (Fig. 675). This is in contrast to the two layers of Tenax wax used as a spacer in the construction of trays for edentulous patients. The reason is that a partial denture tray can be more readily positioned over the tissues than can an edentulous tray. In either case, ample escape must be provided for the impression material so that it cannot exert any hydrostatic pressure on the tissues and cause their displacement.

Impression material

The impression material must be one that will cause the least displacement to the most displaceable tissue in the particular mouth. In some patients, almost any material will cause no displacement; in others only the softest material may be used. The impression material must be very accurate and must set firmly to resist any distortion.

Zinc oxide and eugenol material. For years, I have used a powder and liquid—a zinc oxide and eugenol preparation made by Ackerman.† This material has some shortcomings. Temperature and humidity affect its handling properties. It is messy to handle. It is necessary to duplicate the cast in order to make a refractory model. This duplication is a possible source of error and calls for special treatment.

To minimize the possibility of errors in duplication, I use a method devised by Granger.‡ An alternating heating and cooling tube is inserted in the base of the stone cast (Fig. 676). The duplicating material—diluted hydrocolloid (half the strength of impression hydrocolloid and prepared by adding an equal volume of water to the softened impression material)—is divided into two parts. One part or three quarters of the gelled material is put through an ordinary meat grinder. The remaining quarter of the gelled material is heated in a double boiler. When the heated material becomes homogeneous and fluid, the ground hydrocolloid is added to it and stirred. This lumpy material is immediately poured over the cast, which has been placed in a duplicating flask and has warm water running through the tube in its base. As soon as the duplicating flask is filled, the water flowing through the base of the cast is changed from warm to cold. This causes the gelation of the duplicating hydrocolloid to take place first against the cast. As the rest of the hydrocolloid gels, it cannot cause any shrinkage of the material which has already gelled against the cooling cast. The duplicating ma-

*S. S. White Dental Manufacturing Co., Philadelphia, Pa.
†Ackerman Dental Co., Santa Monica, Calif.
‡Dr. Ernest R. Granger, Mount Vernon, N. Y.

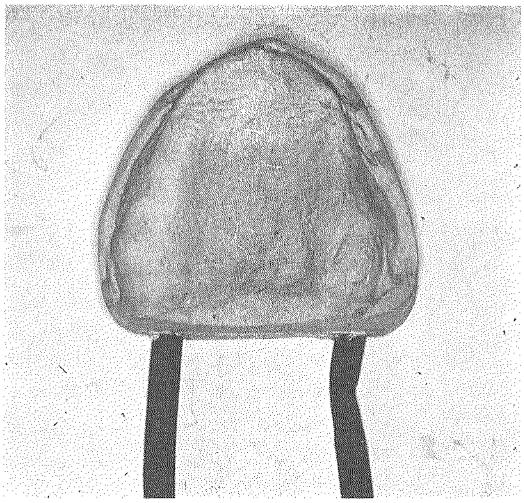

Fig. 676. A ¼-inch copper tube is imbedded in the core of a cast for alternate heating and cooling.

terial which was ground does not undergo shrinkage because it was already gelled. Shrinkage takes place at the gelation point. When completely cool, the cast (with tube in base) is carefully removed from the flask, and the refractory cast is poured with Kerr's Cristobalite.* When the refractory cast is set, it is removed from the duplicating flask and allowed to dry thoroughly. It is then ready to be waxed up for the casting.

It is possible to pour the refractory material directly into the zinc oxide impression. However, great care is required in separating the cast from the impression lest the delicate detail be destroyed. Also, a "miscast" will mean the taking of another impression.

Rubber base material. Recently, a great deal of this work has been eliminated by the use of rubber base material for the mucostatic impression. Like so many things, this material has its advantages and disadvantages, and the individual operator must decide for himself which outweigh the other—always bearing in mind that the basic fundamentals must be adhered to, regardless of his choice.

Kerr's Permalastic (regular), the rubber material which I have used, has certain definite advantages. The refractory model can be poured right into the impression, and several refractory models can be poured from one impression. Moreover, the material is easier to handle and less sensitive to changes in temperature and humidity.

There are some negative features, too. It is relatively impossible to test the impression with accuracy, as compared with a zinc oxide and eugenol impression. Also, because this material does not absorb moisture in setting as does the other,

*Kerr Manufacturing Co., Detroit, Mich.

it is necessary to dry the tissues thoroughly. Furthermore, there is the possibility of distorting the rubber material when the refractory cast is being poured.

Either material, however, will produce satisfactory results when handled properly.

WAXING UP THE BASE ON REFRACTORY MODEL

When the refractory model is thoroughly dry, the next step is to apply the wax to form the pattern for the base. It is desirable to have the base as thin as possible, but at the same time it must be rigid enough to resist distortion under normal use.

Upper base

An upper base is waxed up with one layer of 30-gauge casting wax over the entire base area (Fig. 677). Extreme care must be taken not to thin the wax as it is adapted to the palatal area. It is good practice to apply a very thin layer of sticky casting wax in the rugae area as well as in the median suture of the upper cast, for this permits easy adherence of the sheet wax and also provides a little additional thickness where it is most needed. Over this layer of 30-gauge casting wax, a layer of 28-gauge casting wax is added. Bring this to the inside finishing line laterally (lingual to the acrylic attachment for the teeth) and to the posterior border of the upper base (Fig. 678). The 30 gauge wax on the heels is also covered with this sheet of 28-gauge wax, and the area is shaped so that is is continuous with the inside finishing line and terminates the acrylic attachment area posteriorly. From this edge (over the heel) begin the peripheral finishing line by applying a piece of 18-gauge round wax and carrying it around the periphery. This round wax is flattened with a spatula and seared to the re-

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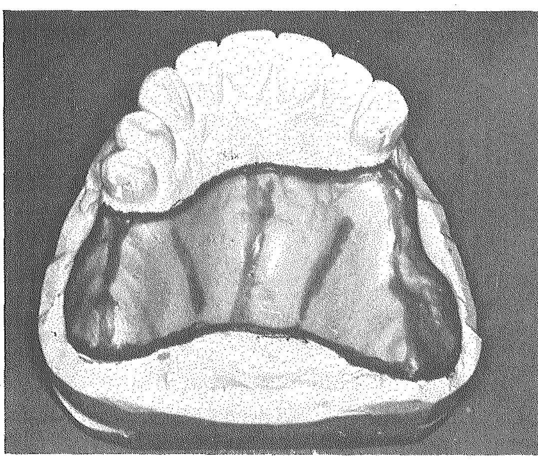

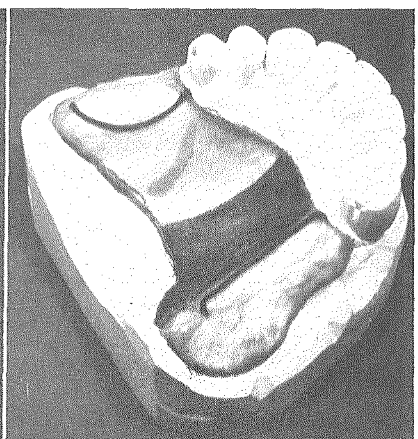

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Fig. 677. For the start of the palate wax-up, 30-gauge casting wax is used.
Fig. 678. The palate is reinforced with 28-gauge casting wax.

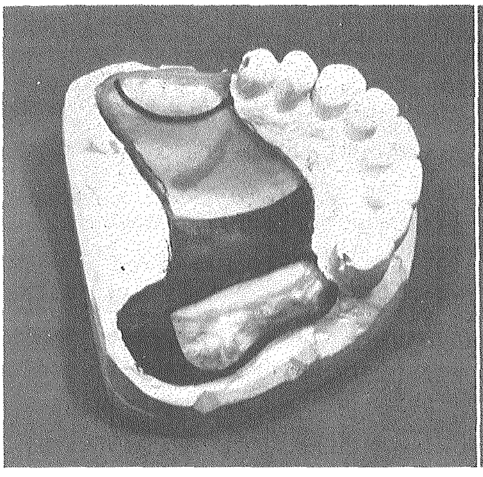
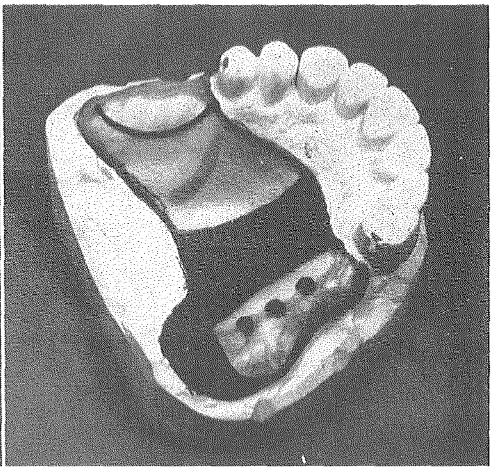
679   680

Fig. 679. Rounded sprue forms of 18-gauge wax are added for the finishing line and flattened to blend with the base.
Fig. 680. Retention forms are added to edentulous areas.

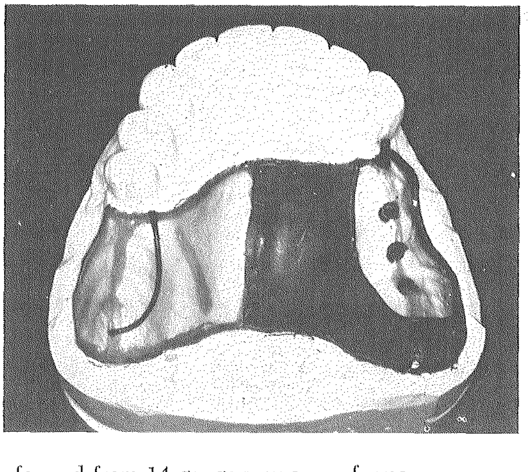


Fig. 681. An upright is formed from 14-gauge wax sprue forms.

fractory cast (Fig. 679). Several retention loops—mushrooms or eye beams—are placed in the acrylic attachment area to engage the acrylic which will hold the teeth (Fig. 680). In addition, a piece of 14-gauge round sprue wax is placed adjacent and parallel to the abutment tooth about in the middle of the saddle area and several millimeters away from the edge of the base (Fig. 681). This sprue wax will cast into a round post, which is used in one of the methods for placing the attachment. This will become clearer when the construction of the struts and the attachment of the male portion of the retainer to the base are described.

When the wax pattern is completely formed, the sprues are attached, the thickness and location of which will depend upon the type of casting machine employed. If an end-over-end centrifugal casting machine is used, a wide, thin sprue is attached at the back end or front end of the base. The appliance is then invested in model Cristobalite, with an asbestos lining in the flask. The usual slow burn-out technique is used for complete wax elimination, and the casting is made of a hard partial denture gold. After bench cooling, the casting ring is immersed in water, and the casting is then removed, cleaned, and *carefully* trimmed prior to being checked in the mouth. When trimming, finishing, or polishing the base, *do not* allow it to become heated. Water should be used on the stones, discs, and polishing wheels. Careless grinding and polishing will ruin a good base.

Lower base

A sheet of 26-gauge casting wax is placed over the saddle area and carried around the lingual aspect as a base for the lingual bar (Fig. 682). (There is no relief of any kind under a mucostatic base, nor is any polishing or burnishing done on the tissue side of the base. The tissue side is cleaned with a soft brass wire wheel. Should there be a tiny bubble or fin, it of course has to be carefully removed, but there is no machining, as is the practice with conventional bases.)

The lingual bar is waxed up as a wide, thin band rather than as a short, thick one (Fig. 683). True, there are exceptional patients for whom this is not possible because of the narrow area between the gingival crests and the muscle attachments. There have been rare patients for whom the lingual bar has had to be placed on the lingual aspects of the lower teeth. (Usually these teeth were covered with restorations of some type.) These, however, are some of the practical compromises which occasionally have to be made.

Before thickening the layer of 26-gauge wax on the lingual bar, form the finishing line of the base by adding a strip of 18-gauge round sprue-former wax along the periphery lingually and on the lower edge of the lingual bar (Fig.

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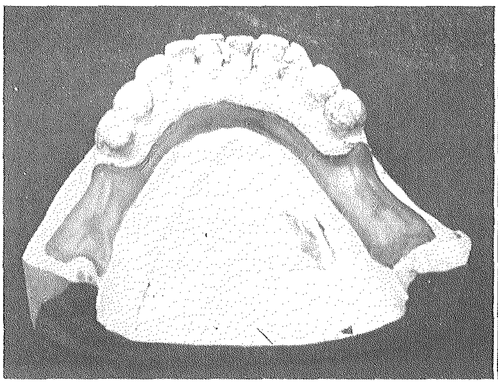

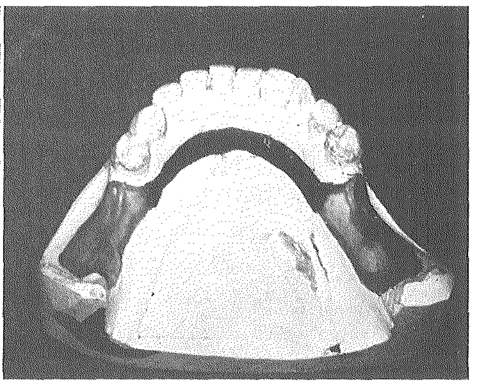

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Fig. 682. In the lower saddle areas 26-gauge wax is used.
Fig. 683. The lingual bar is thickened for strength.

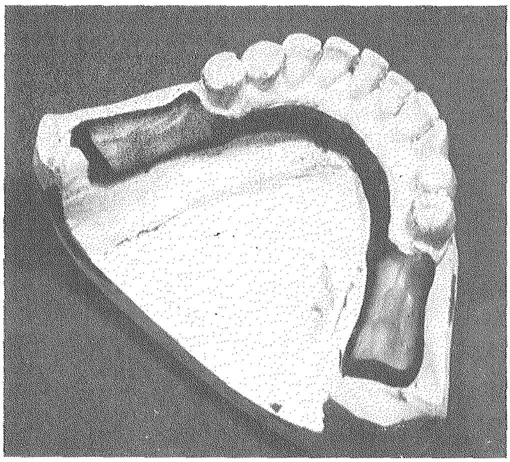
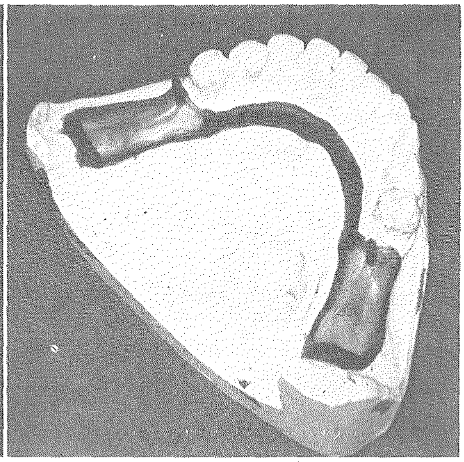
34   685

Fig. 684. An 18-gauge wax sprue former is used to form the finishing line on the lingual aspect.
Fig. 685. A 14-gauge wax sprue former placed upright.

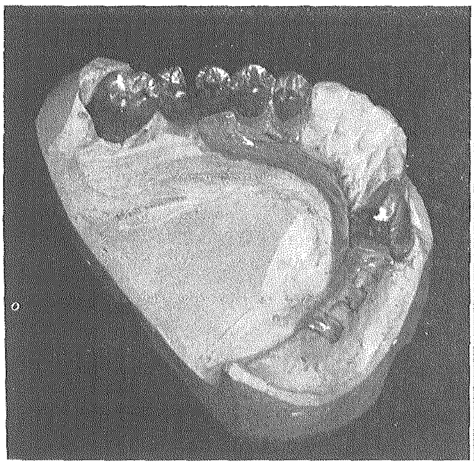
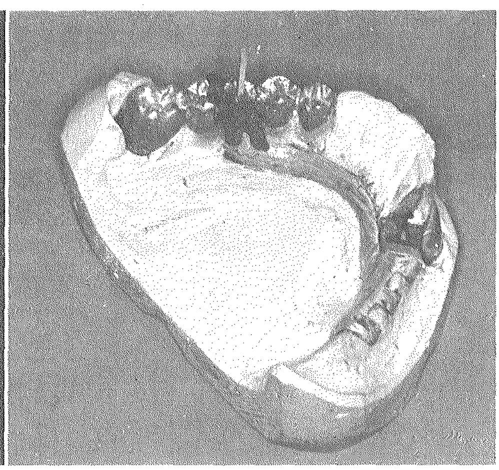
86   687

Fig. 686. A butt joint bar where a split dummy is to be used for the attachment.
Fig. 687. The waxed-up strut against the butt joint.

684). Place a finishing line buccally, beginning at the heel (where there is an additional layer of 28-gauge wax or where some extra wax has been flowed), posterior to where the last tooth is going to be set, and carry it to the end of the saddle area. Anteriorly, the buccal finishing line ends where the strut is to be placed. Thus, there is a continuous line.

On the lingual aspect, a finishing line is placed distal to the abutment tooth. The lingual bar is thickened at this point to form the vertical finishing line which will become continuous with the finishing line later to be established on the strut. A retention of one kind or another is placed on the ridge area in order that the acrylic be well engaged. A piece of 14-gauge round sprue wax is placed vertically about 2 mm. from the edge of the abutment tooth and parallel to it (Fig. 685).

Frequently lower appliances are of a unilateral type. The saddle area on the unilateral side is waxed up as just described. On the other side, there is usually a bridge dummy or a molar restoration which will carry the other attachment. In these appliances, the lingual bar is carried to this abutment area and finished with a butt joint (Fig. 686). The strut for this attachment will later be waxed to this butt and cast as a separate piece (Fig. 687). Then, after the male attachment is in place, the two pieces will be soldered together.

After the lower base is invested, cast, and cleaned, it is ready to be tried in the mouth.

RELATING THE BASE TO THE RESTORATION

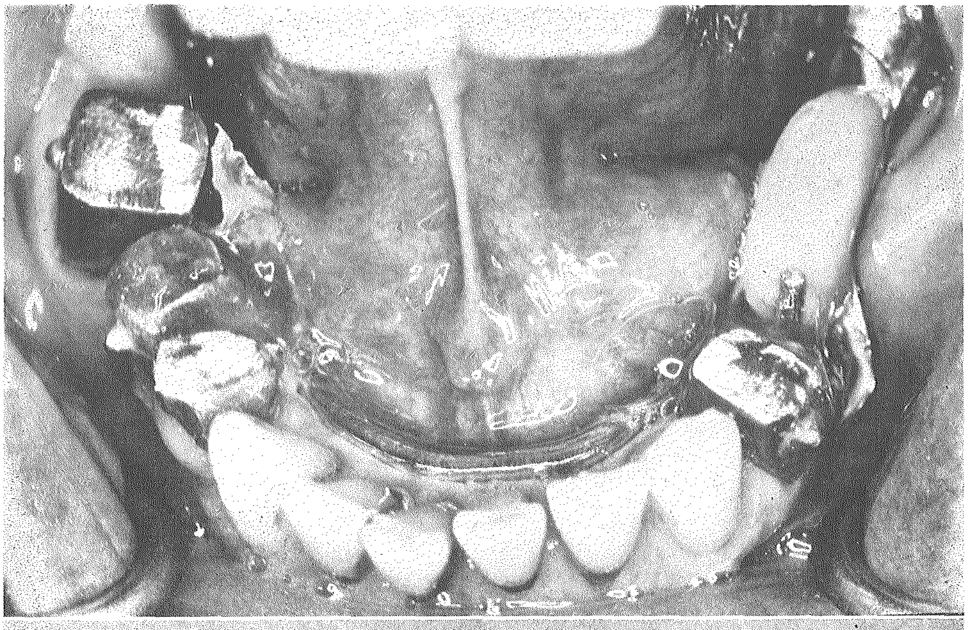
The problem now is to relate the base or bases to the rest of the reconstruction. Let us go back a little and try to tie the steps together in proper sequence.

The bases may be made at any time during the treatment.

In a reconstruction appliance involving a removable partial denture, there are several complications. The absence of some teeth gives rise to the most serious complication. An edentulous distal area on one or both sides makes it difficult to relate the casts properly to each other on the articulator for purposes of developing the articulation. The problem is further complicated by the type of impression taken for the master cast. If metal dies and transfers are used, the problem is not a very difficult one. In such appliances, it is sometimes better to use metal dies and transfers, even though a hydrocolloid or rubber base impression for the master cast would be preferred. Again, this becomes a matter of personal choice, provided that the basic fundamentals are observed.

A suitable working cast must be properly related to the articulator before the development of the articulation can be undertaken. There are several ways of handling the problem.

Let us assume that we have a bilateral distal extension lower appliance, with the cuspid teeth as abutments. If band impressions are taken of the prepared cuspids and transfers are constructed for them, these transfers can be readily related to the metal base for the lower removable appliance. The lower casting must be made before the lower working cast can be related to the upper cast. Assuming that the upper teeth are natural teeth, prepare these and construct a working cast by whichever means desired. The upper working cast is related to the upper bow of the articulator by means of the face-bow transfer to the axis points of the patient. We now need a lower working cast and a centric interocclusal record to relate it properly to the upper cast. The transfers are placed on the prepared teeth, and the lower base is positioned on the tissues and attached to the copings with quick-curing acrylic (Fig. 688). When the acrylic is set, the base will be rigidly held in position. On a metal base, an acrylic bite block or occlusion rim is an aid in attaching the base to the transfers and also enables a centric interocclusal record to be taken in a fairly normal way. The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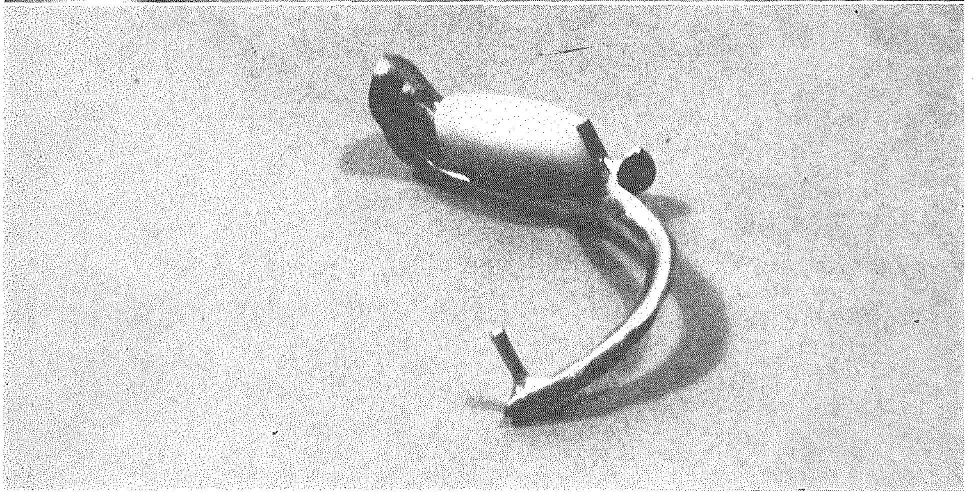
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Fig. 688. Lower base attached to copings with quick-setting acrylic.
Fig. 689. Lower base with acrylic bite block.

acrylic bite block, having been trimmed just short of contact with the upper prepared teeth, permits a wax centric relation record that is not too thick and which can be quite accurate (Fig. 689).

After the centric interocclusal record has been taken according to the method described in Chapter 7, the impression for the lower working cast is taken. This is accomplished by following the remount impression technique outlined in Chapter 19. The compound and hydrocolloid impression permits the base and transfers to be seated with accuracy. The dies are placed in the transfers, and the working cast is poured in stone (Fig. 690). When the stone sets, the cast is removed from the impression and fitted to the upper mounted cast by means of the centric interocclusal record. The lower cast is then attached to the lower member of the articulator (Fig. 691).

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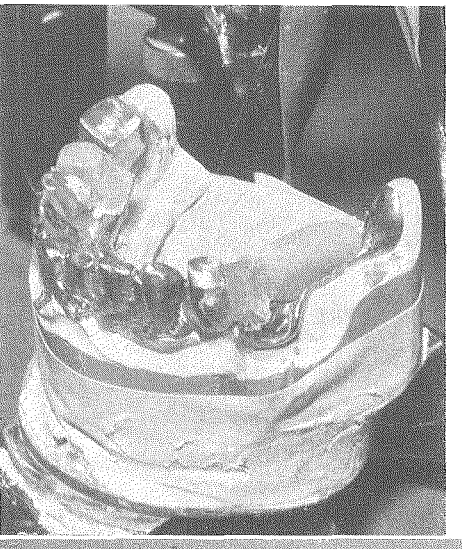

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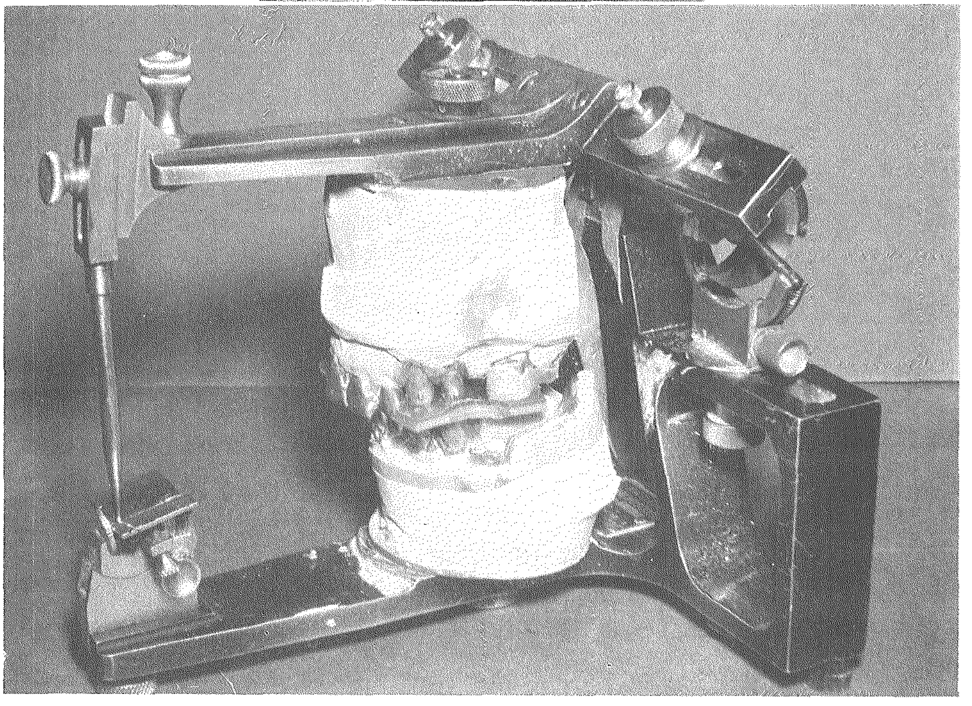
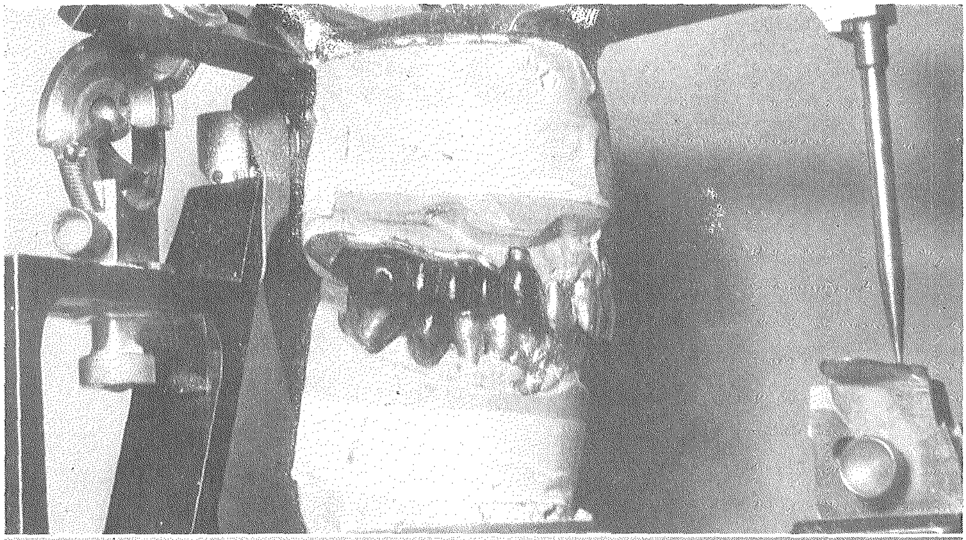


Fig. 690. A lower working cast made from a remount type of impression.
Fig. 691. Lower working cast attached to the articulator.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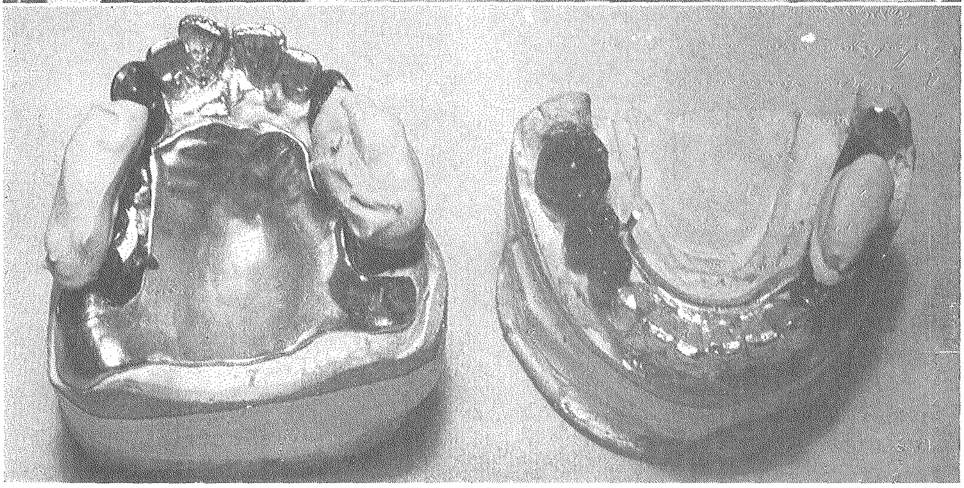
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Fig. 692. The articulation of the restorations in wax.
Fig. 693. Stone indices made of the occlusal surface of the wax articulation.

Now that accurately related casts are properly mounted on an articulator, the next step is to begin the wax carving of the appliance. The articulation is developed on the abutments and on the lower base. The occlusal surfaces of the lower partial denture will be carved in wax and cast in gold because they are to articulate with the gold restorations that are being made for the upper teeth (Fig. 692).

When the articulation is completed to satisfaction, the wax carvings are ready to be separated and prepared for investing and casting. To protect the occlusal surfaces on the lower partial denture, a stone index is constructed (Fig. 693). This will preserve the carvings in case they should become distorted or be broken in handling. The wax occlusal surfaces of the partial denture are thinned down on the index, retention is provided for the acrylic (Fig. 694), and the carvings are invested and cast.

The recesses for the female attachments are placed in the abutment teeth and paralleled (Fig. 695). Although a parallelometer may be used for this operation, most technicians do the final truing for parallelism by viewing across the extension rods on the mandrels. Even those who use a parallelometer finally check the mandrels by eye. When there is sufficient parallel space in the abutment wax patterns, these are sprued and cast. If veneer crowns are involved, windows of course must be created before the spruing, investing, and casting operations are undertaken (Fig. 696).

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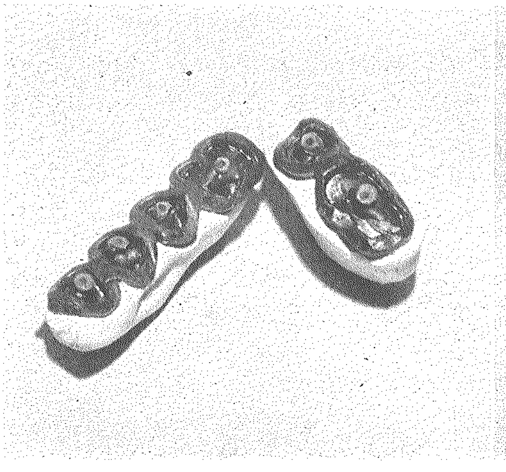

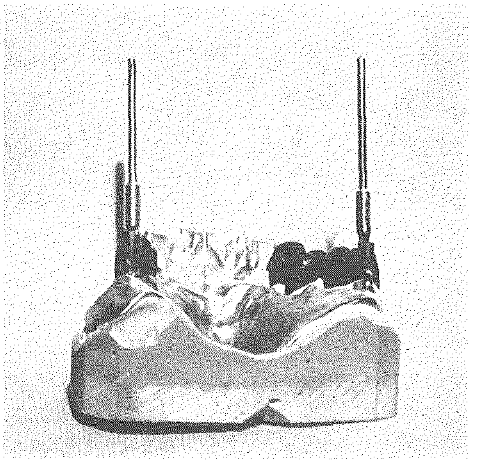

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Fig. 694. Thinned wax occlusal surfaces with retention forms added ready for casting.
Fig. 695. Parallel space established for the female attachments.

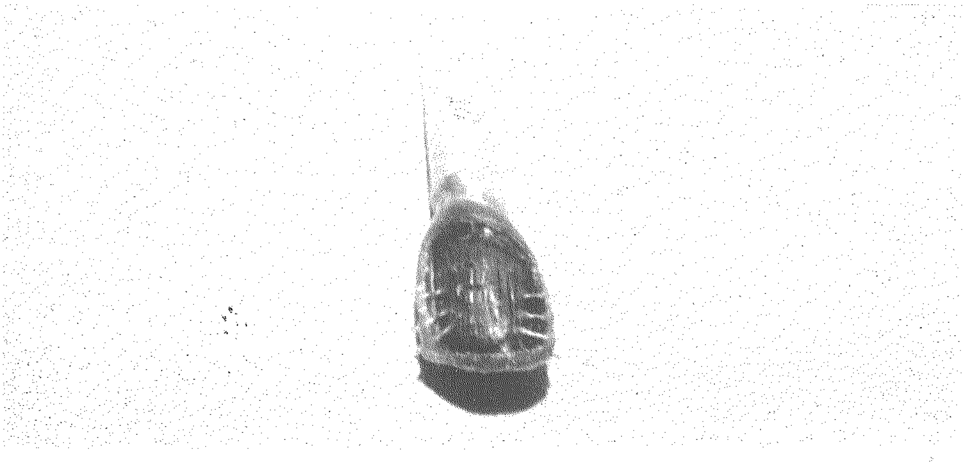

Fig. 696. Window established in an abutment tooth.

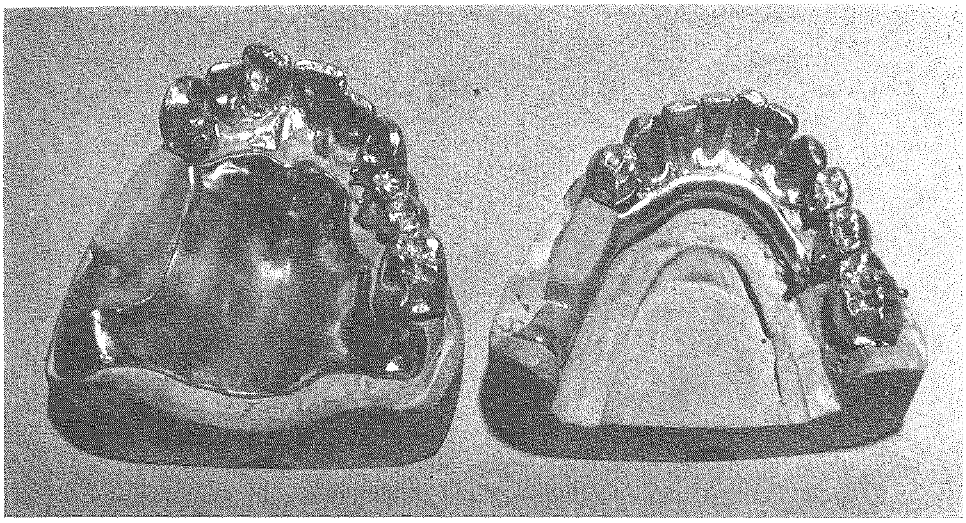

Fig. 697. Complete working casts on which the attachment work may be finished.

After the castings are made and fitted to the dies, the next step is to re-relate the base to the abutment castings. Although this may appear to be a superfluous step, it is worth the few extra minutes that it takes. The base can be related to the abutment castings with a quick-setting stone, a working cast is constructed on which the attachments are soldered into the abutment teeth, and the male attachments are fixed to the base. Complete casts can be obtained by repeating the remounting procedure with the finished castings (Fig. 697).

PLACING THE RETAINERS—LABORATORY PROCEDURE

Paralleling the attachment

The box portion of the attachment is placed in the recess provided for it in the abutment casting. It is made parallel to the other attachment. Make sure that there is a slight space completely around the box—between it and the recess of the casting (Fig. 698). The space may be slight, but it must be there. Although not always possible, the ideal situation is to have the box surrounded by an even amount of space. What must be avoided is to have a portion of the box against the gold casting while another portion of the box is separated from the casting by a large space. This would definitely distort the box and make it difficult to insert the male portion of the attachment.

Investing the attachment

With the boxes properly placed in their respective recesses in the abutment castings and firmly waxed in place with sticky casting wax, we are now ready to invest each box and casting as a preliminary step to soldering the boxes into

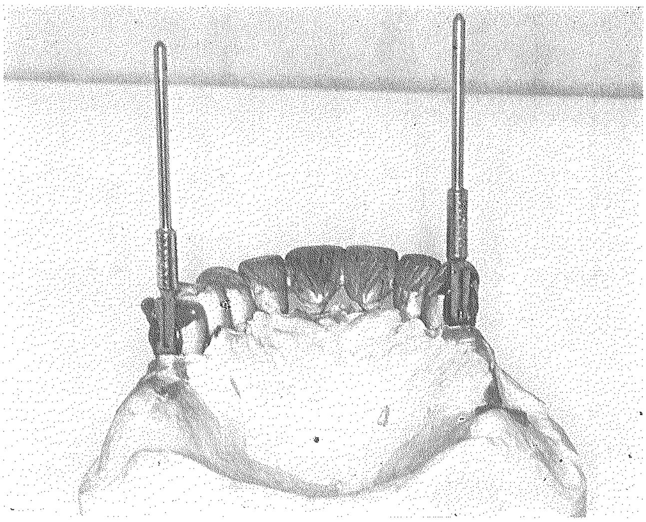

Fig. 698. Space created in the abutment casting to accommodate the attachment.

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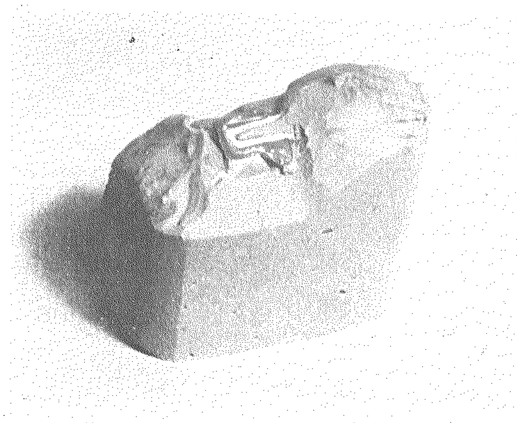

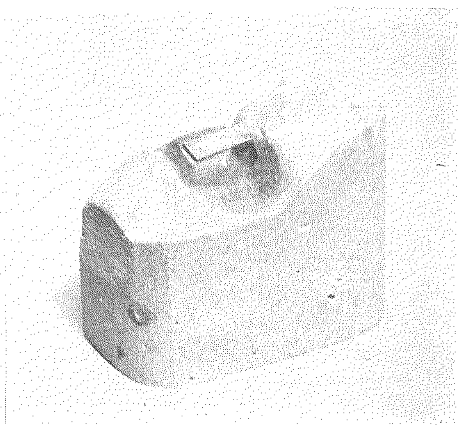

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Fig. 699. The abutment with attachment invested before soldering.
Fig. 700. Wax eliminated between the abutment and the attachment.

the abutments (Fig. 699). A carbon bar supplied with the attachment is placed in the box and is held in position with inlay investment. The investment encases the abutment casting and the carbon bar; thus, when the sticky wax is eliminated, the relationship of the attachment box to the abutment casting is accurately maintained (Fig. 700). The contact plate of the attachment and the edge of the recess in the abutment casting are exposed for easy access during soldering. The wax is washed out of the invested casting and attachment, and the block is preheated for soldering. A large brush flame is used to complete the heating of the invested abutment and attachment.

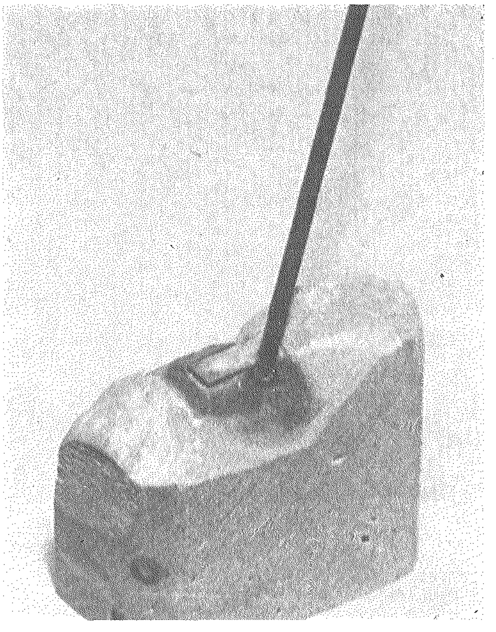


Fig. 701. Solder is fed from one area until the space is completely filled.

Soldering the attachment

When the attachment is sufficiently red from the heat, begin to feed the solder from one corner of the recess edge, taking care not to get any of it on the contact plate (Fig. 701). If the appliance is sufficiently hot, the solder will run around the back of the box and make a good joint. Continue to feed the strip solder from the same corner until the melted solder from the other corner can be seen. This ensures proper soldering, with the box completely surrounded by solder. If the soldering is incomplete, the box can be easily damaged in function.

After the boxes are soldered into the abutment restorations, they are cleaned and tested for parallelism. Any excess solder is removed, and the male portion is fitted to the female portion (Fig. 702). If the soldering has been done carefully, the male attachment should fit as before. If it binds, it is because the box has shrunk. If it fits too loosely, it is because the box was expanded by the soldering process. Both of these conditions are the result of improper or unequal space between the recess in the restoration and the female attachment. When there is too much space (and, consequently, too much solder), the contraction of the solder will cause the box to expand. Too close a contact in some spot between the recess in the restoration and the female attachment will cause an unequal contraction of the solder and a slight bind. The latter condition can usually be corrected by the use of a little Aqua-dag,* a metalizing graphite, which will free

*Hanau Engineering Co., Inc., Buffalo, N. Y.

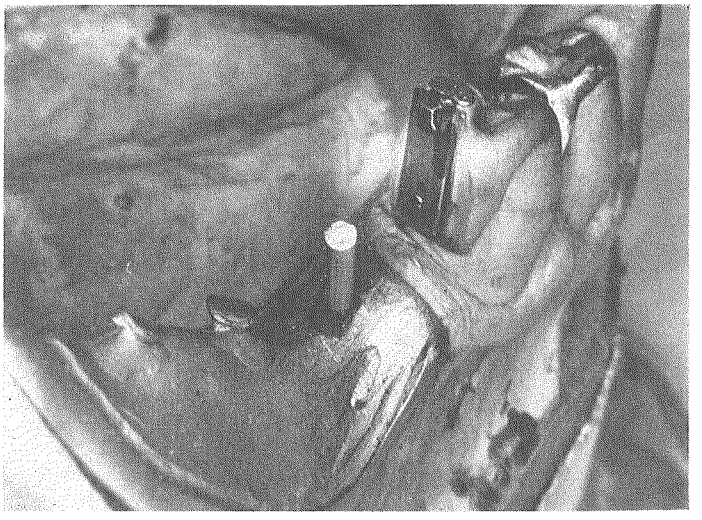


Fig. 702. The male portion of the attachment fitted to the soldered female portion.

the male attachment in the female attachment. The loose attachment is left that way until the appliance is finished. Then if it is still too loose, the male attachment can be spread slightly. Either difficulty will be avoided, however, if the attachment is carefully handled.

Waxing and casting the strut

Having fitted the male portions into the newly soldered attachments, next place the restorations on their dies on the casts and prepare to wax up the struts for joining the male attachments to the removable base (Fig. 703). It is impossible to

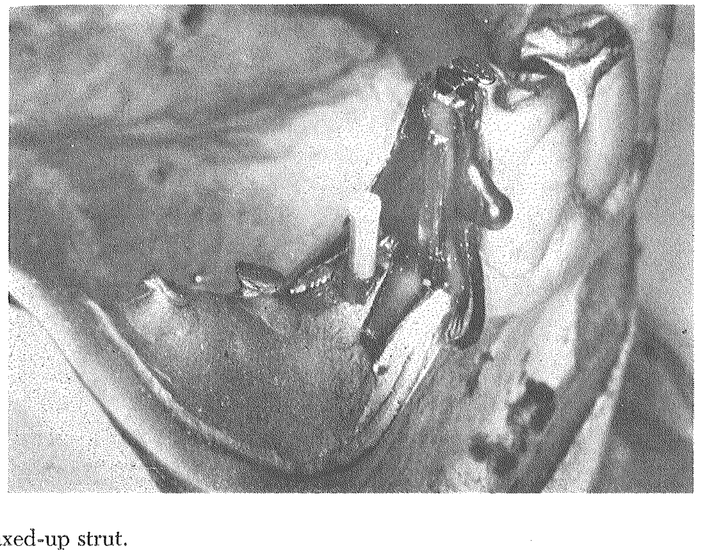
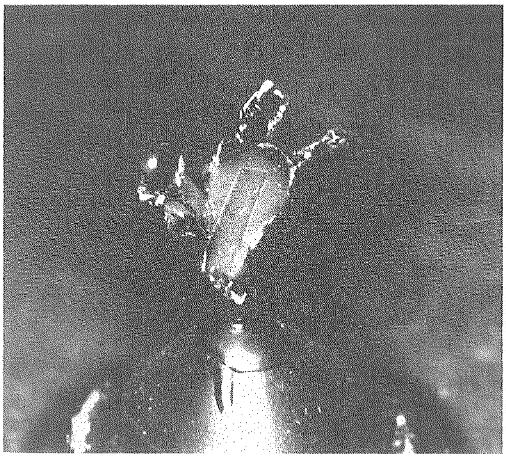


Fig. 703. Waxed-up strut.

make a base that has the identical fit of the impression. Therefore, in order to pick up any discrepancy that may be present in the base, relate the finished base to the abutments as previously described, rather than try to complete the appliance from one combination impression.

Now on the working cast is the removable base, the abutment restorations with the female attachments soldered into them and the male attachments seated in the female attachments. A strut is waxed around the back and sides of the male attachment, with a foot portion extending onto the base and around the round 14-gauge gold upright which was cast as part of the base. This wax pattern has to be treated like a well-fitting inlay. It must be well adapted to the male attachment and to the base. The sides of the strut are finished flush with the front of the contact plate of the male attachment so that it has a snug nest in the wax pattern. Now the wax pattern is removed from the base; the male attachment is removed from the wax pattern, and the latter is sprued and invested just like an inlay (Fig. 704) and is cast.

04 

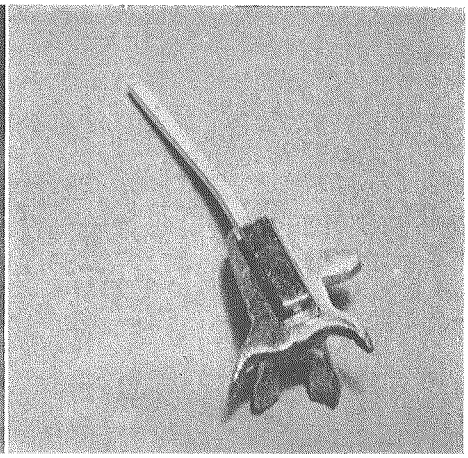
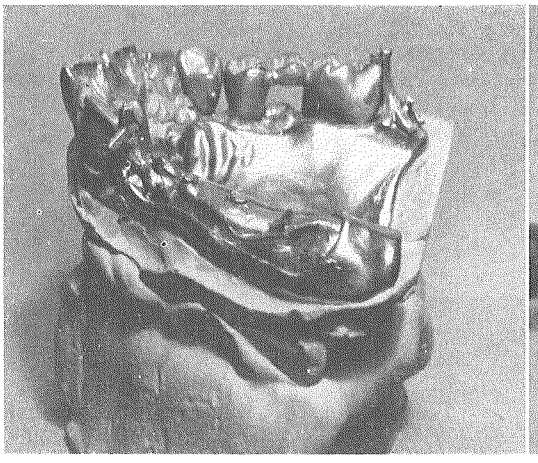
 705

Fig. 704. Sprued wax strut.
Fig. 705. The male attachment fitted to the strut nest.

Attaching the male portion to the base

When both struts are cast, the castings are carefully cleaned, and the male attachment is tried in its nest (Fig. 705). The strut and male attachment are then fitted onto the appliance—the male attachment in the female attachment and the strut foot against the base and around the gold post (Fig. 706). This is why we try to make the post parallel to the abutment restoration when waxing up the base. When the fits are acceptable—and it is very important that the foot part fits solidly against the base—we are ready to solder or sweat the male attachment to the strut. This is done in an open Bunsen flame. A slight groove is cut in the back of the strut to permit the placement of a small piece of 800 solder (Fig.

706 

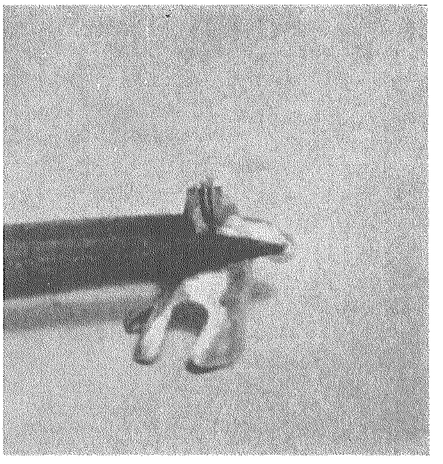
 707

Fig. 706. The strut fitted to the base around the upright post.
Fig. 707. Groove in back of the strut for placement of the solder.

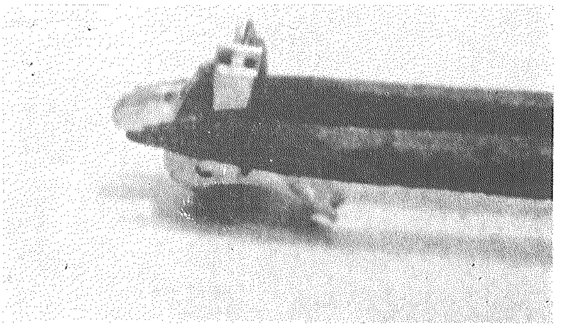


Fig. 708. Male attachment and strut held in lock tweezers for soldering.

707). The back of the male attachment is lightly covered with flux, and the male attachment is placed in its nest in the strut and is held in position with lock tweezers (Fig. 708). The tiny piece of solder is inserted in the groove, and the strut is held in the open flame. Very quickly the solder will encircle the male attachment and be attached to the strut.

When both struts are soldered to the male attachments, the struts must next be attached to the base. There are different ways of accomplishing this.

Riveting. There will be a minimum amount of warpage if the strut is riveted to the base. For this to be done, the foot part of the strut must fit accurately around the gold post of the base. The gold post is shortened until it is about 1 mm. higher than the flat part of the foot. The gold post is then carefully cut with a fine gold saw so that an X is formed on the surface of the post and down to the level of the foot portion of the strut. Then, with a small jeweler's peen hammer, gently tap the cut post, going around the rim until a small edge is turned

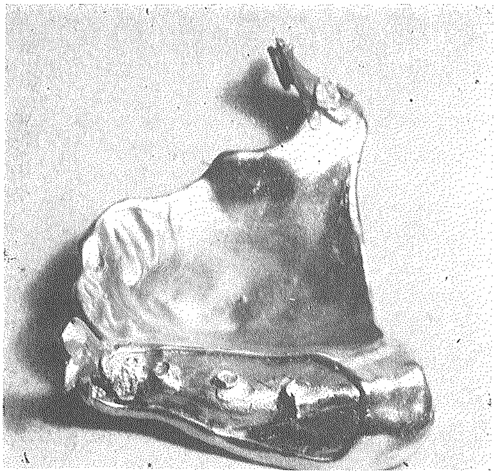


Fig. 709. Gold posts are mushroomed by means of an electric welding machine.

over and holds the foot firmly in place. *Caution!* The foot must be solidly on the base so that the strut will not be pulled over to one side. The blows must be gentle in order not to bend the base. The base must be held down firmly on the cast so that it does not rise up during the riveting.

Spot welding. Another way of attaching the strut to the base is to spot-weld the two parts together and then solder them in the open flame. Maximum warpage will take place when a base is invested and heated. Thus, if the appliance does not have to be invested, the distortion is minimized. By means of an electric welding machine, the gold post is mushroomed down over the foot portion of the strut (Fig. 709). Although this will weld the two parts together, the junction cannot be expected to last indefinitely. Therefore, complete the union by soldering in the open flame. With this procedure, it is extremely important that the fit of the foot be very accurate to the base; otherwise the unequal solder thickness will pull the strut in the direction of the thickest portion, and the attachments will not fit nicely into each other.

If the appliance has to be invested, there are several things one can do to minimize the warpage. One can use as little investment as is necessary to hold the strut related to the base. One can expose as much of the base as possible in order that the soldering temperature can be reached more quickly. Another precaution is to solder one strut at a time. Also, the opposite side should be invested after the first strut is attached.

ANOTHER METHOD OF HANDLING AN ATTACHMENT APPLIANCE

Let us now describe another way of handling an attachment appliance which has likewise been successful.

With this method the casting has to be made after the female attachments are soldered into the abutment restorations. The big problem here is getting an accurate relationship of the working casts in order that the articulation of the abutment restorations can be properly established. If considerable teeth are missing, the problem becomes more difficult because some kind of baseplate and bite-block combination must be used to relate the working casts. At best, these never simulate the exact condition as do the finished bases. In the method previously described, it will be recalled that the final base was used to relate the working cast. This, of course, had to be done with metal dies and transfers. If the preference is for stone dies (hydrocolloid or rubber base impressions), one then faces the problem of having to use a baseplate and occlusion rim combination. This combination can be somewhat enhanced by the use of a so-called stabilized base. This means a baseplate that is very accurately fitted to the working cast and reinforced to prevent warpage. At any rate, the working cast has to be mounted as accurately as possible to the opposing cast and to the articulator.

The appliance is waxed and carved for articulation. Parallel space is established in the abutment teeth, and they are invested and cast. The occlusal surfaces are handled as before, with stone indices and invested and cast. If the fit from the stone dies are trusted to be sufficiently accurate, the female attachments can be placed in position and soldered to the castings. If, however, there is concern about the fit, it is advisable to try the castings on the teeth and take a new relationship of the castings to each other to ensure better parallelism.

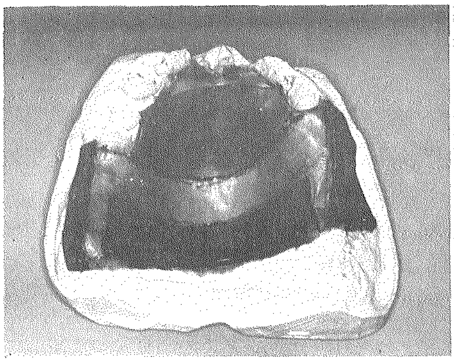
The impression procedure used here is similar to a remount, except that considerable attention is paid to the edentulous area. Be *very careful* about any relief wax that may be used in the preparation of the impression before pouring because the edentulous area must be accurate (see Chapter 19 for a description of the compound core and alginate technique).

On this cast, which has an accurate relationship of the abutment restorations to the edentulous areas, will be constructed a metal framework. The abutment restorations have the female attachments soldered in place, and the male attachments have been fitted. A 26-gauge wax relief is placed on the palate. Two thicknesses of 26-gauge wax are used as a form on either side of a palatal bar which will be fashioned out of Dura-Lay.* The form will make it easier to keep a uniform thickness to the Dura-Lay pattern (Fig. 710).

The Dura-Lay powder and liquid is applied with a camel's-hair brush, and the palatal bar is formed, as well as the struts and clasp arms if so desired. After the Dura-Lay has cured, it can be removed, trimmed, checked, and altered as desired. When the pattern is completed, it is sprued and cast. The casting is now fitted to the attachments and the cast. Usually the male attachments can be soldered in the open flame if the Dura-Lay was carefully adapted around them.

When the male attachments have been soldered and checked for easy removal, an acrylic saddle (relieved with one thickness of 26-gauge wax) is attached to

*Reliance Dental Mfg. Co., Chicago, Ill.



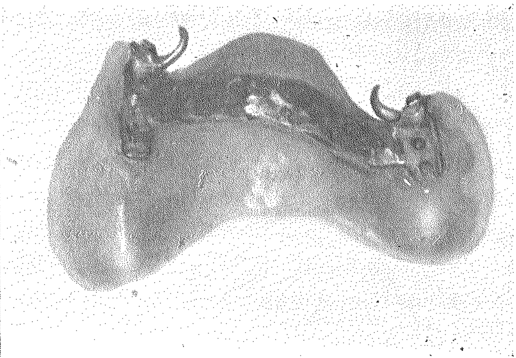


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Fig. 710. Two layers of 26-gauge casting wax are used for the form in which the Dura-Lay pattern will be fashioned for the bar.
Fig. 711. A quick-curing acrylic tray is attached to the bar. The tray is relieved with one layer of 26-gauge wax.

the palatal bar. Now a "wash" inside the relieved acrylic saddle (Fig. 711) can be taken. For a mucostatic impression, Kydac* is used.

The attachment appliance is completed after the occlusal surfaces are properly placed.

With this technique some of the qualities of a mucostatic base may be sacrificed because acrylic is used. On the other hand, the disastrous soldering procedure which ruins every mucostatic metal base has been eliminated. I think it the lesser of two evils.

ESTABLISHING THE ARTICULATION

At this point, by whichever method we chose, the female attachments will have been soldered into the abutment restorations and the male attachments to the base. Now the removable partial denture is tried in the patient's mouth, and new remount casts are related for the purpose of placing the occlusal surfaces in their proper position.

The length of the male and female attachments is trimmed approximately so that a better centric interocclusal record can be obtained. Place the male attachment in the female attachment of the abutment casting and carefully grind the height of the attachments—running the stone from the male to the female attachment in order to avoid drawing it over the male attachment—and lock the male attachment in place.

Place the entire appliance—abutments and removable partial—in the patient's mouth and obtain a centric interocclusal record. (The edentulous space is again built up with self-curing acrylic so that there is an occlusion rim just short of the occlusal surfaces of the upper teeth.) Then take a remount type of impression

*The Motloid Co., Inc., Chicago, Ill.

—a combination of compound and hydrocolloid. Make the remount cast after relieving with wax any undercuts in the base which would make its removal difficult. The lower remount cast is related to the upper cast, and the occlusal surfaces of the appliance are positioned.

The cast occlusal surfaces are positioned and adjusted to the mounted restorations of the upper teeth. It is advisable to place the occlusal surfaces just a little bit high so that, after adjustment, they will be in harmony with the abutment restorations. When the occlusal surfaces are well adjusted to the rest of the appliance, wax up the buccal and lingual contours, being sure to contour them like natural teeth, i.e., wider at the occlusal third than at the gingival and occlusal levels (Fig. 712).

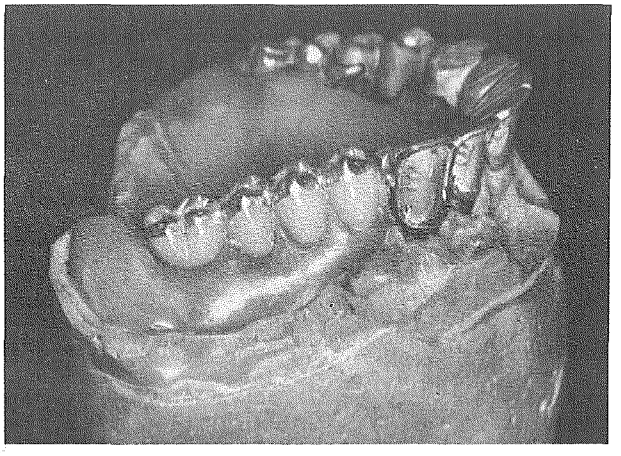
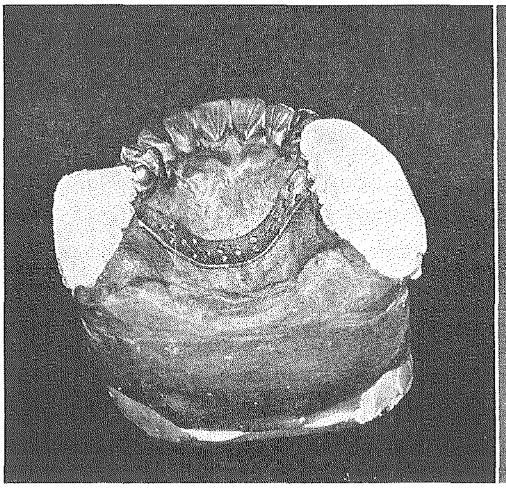


Fig. 712. The cast occlusal surfaces are waxed for buccal and lingual contours.

713 

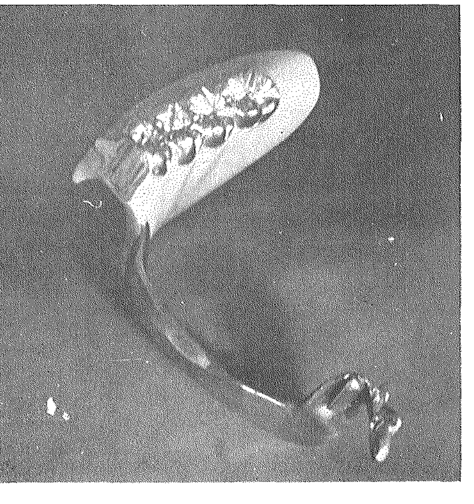
 71·

Fig. 713. Index to maintain the relationship of the occlusal blocks to the base.
Fig. 714. Completed appliance ready for the patient.

The occlusal surface with waxed-up buccal and lingual contours is removed from the base, and the gingival area is trimmed a little short of the base. It is now flasked, and the wax is changed to tooth-colored acrylic. This block is trimmed and polished and again related to the cast base and the upper teeth and waxed into position. An index is constructed to hold this relationship (Fig. 713). The attaching wax is boiled out, and the occlusal block is luted to the cast base with self-curing pink acrylic while the index maintains the relationship. After doing one side and allowing the self-curing acrylic to polymerize, remove the stone index and complete the attachment of the occlusal block to the cast base. If a thin layer of melted wax is applied to the tooth-colored acrylic of the occlusal block in the gingival contour, the pink acrylic can be kept nicely off the tooth-colored acrylic. The wax protection is of course applied occlusally from the gingival outline. Some of the pink acrylic will engage and cover the tooth-colored acrylic, just as in the case of porcelain teeth when they are being attached to a denture base.

The appliance is now trimmed and polished and is ready to be worn for a few days before another remount is made for the final adjustment (Fig. 714).

SPECIAL CONSIDERATIONS

Use of a split dummy

Quite frequently, patients are encountered who are edentulous on one side. On the other side several teeth may be missing, but the second or third molar is in position and can be used for a fixed bridge abutment.

This appliance could be designed so that all the edentulous areas would be replaced by a removable prosthesis. Attachments could be placed in the three abutment teeth, and the two edentulous areas would be connected with a lingual bar. There are good reasons, however, to treat this appliance a little differently.

The side with the second or third molar present should be restored with a fixed bridge, for the original premise which favors a fixed prosthesis wherever possible is still valid. There would now be additional stabilized articulation. Then too, the fact that there would be one less removable appliance would be psychologically good for the patient. In addition, by using a split dummy on the fixed bridge as the attachment on that side, we would have a double abutment which would better distribute the strain of the attachment appliance. The fact that only two attachments are needed instead of three would simplify the appliance as well as make it a better one.

To carry out this design, proceed as follows. The female attachment on the side of the fixed bridge is placed in the lingual cusp of one of the dummies (Fig. 715). The attachment is placed so that the contact plates face the tongue. The male attachment is placed on the removable part of the appliance according to the manner described previously in this chapter—either with a separate strut which is soldered to the lingual bar or else by being soldered to the strut which

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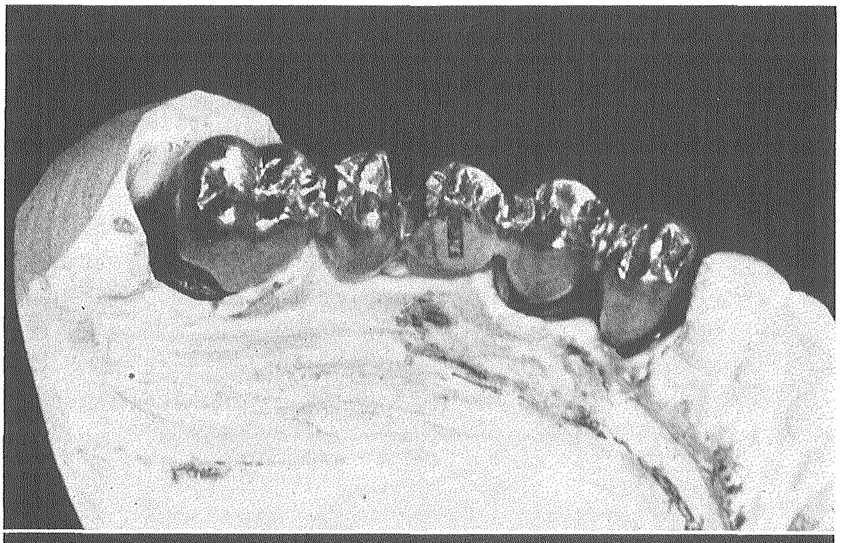

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Fig. 715. Attachment placed in the dummy of a fixed bridge.
Fig. 716. Buccolingual groove to accommodate the removal bar.

is cast as part of the lingual bar. For the latter method, the mucostatic impression for the base must be taken after the female attachments are soldered to their respective restorations.

When using the split dummy for the female attachment, form a buccolingual groove on the occlusal surface of the dummy (Fig. 716). In this groove, have a crossbar which is attached to the strut and extends buccally a slight bit. This little projection acts as a thumbnail catch and enables the patient to remove the appliance easily.

The procedure for establishing a split dummy in a fixed bridge is as follows. When the articulation is completely developed in wax and prior to separating the wax patterns for the final marginal adaptation, establish the recess for the attachment in the lingual aspect of the selected dummy. The recess is made parallel to the recess in the other abutment. A groove is established buccolingually near the recess to house the crossbar. The sides of the crossbar groove must be parallel to the recess for the attachment.

After the restorations are cast and remounted (and related to the removable portion of the appliance), the female attachments are paralleled and soldered to place. Next, wax up the struts. The strut for the split dummy side is a little more intricate and must be carefully handled. In addition to forming a nest for the male attachment, it must also butt against the lingual bar which extends to this area. Also, the crossbar must be waxed as part of the strut. Difficulty may be encountered if the walls of the recess for the crossbar are not parallel to the box in the dummy. If such is the case, the sides of the walls should be carefully altered with a bur, stone, or disc until the walls of the recess are parallel to the attachment, thus permitting the removal of the wax pattern for the strut and crossbar. This wax pattern is then invested in inlay investment and is cast.

Use of an external lingual arm

When any attachment appliance is being designed, a must is to allow for as long an attachment as possible. However, in spite of the best efforts, there will sometimes be situations in which an attachment of the desired length cannot be used. In these instances, I prefer to use a lingual arm which will furnish a little external friction to make up for the shortness of the attachment (Fig. 717). The attachment in such appliances acts as a precision rest, and the lingual arm acts

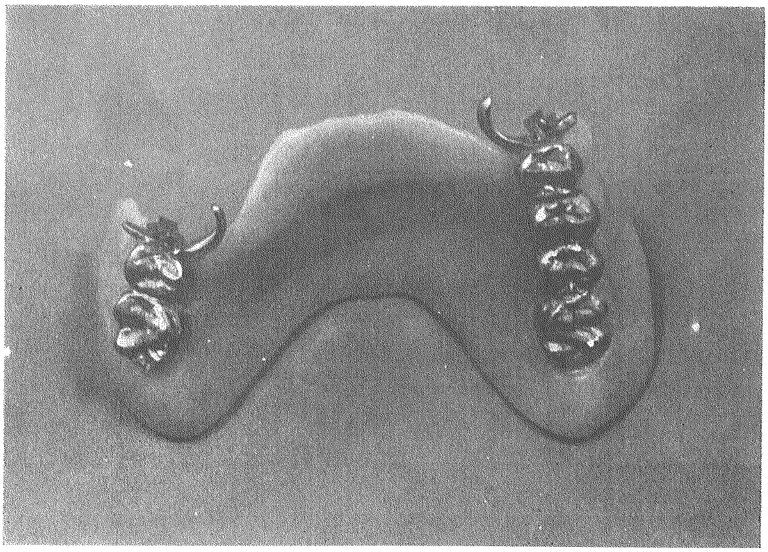


Fig. 717. Lingual arms to increase the frictional retention of the attachments.

as a frictional resistance. Occasionally, a buccal arm may be used, particularly for elderly people who may have difficulty in managing an attachment prosthesis.

The lingual arm can be recessed in the lingual portion of the crown, where it will not interfere with the patient's tongue.

Stress-breaker attachments

There are patients for whom a stress-breaker may be used to advantage, although with the advent of mucostatic bases the need for this type of attachment has diminished. Occasionally, however, when a unilateral removable appliance is made, using double bicuspid abutments, the distalmost attachment is a stress-breaker. These patients are rare, and the conditions must be ideal in order to make such an attachment without a lingual bar. The bicuspid abutments must be in good condition, and the ridge must have some resistance to lateral displacement.

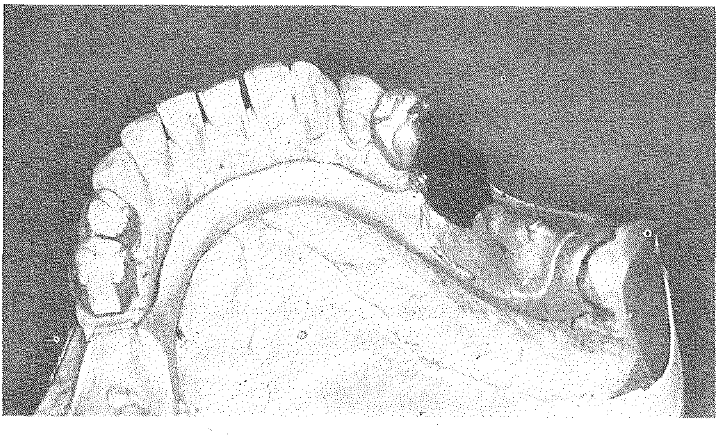


Fig. 718. McCollum stress-breaker box waxed to place on base.

There are several types of stress-breakers that can be used. The proper kind will permit vertical movement of the saddle area while still transmitting vertical stresses to the long axis of the abutment tooth. The McCollum type of stress-breaker* is such a unit.

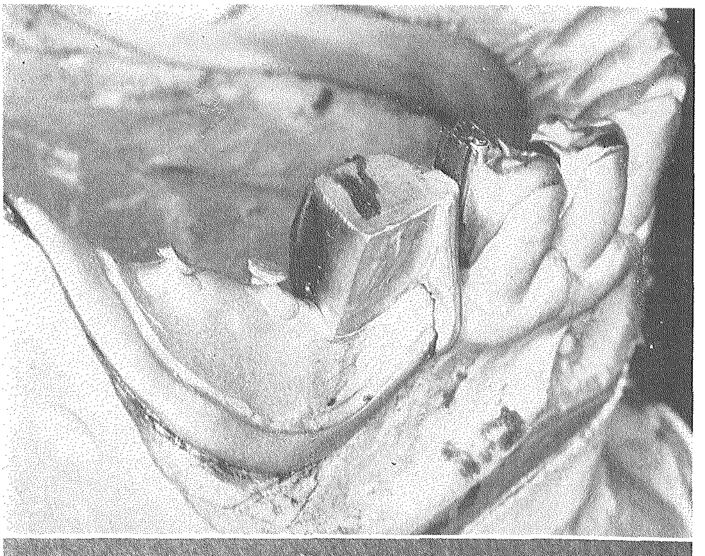
The McCollum stress-breakers are assembled for right and left sides. They may also be obtained unassembled so that, by soldering the tube on the side of the attachment bar housing, one can make his own right or left attachment.

The easiest way to construct a stress-breaker is to make use of the separate base technique. After the abutments have been cast and related to the base, and a working model made, the female attachments are soldered into the abutment castings. The male portion of the stress-breaker is positioned in the female attachment, and the bar housing is placed on the male stress-breaker bar. The tube of

*Stern Dental Co., Inc., Mount Vernon, N. Y.

the housing is toward the lingual aspect. Wax is placed around the housing to make a butt joint to the base. The wax is carried to the back of the male attachment and is made flush with the house opening. There is a thin layer of wax over the top of the housing to reinforce it (Fig. 718). There must be enough room for the occlusal surface of the first tooth in the edentulous area, which is usually cast in gold with the rest of the occlusal surfaces distal to it. If porcelain teeth are to be used in the edentulous area, it is still a good idea to have the occlusal surface over the housing in gold. Porcelain would have to be too thin and could break easily.

The labial aspect of the housing is thinly waxed up to provide room for veneer material. If a porcelain facing is to be used, it must be fitted to the housing and waxed up at this time.



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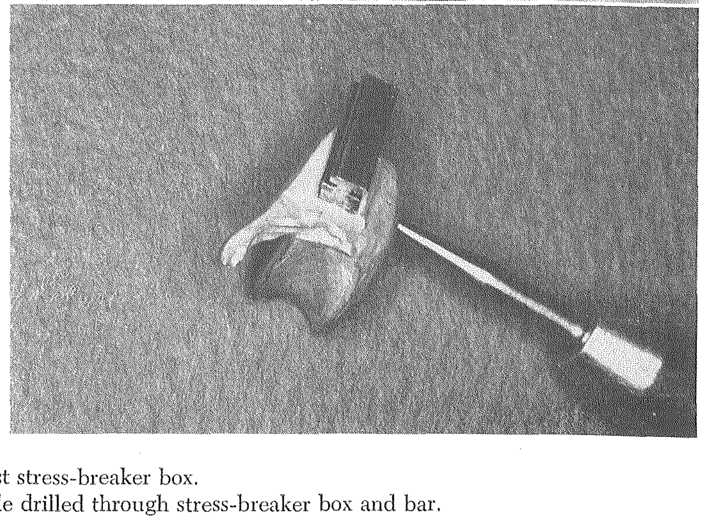

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Fig. 719. Cast stress-breaker box.
Fig. 720. Hole drilled through stress-breaker box and bar.

When the housing is completely waxed up, the male portion is removed from the housing, which is then sprued, invested, and cast (Fig. 719). Special carbons are furnished with the stress-breaker to protect the box in the housing, as well as the hole which is to receive the screw.

After the housing block is cast, the carbons are removed, and the hole is drilled through the housing from the lingual aspect, but not through the buccal side. The hole is also drilled through the stress-breaker bar of the male attachment. This is done after careful marking of the hole opening from the lingual hole in the housing block when the male attachment is in its proper location (Fig. 720).

The lingual hole in the housing block is tapped with a tap of proper size, and the screw is adjusted for length so that it reaches the other side of the housing (Fig. 721). Thus is can be locked in place, holding the stress bar and preventing

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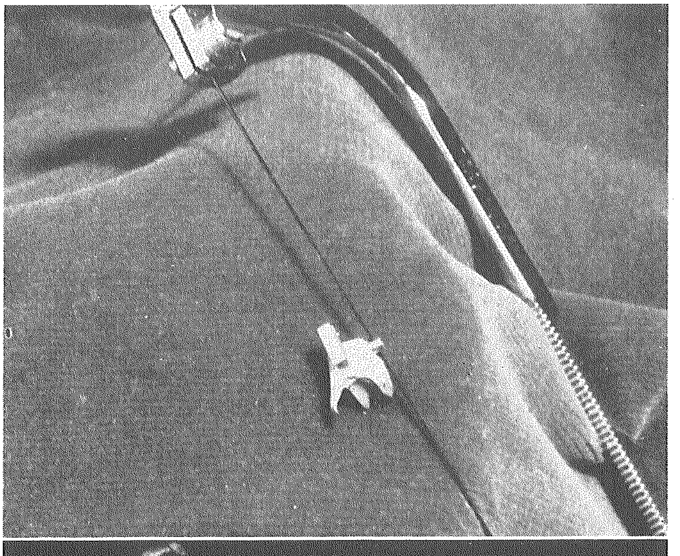

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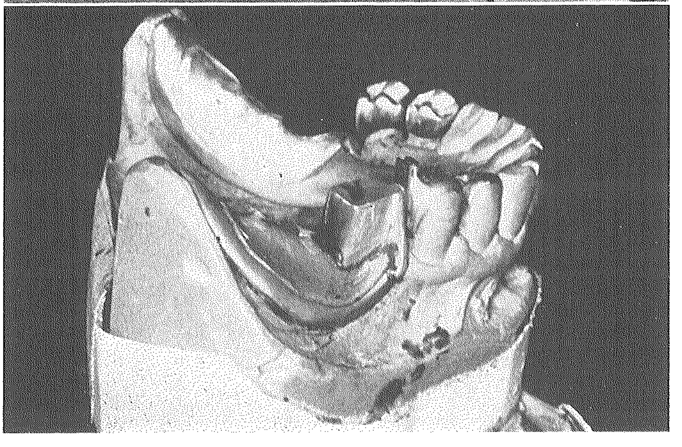


Fig. 721. Screw fitted and cut to proper length for stress-breaker.
Fig. 722. Stress-breaker box soldered to base.

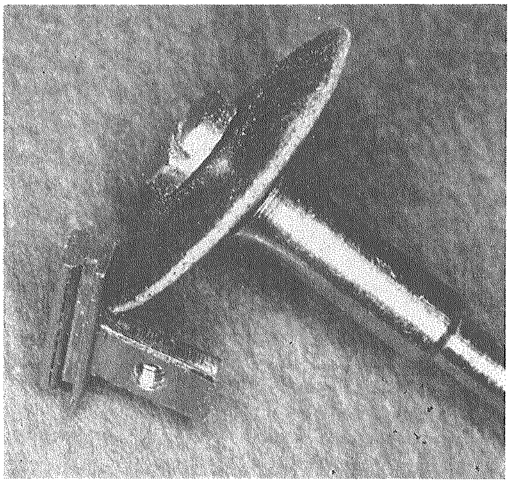


Fig. 723. Rubber wheel used for adjustment of stress-breaker action.

it from coming out. The head of the screw should be flush with the lingual cast surface of the housing block.

When all these steps are completed, the housing is soldered to the base. The housing is waxed in position, and the relationship is held with a minimum of investment. The housing is then soldered to the base in this related position (Fig. 722). Care should be taken not to get any solder on the screw or in the screw hole or in the stress-breaker bar housing.

The amount of stress-breaker action can be established after the appliance is completed by using a rubber wheel on the top of the distal end of the stress-breaker bar. Usually very little adjustment is necessary. Sometimes the lower edge of the bar anterior to the screw may also have to be relieved with a rubber wheel (Fig. 723). This will permit a downward movement of the distal extension appliance without tipping the abutment tooth distally. The stress is still vertical and in the long axis of the tooth.

CHAPTER 26

The gnatholator and checkbites

The most accurate means of recording the basic functional movements of the masticatory mechanism is undoubtedly the extraoral tracing method developed by McCollum* and associates. Refinements in the tracing apparatus by Granger† and in the articulator by Stuart‡ have made this procedure simple and more accurate. These points are discussed in earlier chapters.

As a means of studying jaw relations, the beginner would do well to start with a checkbite technique. Although there are inherent weaknesses in any checkbite procedure, this type of technique is probably a little easier to comprehend and execute for one who has not been thinking about jaw relations extensively. It may even be used successfully in practice for the construction of full dentures, but it is not recommended for patients requiring extensive mouth rehabilitation.

It was the need for a student instrument that prompted Granger to design the gnatholator.§ This is an excellent checkbite instrument because it permits the engaging and disengaging of the upper and lower members of the articulator with ease.

BASIC ERRORS IN MOST CHECKBITE METHODS

In most articulators, any closure of the vertical dimension changes the angulation of the condyle path inasmuch as the inclination is fixed to the lower member of the articulator. In the patient, the condyle path is constant to the upper teeth or jaw. Therefore, to reproduce jaw positions faithfully, an articulator must have the condyle slot fixed to the upper bow on which the cast of the upper teeth (or jaw) is fastened. Any closure of the vertical dimension (lowering the upper bow) on such an articulator will also change the inclination of the condyle slot, thus maintaining the same relationship as exists in the patient's head.

A checkbite must be taken with the jaws in an open position. With most articulators, subsequent closure of the instrument after the checkbite is removed causes malrelationship of the parts. This is one of the difficulties encountered with such instruments.

*Dr. B. B. McCollum, Sepulveda, Calif.
†Dr. Ernest R. Granger, Mount Vernon, N. Y.
‡Dr. Charles E. Stuart, Ventura, Calif.
§H. D. Justi & Son, Inc., Philadelphia, Pa.

Another weakness of most checkbite methods is the fact that the checkbite is not used on the opening and closing axis. This introduces a tremendous error and negates any value that the checkbite may have had. It is actually possible to demonstrate that the *same* checkbite used with and without the axis will produce entirely different results.

Fig. 724 is a diagram showing the centric mounting of two casts by means of a checkbite. No effort was made to correlate this mounting to the true axis of the patient; they were arbitrarily mounted. The frame represents an articulator, and the intersection at the upper left-hand corner represents the centric relation of the upper and lower members of the articulator.

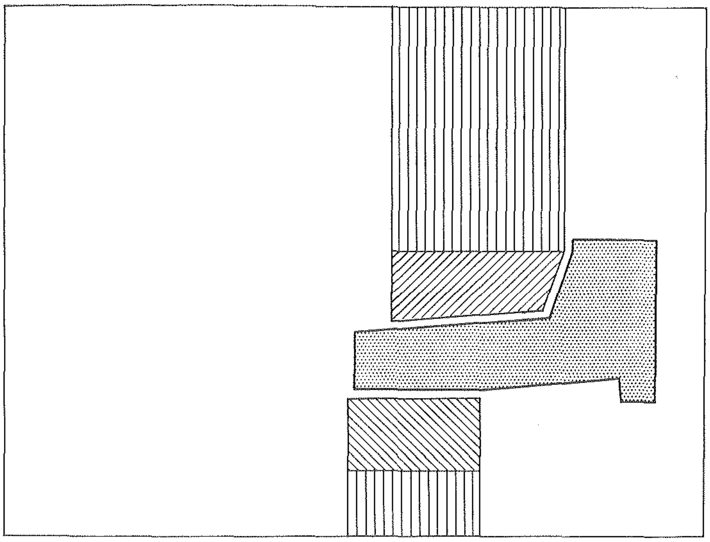


Fig. 724. An arbitrary centric mounting of casts to the axis. Intersection of frame at upper left-hand corner represents the centric position of an articulator.

In Fig. 725, the protrusive position of the checkbite has been used to determine the angulation created by this record. The second position of the frame represents the protrusive position of the articulator. By joining these two—the centric intersection and the protrusive position—we have determined the condyle path. This is the way checkbites are used—two points determining a line. The first point is the starting point or centric position; the second point (located by the second record position) is the place to which the first point travelled, as recorded by the protrusive checkbite.

In Fig. 726, the same simulated casts with the *same* checkbite in another position (arbitrary) have been mounted in the frames of the articulator. In Fig. 727, with the protrusive position of the same checkbite, the protrusive position of the same frames has now been located, and the inclination of the condyle path so produced has been indicated in the upper left-hand corner.

These two paths are transposed from the same centric relation starting point in Fig. 728. Note the difference in the two inclinations! Remember, the same checkbite was used for both recordings, the only difference being the relation of

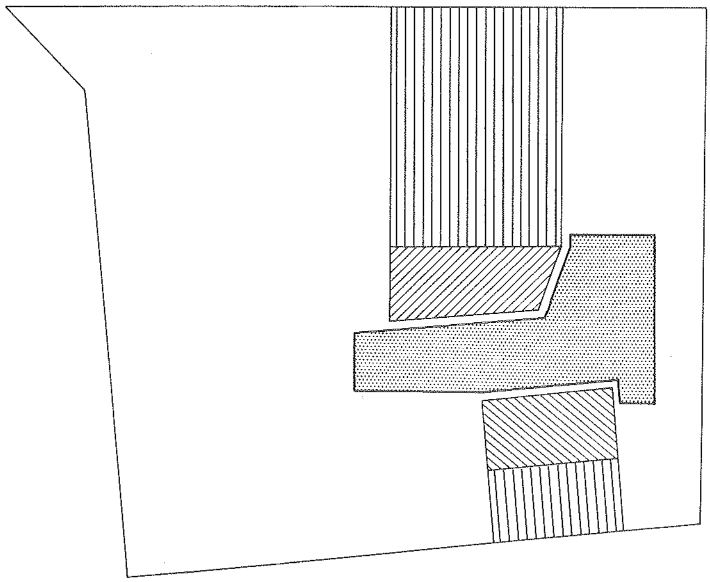


Fig. 725. The protrusive position is determined by the protrusive checkbite. The line joining this point (upper left-hand corner) with the previous centric position gives the condyle path.

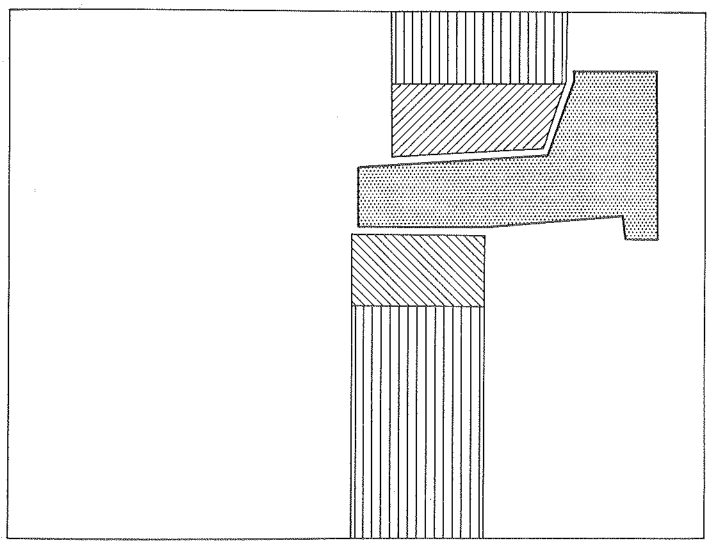


Fig. 726. The same casts are mounted with the same centric checkbite in another position on the articulator.

the simulated casts to the axis. In other words, if the true axis-to-cast relationship was the one recorded in Fig. 725 and if the relationship shown in Fig. 727 is arbitrarily used, the indicated discrepancy would be apparent. Although the

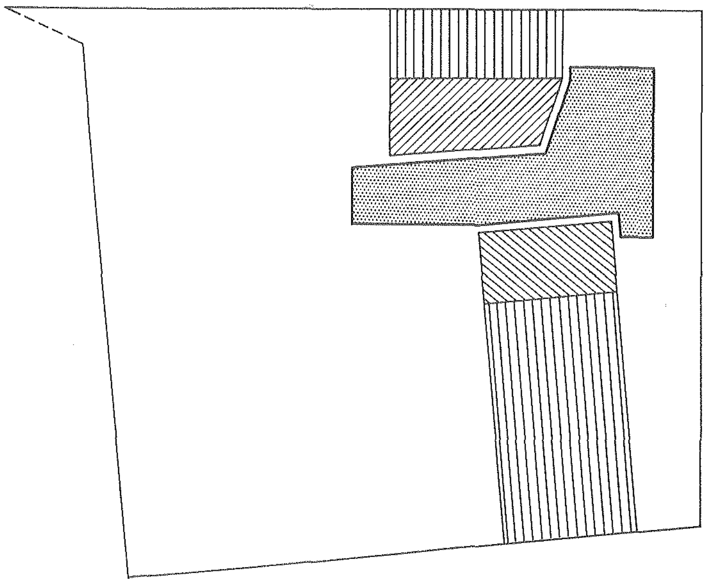


Fig. 727. With the same protrusive checkbite as before, the protrusive position has been located on the articulator.

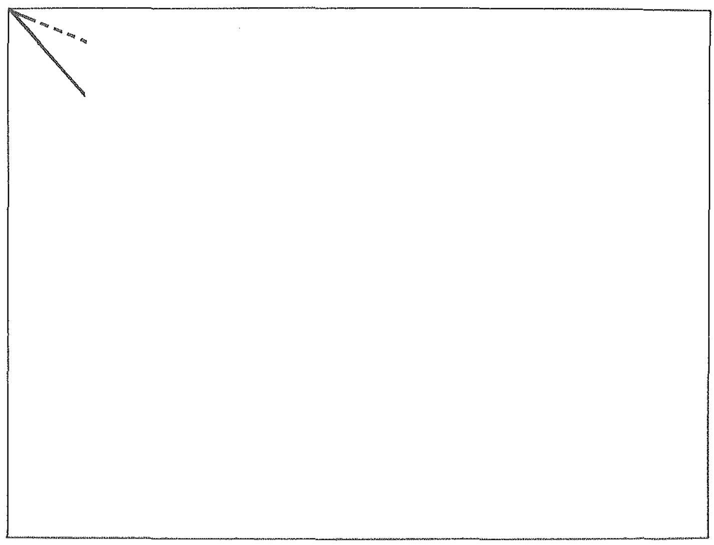


Fig. 728. From the same centric relation starting point, *two* protrusive condyle paths determined by the same checkbites have been established.

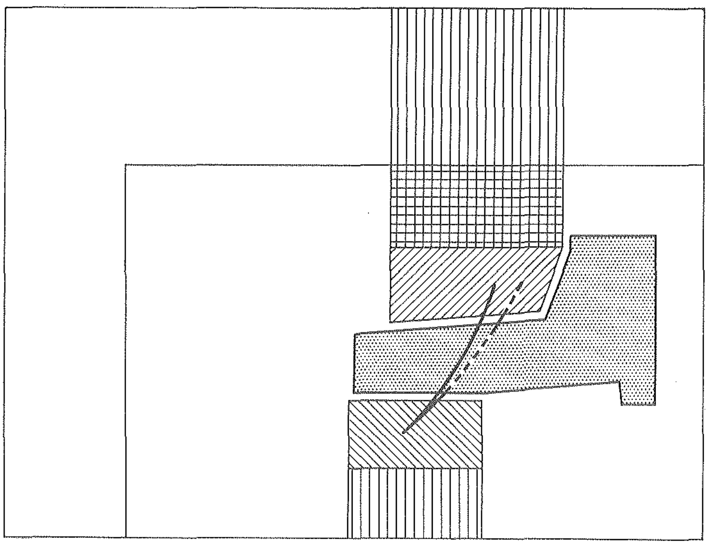


Fig. 729. The two arcs of closure possible by the two mountings, even though the same checkbites were used in both cases.

malpositioning of the simulated casts may have been exaggerated to demonstrate the point vividly, still any discrepancy between the actual axis and a "guesstimated" position will produce a corresponding degree of error in the checkbite procedure.

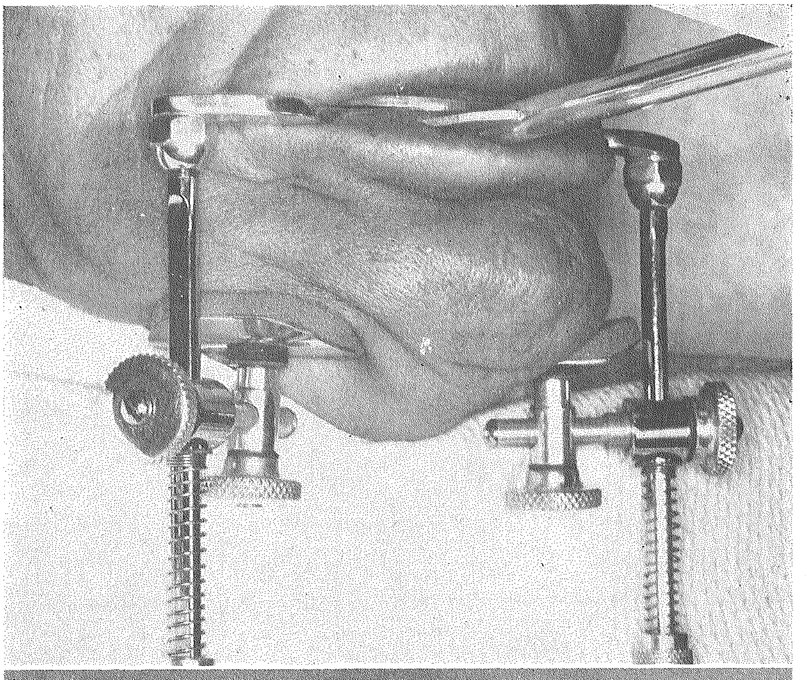
Fig. 729 shows the two arcs of closure that would be possible if the axis had not actually been used for the mountings. Note that as the checkbite is removed and the casts are closed together through the thickness of the checkbite, different arcs of closure are used. Thus, areas (teeth) would come together on the articulator that did not come together in the mouth. So, it is apparent that checkbites are useless in reproducing jaw relations unless they are used in conjunction with the hinge axis.

When called upon to construct a set of dentures, one sometimes resorts to the modern checkbite technique which has overcome the basic errors just discussed. It is adequate for edentulous situations, but I would not recommend this method when there are sufficient teeth to retain a clutch adequately. In such patients the extraoral tracings are superior by far.

In the construction of full dentures, the recording of the patient's jaw movements should be separated into two steps—the location of the hinge axis and the determination of the paths of the centers of rotation.

LOCATION OF THE HINGE AXIS

Let us consider the first step in securing functional records from edentulous patients—the location of the hinge axis.



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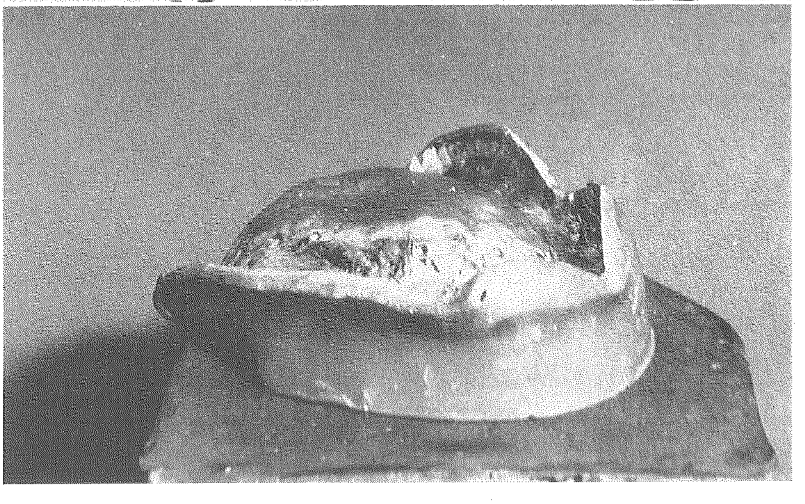

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Fig. 730. The Lauritzen chin clamp in place.
Fig. 731. Stabilized baseplate and occlusion rim.

It is a good idea to use the trainer on the patient before placing the apparatus. This will facilitate the location of the axis.

A hinge-bow is attached to a face-bow fork, which in turn engages a tray that is fitted to the lower ridge and held firmly in place by means of a special clamp. I prefer the clamp designed by Lauritzen* because it is quickly fastened

*Dr. Arne G. Lauritzen, Seattle, Wash.

in position, holds the tray rigidly, and allows ample room for guidance of the patient since it leaves the chin area free (Fig. 730). The finished upper base with an occlusion rim on it may be used as a stop against which the lower tray (and fork) can contact as the patient closes the jaws. In the absence of a finished upper base, a stabilized baseplate and occlusion rim may be used (Fig. 731). A set of lined cards can be held over the joint area by means of a spring headpiece or by the assistant to cover any skin movement that may take place (Fig. 732). The lower tray is lined with heavy rubber base material so that the clamping will be as comfortable as possible. When this apparatus is firmly in place, the patient is instructed in the hingelike movement.

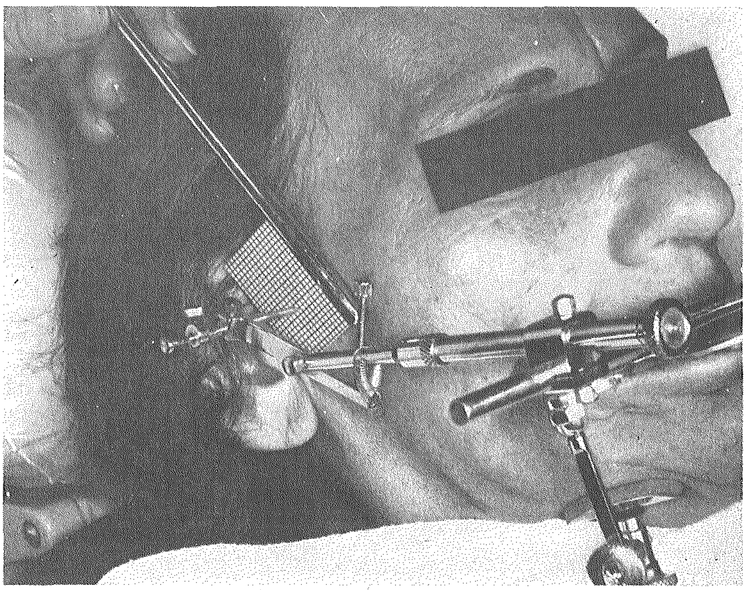


Fig. 732. Lined card covers skin movement and aids in the accurate location of the axis.

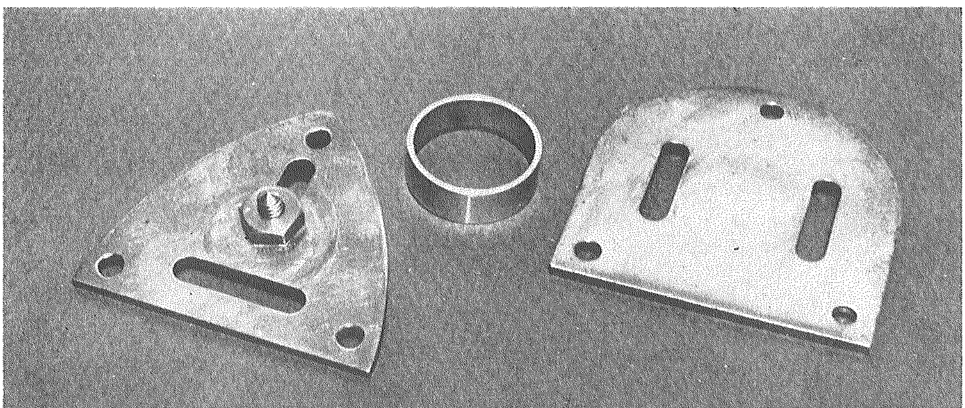
One practical way of doing this is to have the patient put his hand on the operator's chin while he demonstrates the hingelike movement. The undesirable protrusive movement should be pointed out, and the patient should be instructed to avoid it.

Now, by trial and error, as described in detail in Chapter 3, the center of rotation is located on each side. After locating the point at which the tip of the stylus rotates without arcing, carefully mark this on the side of the patient's face. Remove the lined card, make certain to have the patient's jaws fully retruded, sit the patient upright so that there is no skin displacement, and transfer the mark to the skin by pressing the inked tip of the stylus against the skin. With a fine tattoo needle and English vermilion dye, this point is permanently marked on the patient's face. When both sides are located and marked, select a third point on the side of the nose opposite the infraorbital notch and make a permanent mark there. This third point with the two hinge axis points locates the axis-orbital plane—the plane of future reference to which the records and all other mountings of casts will be related.

PREPARING CHECKBITE PLATES FOR THE PATIENT

With the axis-orbital plane as a reference, a face-bow transfer is made of the finished upper base or stabilized baseplate. A centric relation record is taken with the finished lower base or stabilized baseplate against the upper base. By means of these records the upper and lower bases are related and attached to the articulator to enable the checkbite plates to be placed accurately in position (see Chapter 6 for a detailed description of the method for using the mounting frame).

Granger recently designed checkbite plates* for student use which are inex-



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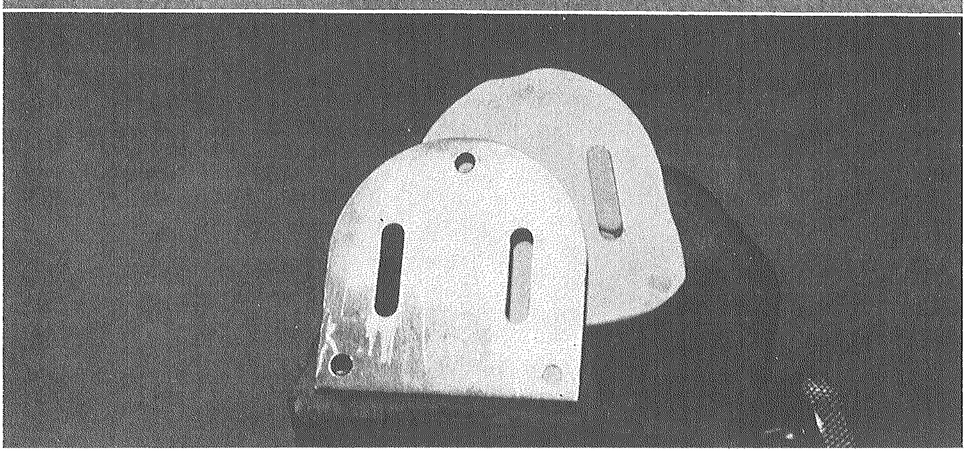

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Fig. 733. Granger checkbite plates.
Fig. 734. Slots on upper plate for accurate seating of stone checkbite.

*H. D. Justi & Son, Inc., Philadelphia, Pa.

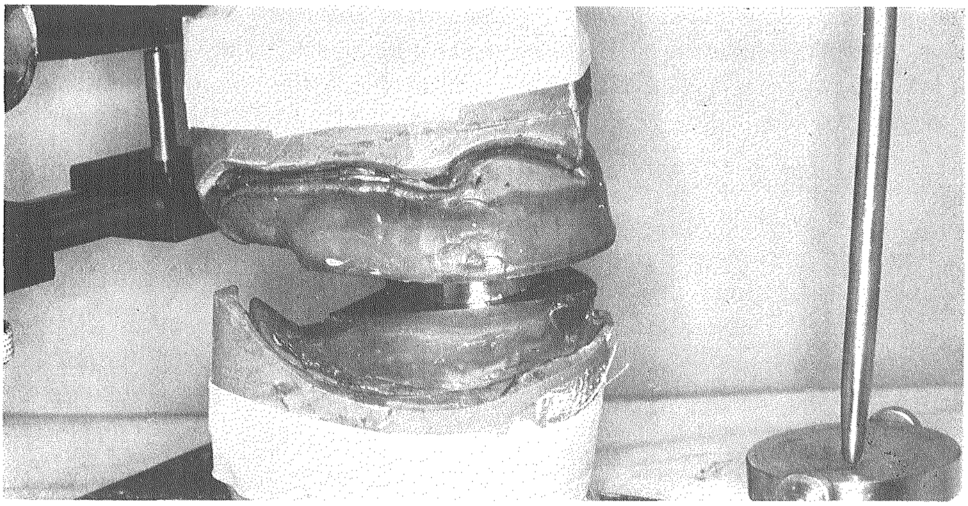

Fig. 735. Ring for adequately spacing checkbite plates.

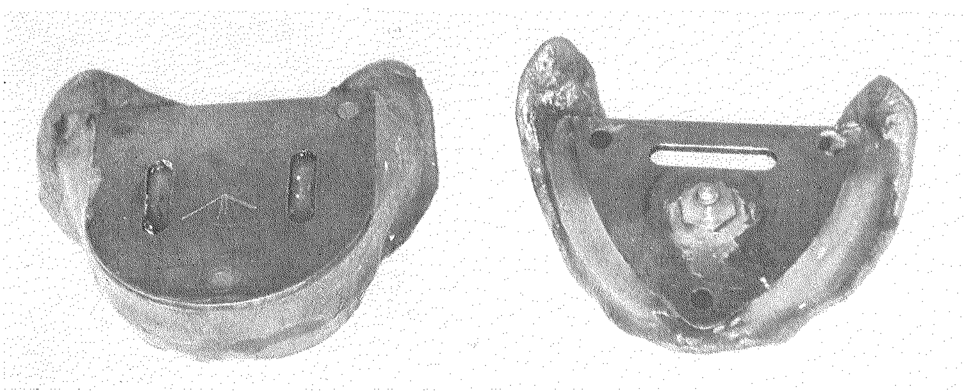

Fig. 736. Undercut areas are blocked out with baseplate wax.

pensive and timesaving (Fig. 733). There are slots in the upper and lower plates which permit accurate seating of the stone checkbites when the articulator is set (Fig. 734). A ring is furnished with the plates that makes it easy to space them properly when they are attached to the occlusion rims (Fig. 735). The lower plate has an adjustable screw which bears against the upper plate and scribes the Gothic arch tracing.

These plates are luted to the occlusion rims (and bases) and tacked with quick-setting acrylic, and the intervening spaces are filled with a hard baseplate wax. This eliminates any possibility of an undercut area which would prevent easy separation of the occlusion rim from the checkbite (Fig. 736).

SECURING THE CHECKBITES

The bases with the attached checkbite plates are placed in the patient's mouth, and the patient is instructed to move the jaws in every direction without separating the plates—forward and backward and to the right and to the left (Fig. 737). He will soon scribe a Gothic arch tracing. If he carries out the movements in every direction, he will make a complete rhomboid (Fig. 738).

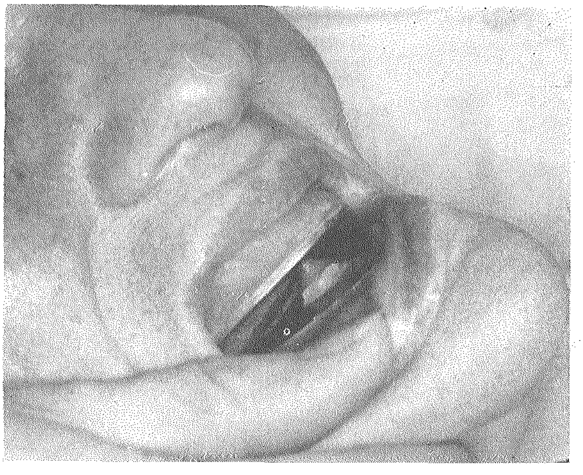

Fig. 737. Gothic arch tracing made by patient.

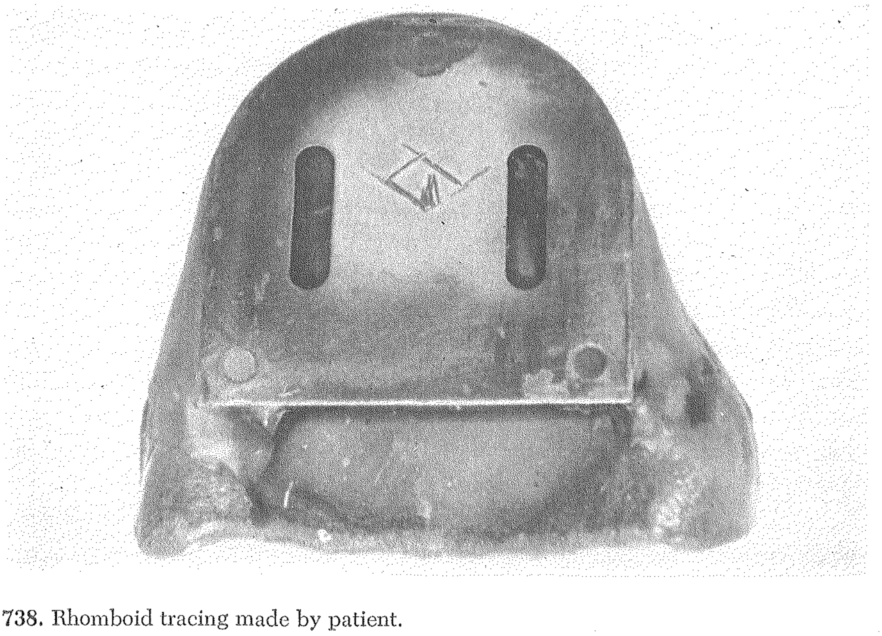

Fig. 738. Rhomboid tracing made by patient.

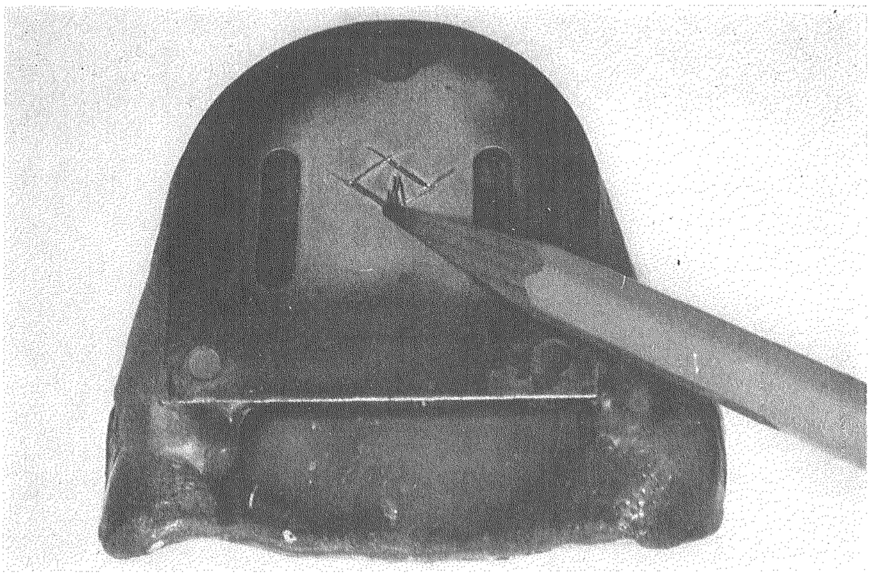

Fig. 739. Location of centric relation on tracing.

Because the tracing is made on the upper plate, the location of centric relation is at the farthest point posteriorly—the apex of the Gothic arch (Fig. 739).

Indentations

To aid the patient in holding the recording position, a slight indentation is made on the paths at the desired location. But no indentation is made in the centric position! Centric relation is so important and so exact that it is impossible to make an indentation in that position without causing some deviation of the relationship. Centric relation, therefore, is secured by executing the terminal hinge closure before the stone sets and having the patient hold this position until the stone has set completely.

It is necessary to make slight indentations at the protrusive and lateral locations (stations). Such an indentation will enable the patient to hold the position steadily while the stone sets. The indentation is made with a No. ½ round bur and is only an indentation, *not a hole.* The protrusive indentation is made at a convenient distance from the apex; it must be distant enough to permit a definite setting of the articulator (Fig. 740). The setting is accomplished by establishing a second point away from the centric location, two points determining a straight line. The second point must not be too far away from the centric point because the inclination might then be set by a point on the path too far from the functional area. If the path had considerable curvature, there would be an appreciable difference between the inclination of the path in the functional area and that inclination set by the distant second point (Fig. 741). A distance usually convenient is about 4 mm. from the apex on the protrusive path.

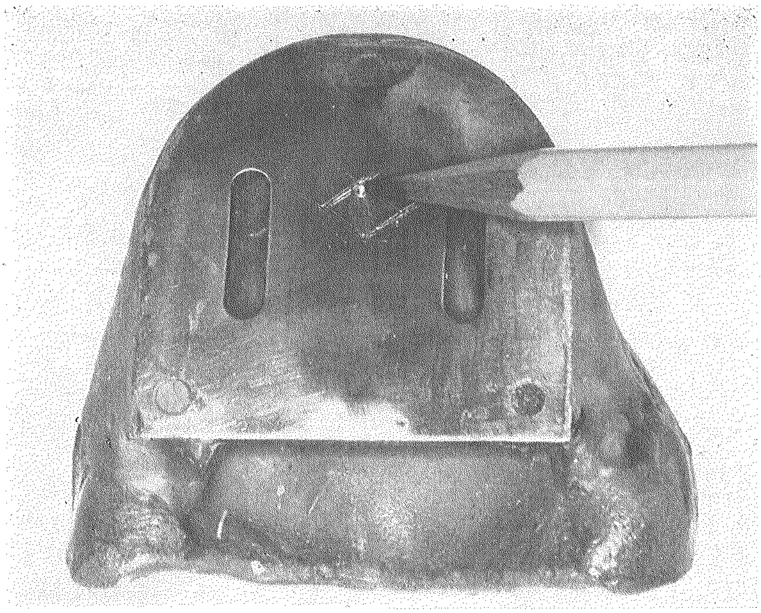

Fig. 740. Location of protrusive position on tracing.

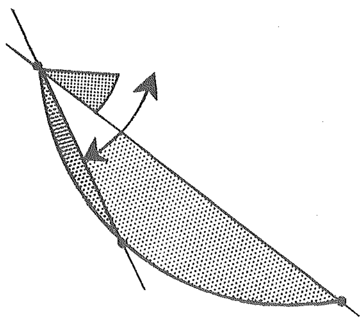

Fig. 741. Drawing shows the discrepancy possible when too great a distance is used for the protrusive position.

A most important consideration is the location of the indentation in the lateral position in relation to the protrusive indentation. These indentations must be so located that they will cause the lateral condyle path to be in the same linear position as the protrusive condyle path. That is to say, the condyle will travel the same distance on the path in the protrusive position as it will travel in the lateral position. If this is not accomplished, it will not be possible to set the articulator so that it will accept all the checkbites!

How can we be certain that the travel will be the same in these two stations?

The surfaces of the checkbite plates are lubricated with a thin film of petrolatum. By means of a plaster gun or cellophane cone (Fig. 742) some specially pre-

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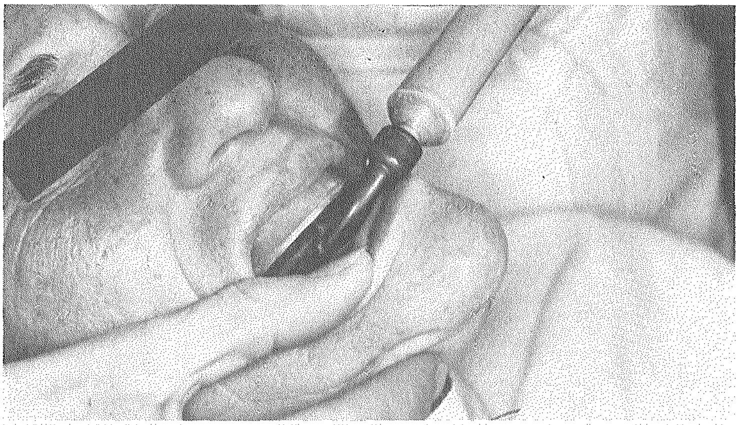

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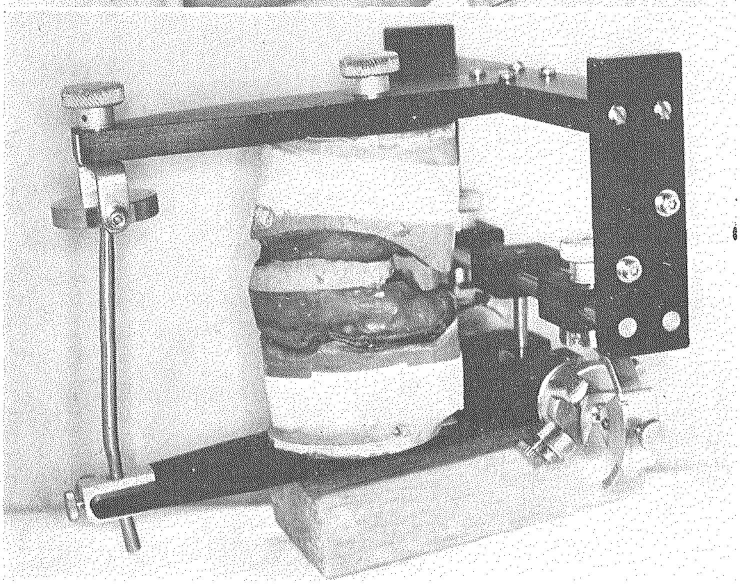


Fig. 742. Plaster gun places quick-setting stone between the plates.
Fig. 743. The lower cast is remounted by means of centric relation checkbite.

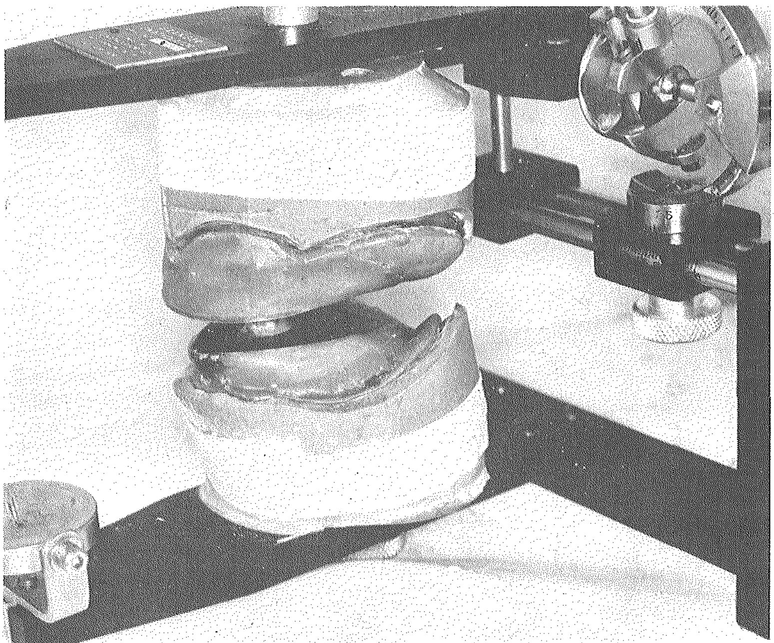
pared quick-setting stone* is inserted. Before it sets, the patient must open and close the jaws repeatedly in the centric position and then firmly hold this closed position until the stone has set (usually 1 minute).

Generally the upper and lower bases, held together by the stone wafer, can be removed in one piece. Remove the lower cast from the articulator mounting and remount it by means of this assembly (Fig. 743).

After the lower cast has been remounted to the correct centric relation, the in-

*The setting time of most stones can be controlled by adding some *ground-up set stone* to the water before adding the stone for spatulation. The ratio of ground-up set stone to the water used will have to be tested to establish the desired setting time.

dentations are made on the Gothic arch of the upper plate. Make the protrusive indentations first—about 4 mm. from the apex of the Gothic arch. Now close the articulator and move the upper bow posteriorly until the pin of the lower plate catches the protrusive indentation. The articulator is held in this position—both condyles the same distance from the ball stop (Fig. 744). Place a jackscrew in one condyle path until it just contacts the ball (Fig. 745) and allow the other condyle to reach the ball, thus putting the articulator in a lateral excursion (Fig. 746). With a piece of carbon paper between the pin of the lower base and the plate of the upper base, mark this pin location (Fig. 747). This mark may not



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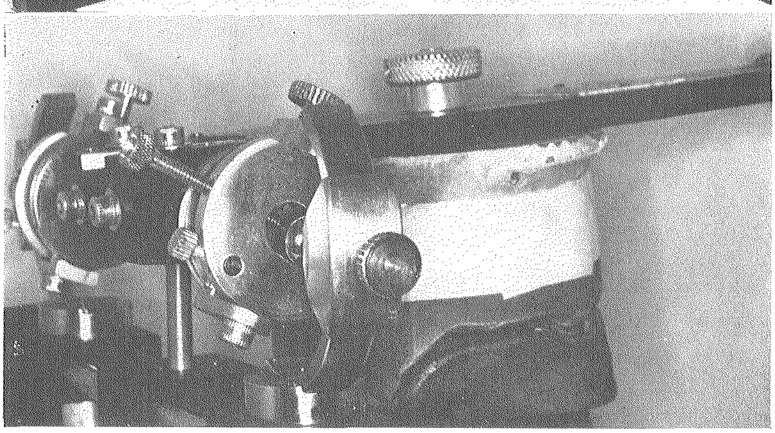

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Fig. 744. Condyle away from the centric stop when the pin is in the protrusive indentation.
Fig. 745. Jackscrew contacting the ball.

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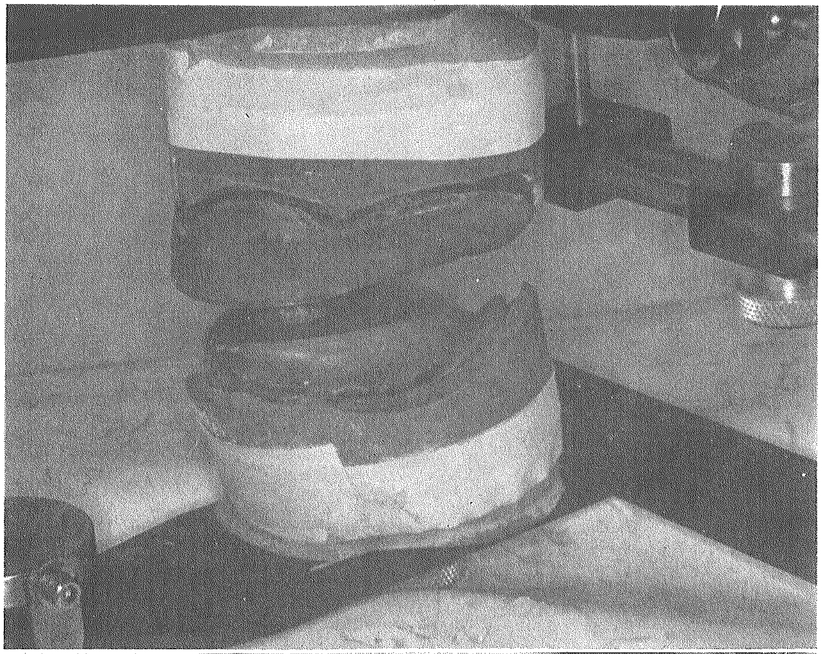

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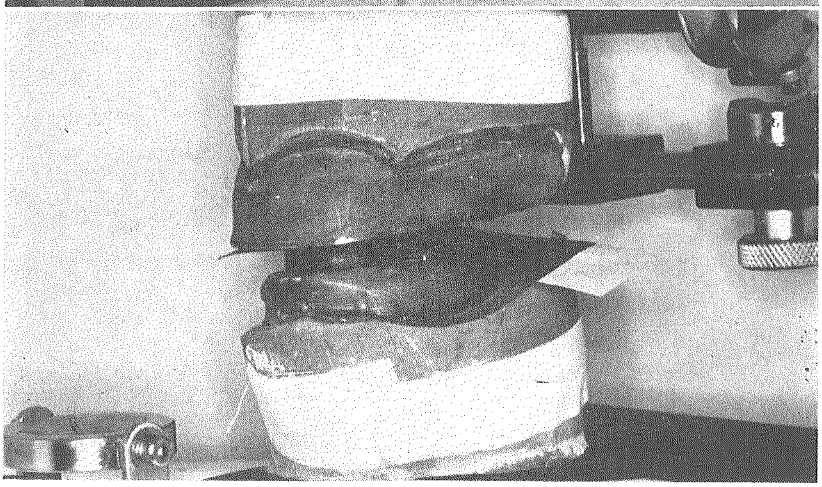

Fig. 746. The articulator in a lateral position.
Fig. 747. Carbon paper mark for locating the pin in relation to the plate.

be exactly on the lateral path made by the patient, but it will be close. Make the indentation on the patient's lateral path where the carbon paper mark would be if it were exactly on the lateral path (Fig. 748). If the mark is too far off the lateral path, this can be corrected by changing the intercondylar distance, i.e., by moving the center of rotation on the opposite side in the indicated direction (see Chapter 8 for the principles of articulator setting). Repeat this procedure for the opposite lateral position.

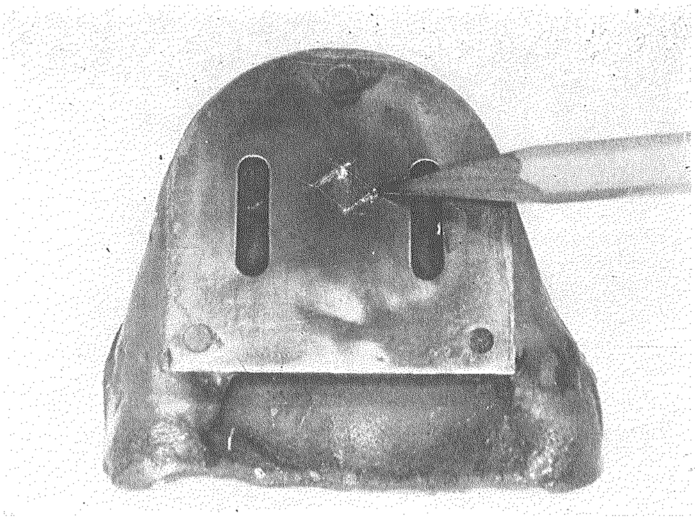

Fig. 748. Carbon paper mark transposed to the path of the patient.

Granger maintains that these stations—the lateral and the protrusive—can be located by measuring 3 mm. directly in front of the apex of the Gothic arch and then setting a compass with a radius of 7 mm. With this radius, an arc is scribed which intersects the lateral wings of the Gothic arch made by the patient and the protrusive path. At these intersections the indentations are made, and they will bring the condyle paths the same distance in the lateral and protrusive excursions.

After locating the indentations, the remaining checkbites can be secured.

Protrusive checkbite

Instruct the patient to find his way into the protrusive position until the bearing pin rests in the indentation. The quick-setting stone is inserted between the lubricated plates, and the patient is told to hold the position firmly until the stone has set. In taking these checkbites, it is important that he patient be prevented from dropping into physiological rest. By having him firmly hold the position, this error is guarded against.

When the protrusive wafer has been formed, again attempt to remove the upper and lower bases as a unit to obviate reassembling the bases to the checkbite.

We are now ready for the first part of the articulator setting.

Adjusting condyle path inclination; utilizing height gauges

Begin by attaching the height gauges to the articulator. The long, double-ended gauge is attached to the upper bow so that the points are in line with the axis of the articulator. The two posterior gauges are attached to the lower member

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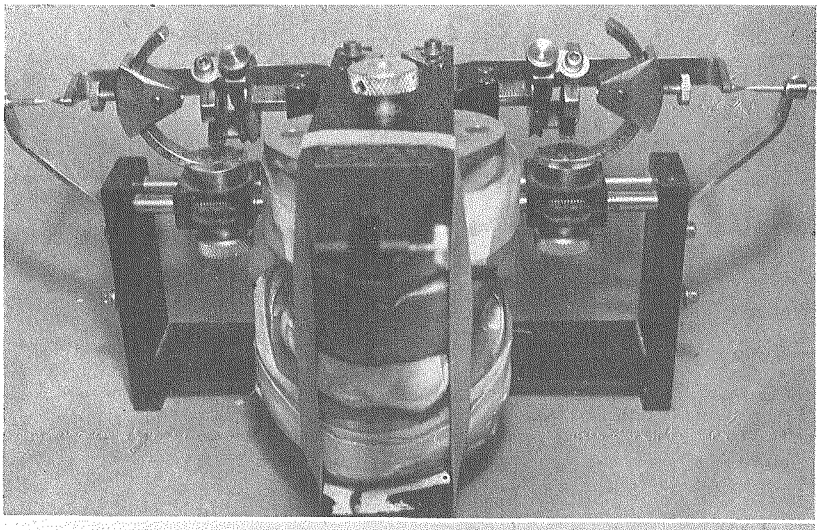

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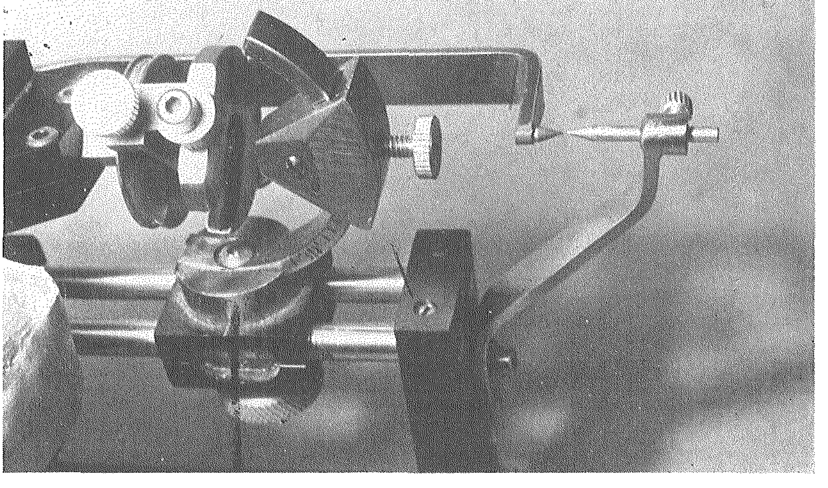

Fig. 749. Posterior height gauges in place.
Fig. 750. Lower left posterior height gauge adjusted to upper height gauge.

of the articulator—one on each side—and held in position with the posterior Allen head screws and washers (Fig. 749).

Remove the condyle balls from the articulator and position the upper bow to the lower bow by means of the protrusive checkbite. Holding the instrument rigidly together (the rubber band shown in Fig. 749 is for purposes of photography only), carefully adjust the points of the height gauges on the lower member to coincide with the points of the gauge on the upper bow (Figs. 750 and 751). Then lock the gauges securely.

Now carefully remove the upper bow by disengaging the checkbite and replace the condyle balls on both sides, restoring the upper bow to its previous position as dictated by the protrusive checkbite (Fig. 752). Changing the inclina-

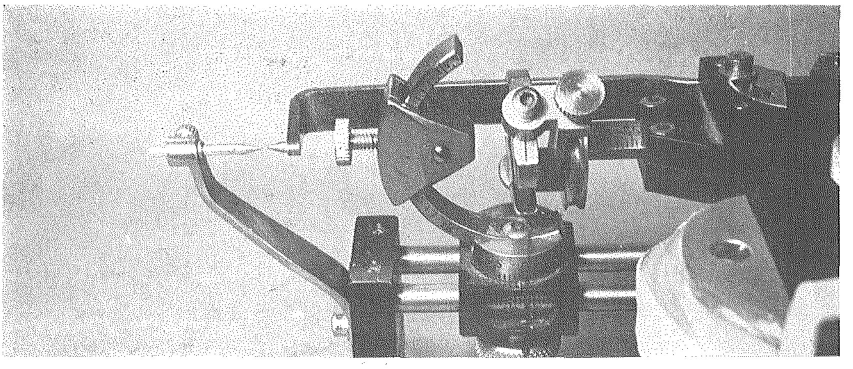

Fig. 751. Lower right posterior height gauge adjusted to upper height gauge.

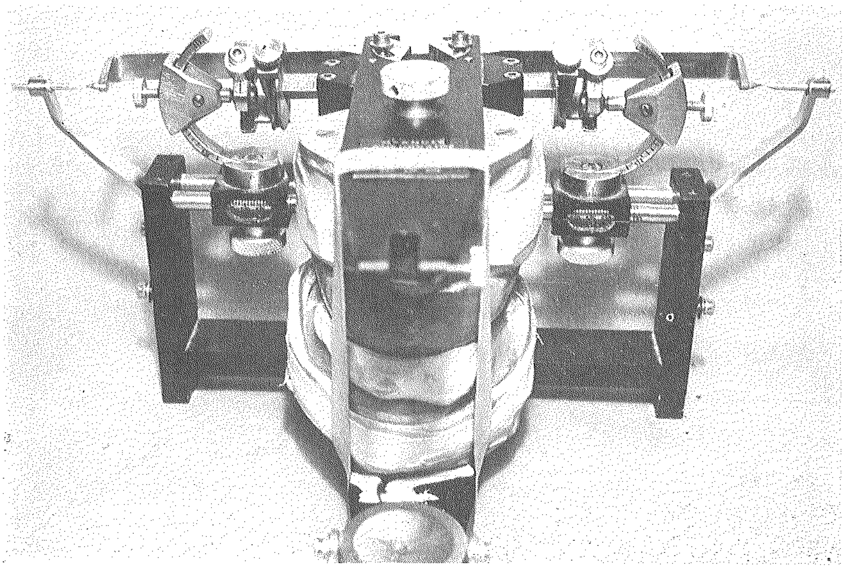

Fig. 752. Condyle balls replaced and condylar inclinations adjusted.

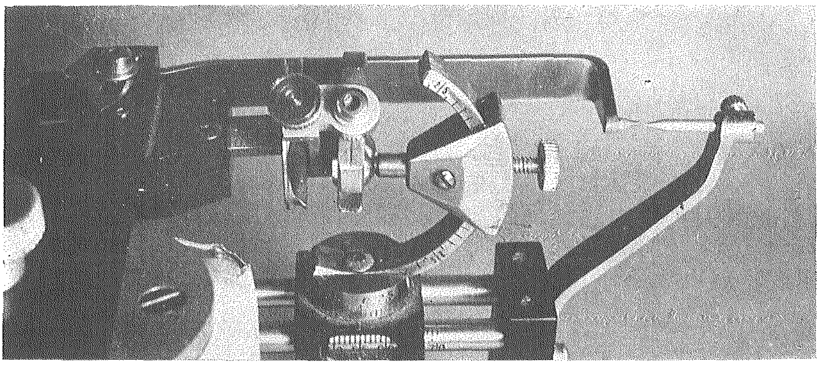

Fig. 753. Left side adjusted.

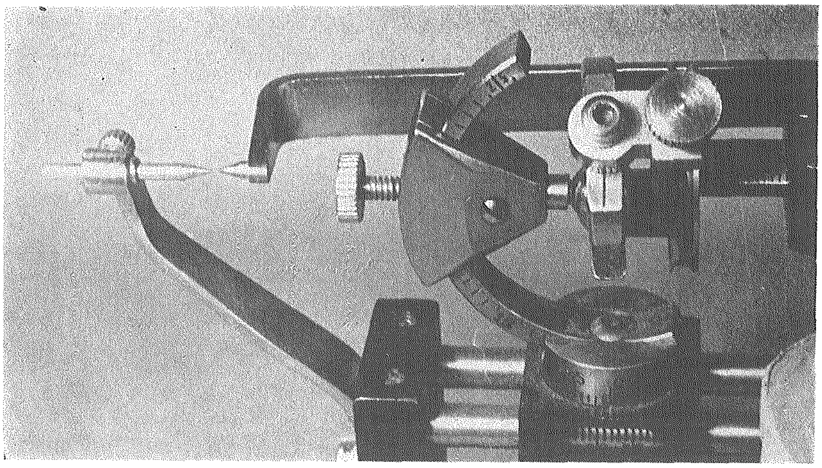

Fig. 754. Right side adjusted.

tion of the condyle path again makes the points of the height gauges coincide (Figs. 753 and 754).

The reason for using height gauges should now be obvious. They are the means by which the settings are accurately made. They magnify the parts or, rather, their relation to each other and thus permit a much more accurate adjustment of the articulator.

Lateral checkbites

Having adjusted the inclination of the condyle path by means of the protrusive checkbite, now secure the two lateral checkbites.

The patient is instructed to find his way to the indentation for the lateral excursion and then to hold his jaw firmly in that position. Quick-setting stone is inserted and allowed to set. The checkbite is removed and labeled.

The same procedure is followed to obtain the other lateral checkbite. The checkbite is then removed and marked.

COMPLETING ADJUSTMENT OF THE ARTICULATOR

The setting of the articulator can now be completed. Since this is a time-consuming procedure, the patient is dismissed, and the setting is completed at the operator's convenience.

The anterior height gauges must be added to the lower frame of the articulator (Fig. 755). The condyle balls are removed, and the upper member of the articulator is related to the lower member by means of one of the lateral checkbites. The Bennett guides are unlocked and placed in the open position so that they will not limit the degree of side position necessary to fit the checkbite plates into their checkbite. In Fig. 756, the left lateral checkbite is in position. The height

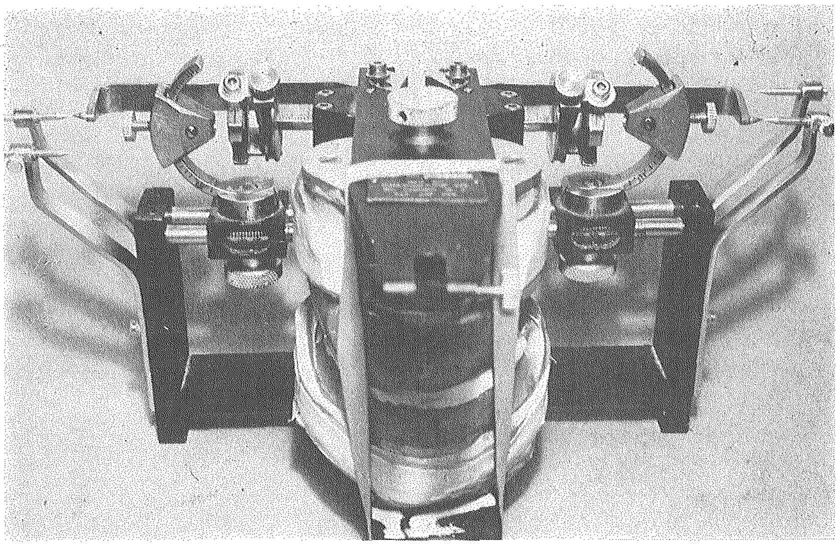

Fig. 755. Anterior height gauges added to lower frame of articulator.

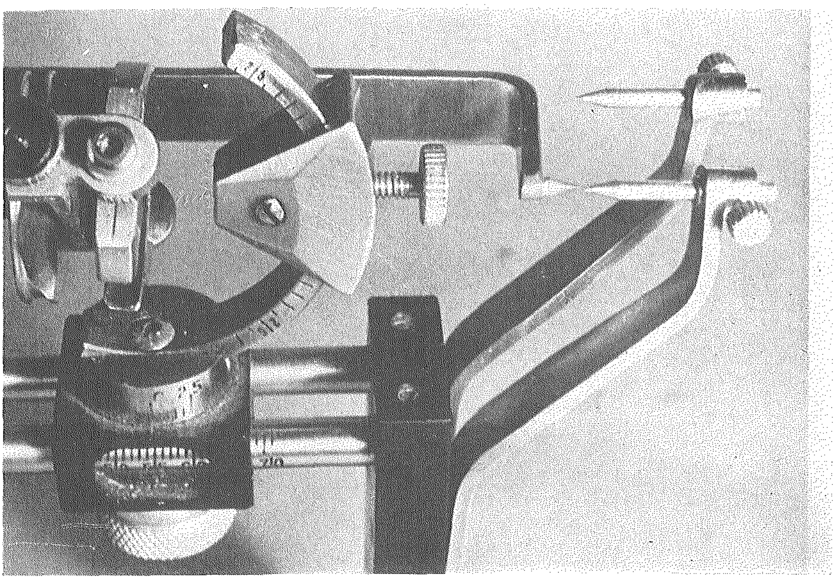

Fig. 756. Left lateral checkbite is in position, and pins are made to coincide.

gauge on the working side (the forward one on the lower member) is adjusted until it concides with the height gauge of the upper member, as in Fig. 756. The height gauge on the balancing side (the posterior one on the lower member) is adjusted to the height gauge attached to the upper member (Fig. 757). After

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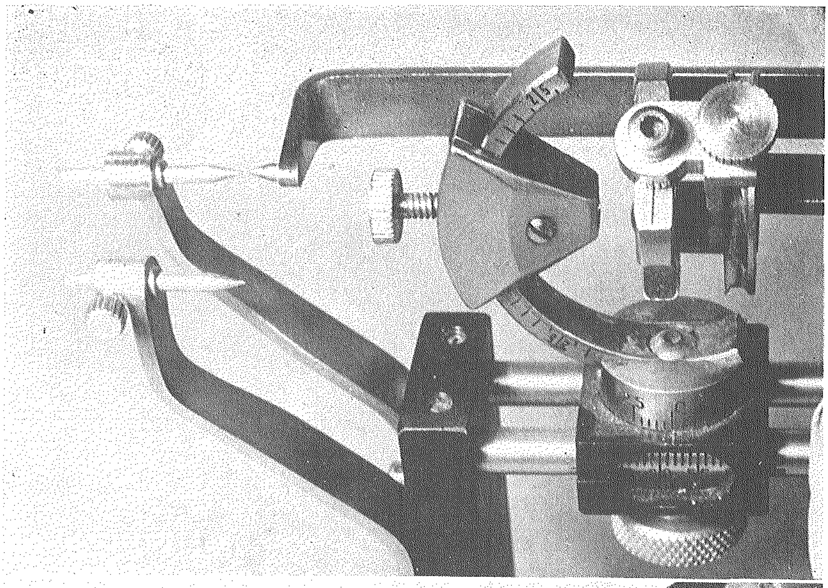

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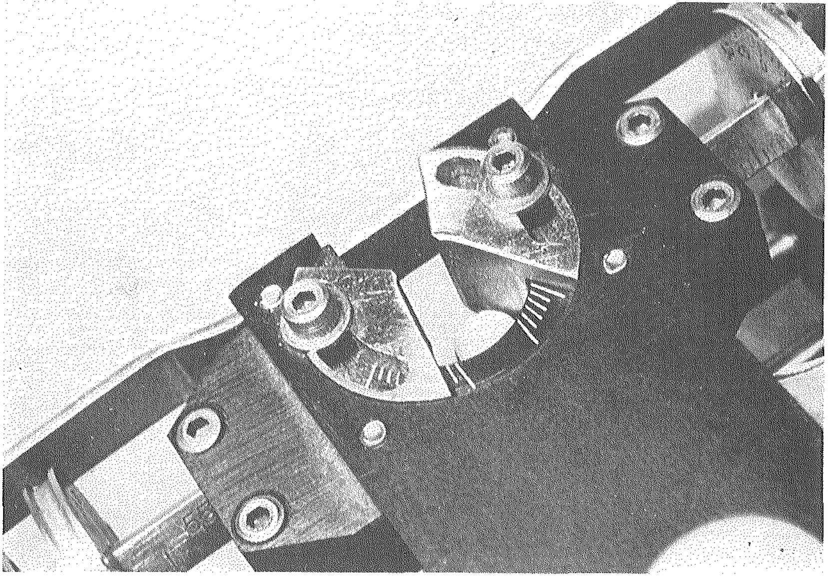


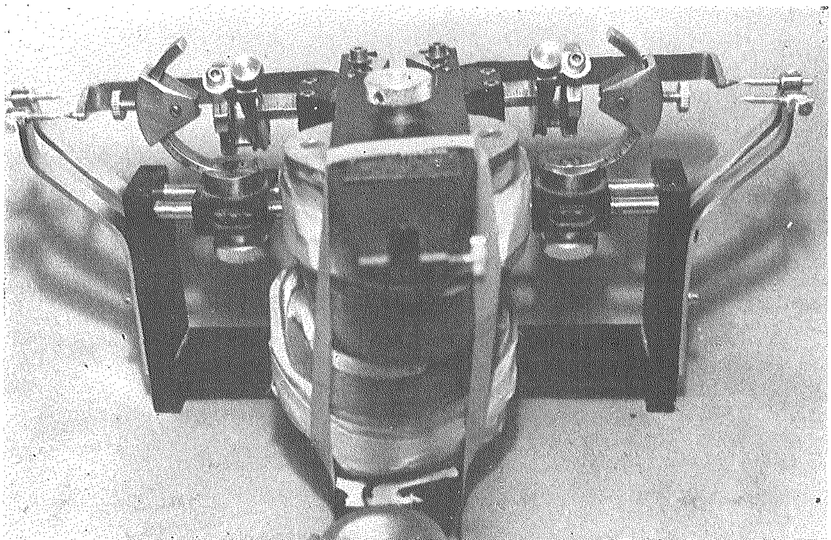
Fig. 757. The balancing side gauge is adjusted until it coincides with the upper gauge.
Fig. 758. The Bennett guide on the working side is made to contact the guidepost.

these gauges are adjusted accurately, close the Bennett guide on the working side until it just contacts the Bennett guidepost (Fig. 758) and lock it in position.

Once these height gauges are set, they must not be disturbed until the setting is completed.

Now remove the left lateral checkbite and replace it with the right lateral checkbite. Then adjust the corresponding gauges (Fig. 759). The forward gauge on the lower member is adjusted on the working side to the respective gauge on the upper (Fig. 760). The posterior gauge of the lower member is adjusted to the gauge on the balancing side of the upper member (Fig. 761). The Bennett guide on the working side is closed until it just contacts the Bennett guidepost (Fig. 762), and then it is locked securely.

Next the condyle balls have to be replaced, and with the lateral checkbites the instrument must be so adjusted that the height gauges will again coincide as



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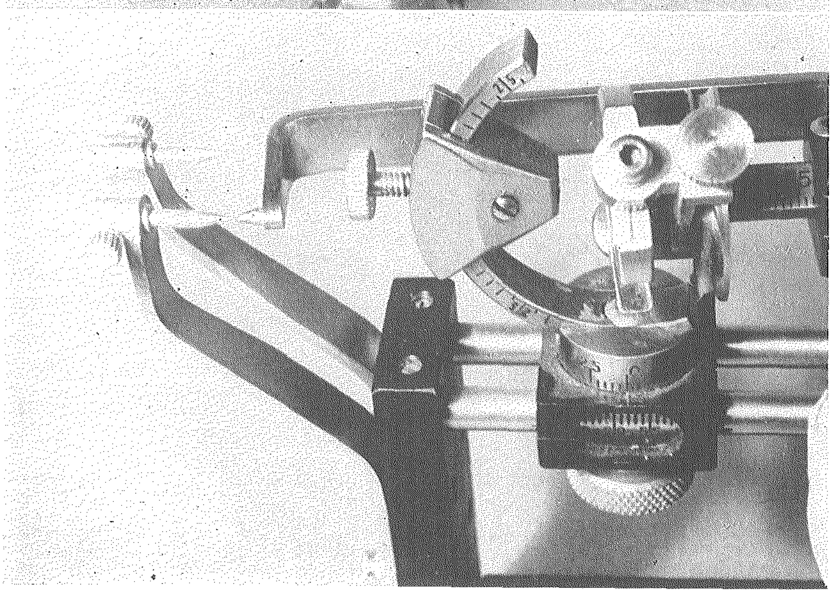

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Fig. 759. Right lateral checkbite in position.
Fig. 760. Gauge on working side adjusted to upper gauge.

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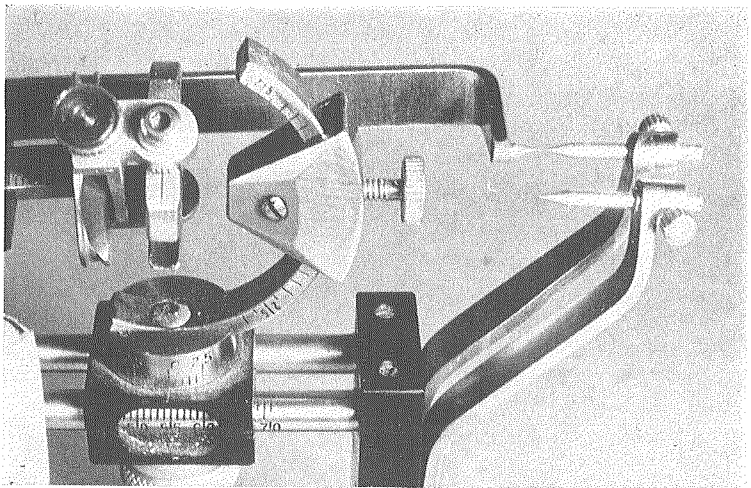

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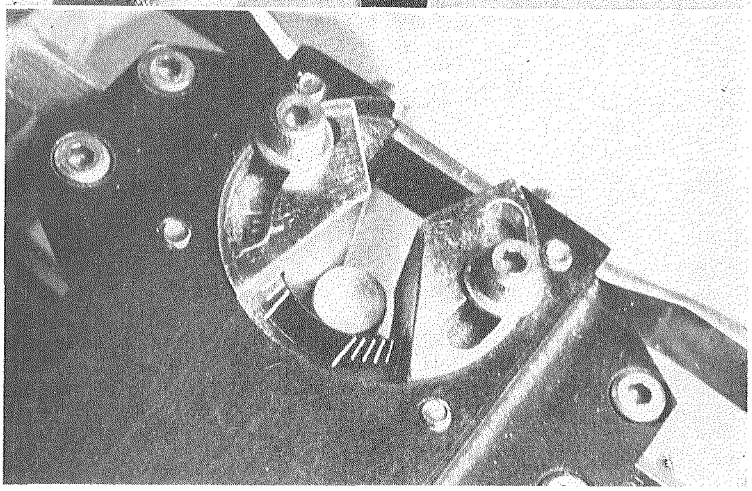
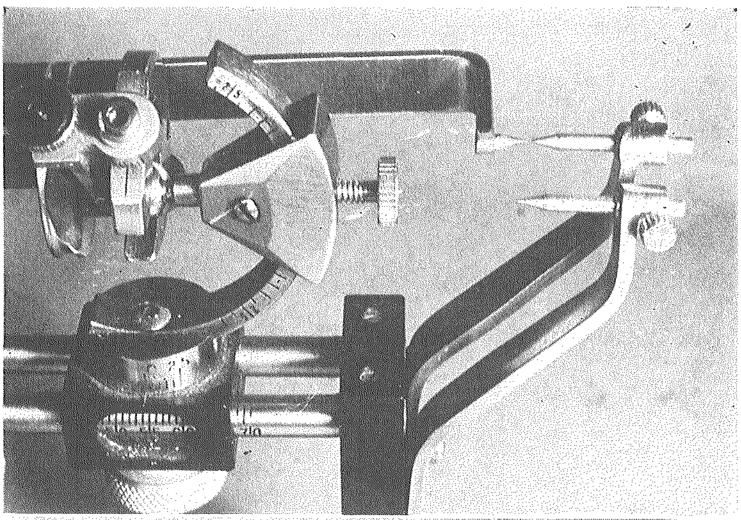


Fig. 761. Gauge on balancing side is adjusted until it coincides with the upper gauge.
Fig. 762. The Bennett guide is adjusted until it touches the guidepost.

they did when the balls were not in place. In other words, the instrument had been disconnected—the upper member from the lower member—and the positions of the excursions had been related by the checkbites. The height gauges recorded these positions. Now with the upper and lower members again connected by means of the condyle balls, settings which will duplicate the special positions of the upper and lower members as they were recorded by the checkbites must be found. When this is accomplished, the articulator will reproduce these positions without the checkbites and without the height gauges.

After connecting the upper and lower members of the articulator by reinserting the condyle balls and after replacing one of the lateral checkbites, re-examine the height gauges, which should approximate each other for the checkbite inserted. For example, with the left lateral checkbite in position, examine the height gauges on the balancing side (posterior on lower frame). If they coincide as they do in Fig. 763, no axis tilt is required. Now change to the right lateral checkbite. After examining the corresponding height gauges on the balancing side, one may find that they do not coincide (Fig. 764). Tilting the axis, as in Fig. 765, can correct this.

With the same (right lateral) checkbite in position, examine the height gauges on the other side—the working side. They may or may not coincide. If they do not, it may be necessary to increase the intercondylar distance by moving the centers of rotation of the articulator outward (Fig. 766). This will cause the



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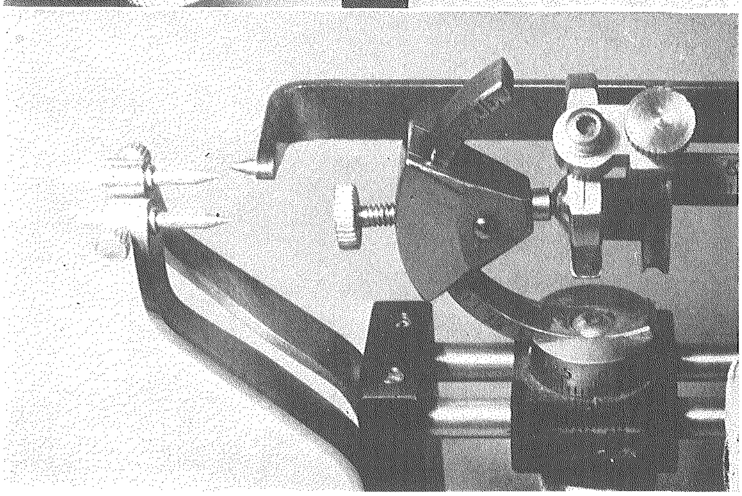

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Fig. 763. No axis tilt is required if the gauges coincide after the balls are replaced.
Fig. 764. Gauges on balancing side do not coincide.

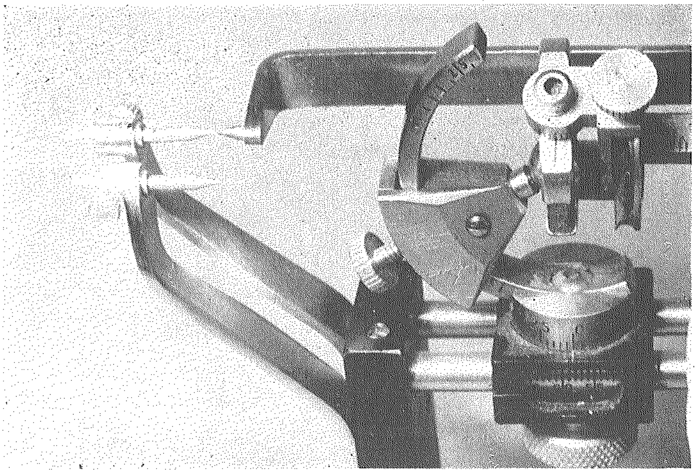

Fig. 765. Tilting the axis permits coincidence of the gauge points.

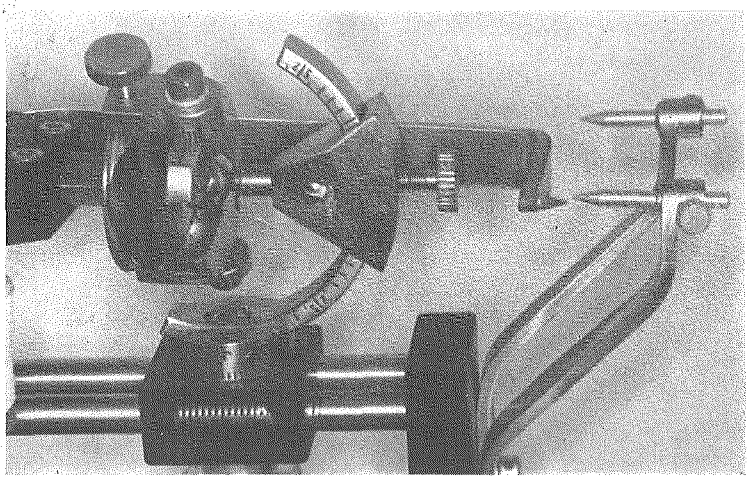

Fig. 766. Upper bow height gauge pin is below working pin.

height gauge on the upper member of the articulator to be raised (Fig. 767). Conversely, shortening the intercondylar distance will cause the upper bow and its height gauge to be lowered. This is the reason for starting the adjustments at a neutral position of 55°.

NOTE: *The upper and lower members of the articulator are moved in or out. Their settings must correspond exactly. If they do not, then the upper and lower members will not be centered. It is of extreme importance that changes in the settings be made very carefully.*

Now change to the other lateral checkbite (the left lateral) and examine the height gauges on the other working side. If the point of the height gauge attached to the upper member of the articulator has to be raised to correspond with the gauge on the lower member, then the intercondylar distance has to be increased by moving the center outward (Figs. 768 and 769). Again care must be taken to move the upper and lower members the same degree.

Still with the left lateral checkbite in position, examine the balancing side. The adjustment previously made may now be off because of the increased inter-

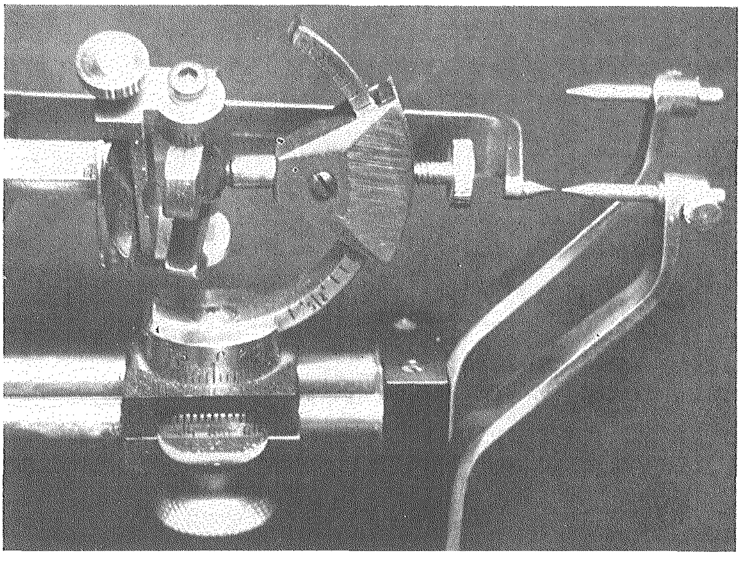

Fig. 767. Increasing the intercondylar distance produces coincidence of the gauge points.

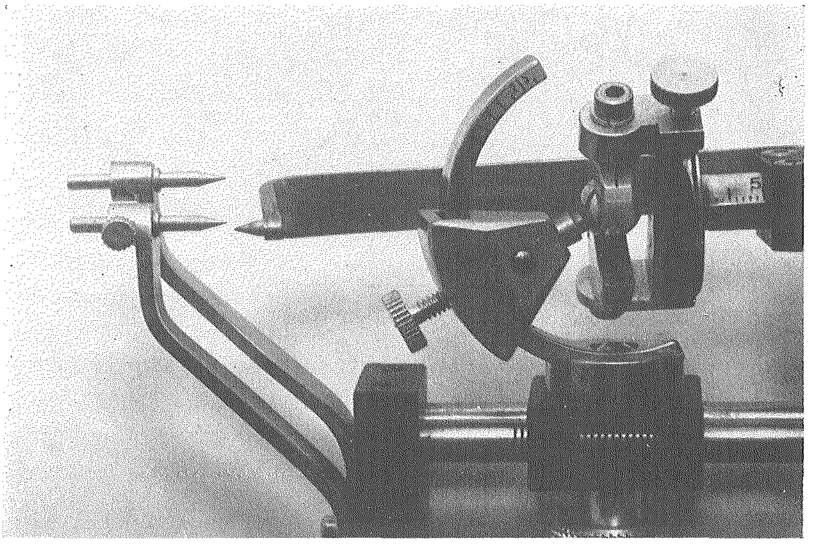

Fig. 768. The other working side requires the intercondylar distance to be increased.

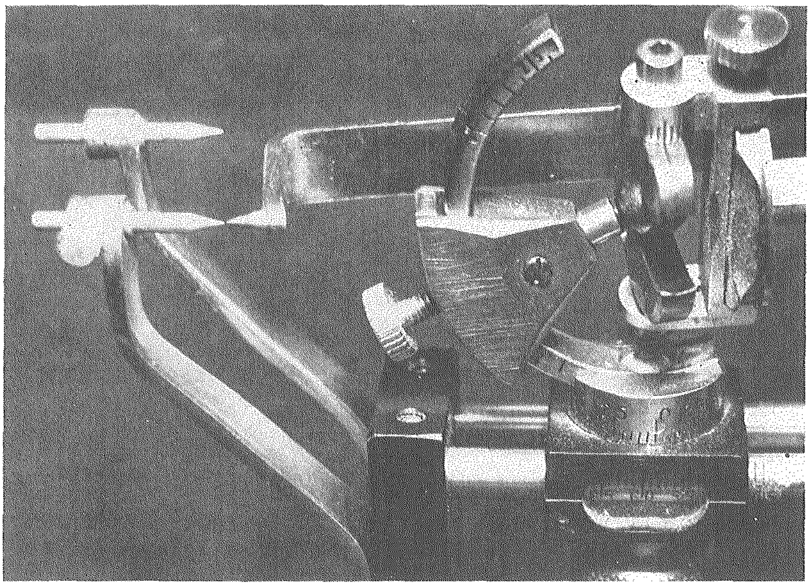

Fig. 769. Coincidence after the intercondylar distance has been increased.

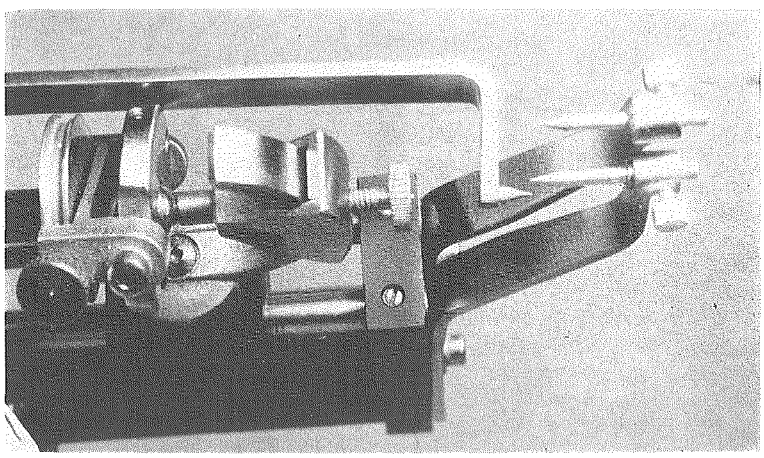

Fig. 770. Gauges viewed from above indicate lack of coincidence.

condylar distance. This may necessitate a slight change in the axis tilt from what it was before the intercondylar distance was changed.

This step is repeated with the other checkbite after the intercondylar distance is altered.

Thus it is necessary to refine the adjustments systematically until the setting will satisfy in all excursions.

When the horizontal adjustments are completed and the height gauges coin-

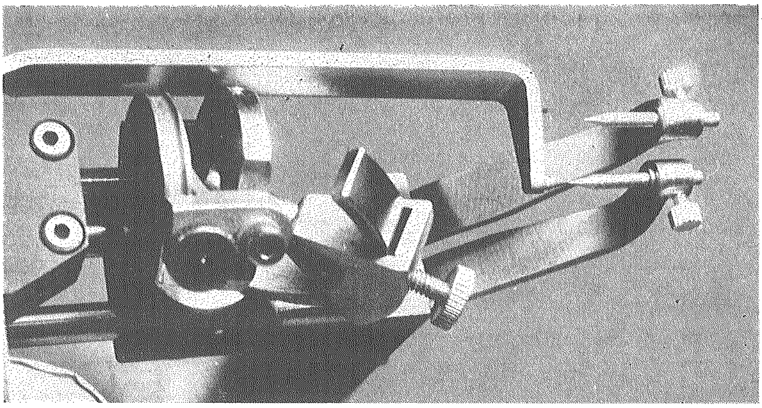

Fig. 771. Rotation of the axis produces coincidence of the gauges.

cide for both lateral checkbites as they are viewed from the front, one more adjustment may be necessary. This is determined by viewing the gauges from above (Fig. 770). On the working side, anteroposterior adjustment is made by rotating the axis until the pins of the gauges coincide (Fig. 771). Repeat this for the other checkbite on the other working side.

Now examine the height gauges of the balancing side. After the axis has been rotated, it may again be necessary to make a slight change in the intercondylar distance. Thus both sides must be examined, and such changes as are indicated must be made until a satisfactory setting is achieved.

GUIDES FOR GNATHOLATOR SETTING WITH HEIGHT GAUGES

The following guides should be used in setting the gnatholator with height gauges:

1. Condyle path inclination
   (a) Set with protrusive checkbite.
   (b) Disengage articulator by removing condyle ball and shafts.
   (c) Set posterior gauges on lower member to gauge on upper bow.
   (d) Re-engage articulator by replacing condyle balls and shafts.
   (e) Set angle to make gauges coincide again.
2. Bennett guides
   (a) Set when height gauges are set.
   (b) Use lateral checkbite.
   (c) Disengage articulator.
   (d) Set Bennett guide on working side (one side at a time with corresponding checkbite).
3. Axis inclination on one side
   (a) Re-engage articulator (condyle balls and shafts in place).

(b) Examine balancing side.
(c) Adjust to rear height gauge.

4. Axis inclination on other side
   (a) Re-engage articulator.
   (b) Examine balancing side (with other checkbite).
   (c) Adjust to rear height gauge.
5. Condyle head position on one side (intercondylar distance)
   (a) Engage articulator.
   (b) Examine working side.
   (c) Adjust to front height gauge.
6. Condyle head position on other side (other lateral checkbite)
   (a) Engage articulator.
   (b) Examine working side.
   (c) Adjust to front height gauge.
7. Refining
   Repeat steps 3, 4, 5, and 6 as many times as necessary to finish horizontal adjustment of the height gauges, alternating one lateral checkbite and the other.
8. Anteroposterior alignment of height gauges
   (a) Examine working side (one checkbite and then the other).
   (b) Engage articulator.
   (c) Adjust to front gauges.
9. Axis rotation
   (a) Adjust intercondylar distance on balancing side.
   (b) Engage articulator.
   (c) Adjust to rear height gauges.

SOURCES OF ERROR IN TAKING CHECKBITES

The following possible sources of error are present in the checkbite procedure:

1. Tipping of bases due to malplacement of bearing pin.
2. Tipping of bases due to interferences in tuberosity area.
3. Dropping of condyles into rest or semirest position while stone is setting.
4. Incorrect centric relation, precluding possibility of ever getting accurate setting of the articulator.

CHAPTER 27

Servicing appliances

The better reconstruction appliances are designed and constructed, the less need will there be to service them over the years. The appliances which have given me the most trouble in the way of subsequent service are the ones in which something was compromised in the design or construction. Sometimes, against my better judgment, a prosthesis is completed before sufficient time has elapsed. This will cause grief later.

TEMPORARY WEARING OF APPLIANCES

It is good practice to keep an appliance in the mouth temporarily until one is sure that all the kinks are eliminated. It is easy to make slight changes when the appliance can be removed from the mouth for correction. Here is a good rule to follow: When the operator thinks a prosthesis is ready to be permanently cemented, he should wait another six months before doing so. If at the end of that time it still checks out satisfactorily, then it is safe to cement it permanently.

Another excellent rule is not to cement any appliance permanently that does not hold temporary cement for at least a three-month period. This means that either the restorations do not fit sufficiently well or else the articulation is not perfect. Usually it is the latter. If an appliance will not hold temporary cement for three months, it will not be held by permanent cement. It may take a while for this to become evident, but sooner or later the restorations will leak or break loose. It is rather discouraging to have one bridge abutment break loose, while the other one holds firmly!

FOLLOW-UP EXAMINATION

After an appliance is completed, make a set of study casts of the finished work. These are carefully mounted on an articulator and are used for future comparison of the prosthesis. Whenever a patient comes in for a routine checkup and prophylaxis, the operator should always examine the function of the patient's appliance. Is the centric relation still solid? Are the excursions working satisfactorily? Sometimes a slight shifting or settling of a tooth will cause the appliance to function abnormally. Recognition and correction of a minor discrepancy can prevent much damage and preclude the need for extensive repair. Such damage, however, rarely occurs if the appliance has been completed satisfactorily in the first place.

At each follow-up examination, all margins must be carefully checked. In spite of our best efforts, a margin will occasionally go bad. Early diagnosis of this condition can prevent the possible loss of a tooth from decay.

HOME CARE

The follow-up examination will also reveal whether the patient is using sufficient home care. This is extremely important if the patient is to avoid future problems. Proper cleaning of the teeth and adequate gingival massage are essential for a healthy mouth. Stimulation with toothpicks is more important in some areas and in some mouths than in others.

Patients may have to be reinstructed in proper home care. The need to protect their investment in the mouth should be impressed upon them. Bad habits can be detected, and an attempt to get patients to correct the habits before serious harm is done should be made.

SERVICING ATTACHMENT APPLIANCES

The attachment appliance perhaps needs the most servicing of any restoration. Here again, this will depend upon the quality of the design and the construction. If the attachments are of sufficient length and if the prosthesis is well articulated on a mucostatic base, the servicing will be at a minimum. Well-made attachment appliances seldom require attachment expansion for frictional retention. Occasionally, a patient will insist on keeping an attachment appliance very tight, and this in time will cause wear and necessitate changing the attachments. Fortunately, it is the male attachment that usually wears. Rarely is it necessary to replace a female attachment.

Replacement of a male attachment is a simple laboratory procedure. A retention loop is soldered to a special female attachment which is kept for this purpose only. The retention is used to anchor the female box securely in a stone cast. The cast is made with the special female attachment on the male attachment of the appliance to be replaced. This gives a cast which will accurately hold the relationship of the male attachment to the female one. The old male attachment is then removed from the appliance. A new one is placed in position by the relating female attachment on the cast, and the appliance is repaired.

REMAKING A CROWN OR INLAY

Sometimes secondary decay will necessitate the remaking of a crown or an inlay. This is not a difficult procedure and can be done without making a complete mounting. Usually a sectional model and a counter cast are all that are needed. The cast can be hand-manipulated for carving the occlusal surface, with some necessary adjustment in the mouth.

LOSS OF A TOOTH

Loss of a tooth for any reason may present a problem, depending upon the location of the tooth in relation to the other restorations. If it is an abutment tooth for an attachment appliance, there are some complications which will necessitate redesigning the removable appliance and possibly remaking the prosthesis. How much will have to be remade will depend upon the individual appliance. If the tooth to be removed is a bridge abutment, we will have to remake the bridge or even construct a removable appliance.

Let us suppose that an end tooth is lost. Here the concern is with the teeth opposing the space formerly filled by the end tooth. They must be kept in function. It may be necessary to splint the opposing teeth to prevent the extrusion of the unopposed tooth. It may be possible to replace the lost end tooth by cantilevering a half-tooth sufficiently to maintain function with the opposing teeth.

If the lost tooth happened to have been between two other teeth, it is then necessary to remove the restorations on the adjacent teeth and to construct a simple fixed bridge to replace the missing tooth.

Today, fortunately, the endodontist can treat teeth which several years ago would have had to be sacrificed. When extensive preparations are necessary, a pulp sometimes may be injured but will not become entirely involved for several years. In such a case, even if the reconstruction is completed, a competent endodontist can save the day. A hole is cut through the restoration, the endodontia is completed, and then a small occlusal inlay is placed to repair the hole.

SERVICING VENEER CROWN RESTORATIONS

Because of the nature of the plastic material so frequently used in veneer crown restorations, some men do not place restorations permanently. Thus, if there is a need to change the veneer material, it can be easily done since the restorations can be removed with facility. The disadvantage of not permanently placing restorations, however, is that the temporary cement may wash out between checkups, and decay may result. If we had a cement which resisted washout and yet could be removed easily, then temporary cementation would be a better procedure.

Someday, perhaps, there will be a veneer material that will not wear or change in color. Efforts in this direction are being made with porcelain and gold. At the present time, however, these materials present other problems which are possibly as great as those encountered with acrylic veneers.

All these factors point up the fact that patients who have had the mouth rehabilitated must be followed up carefully. It is extremely important that these patients be examined every six months to determine whether any changes have taken place. Improper toothbrushing and home care can thus be spotted and corrected before too much harm is done. Adequate scaling and curettage can be instituted to maintain the health of the gingival tissues. Let us not forget, after all, that unless the periodontal tissues remain healthy, efforts at rehabilitation have not been successful.

CHAPTER 28

Management of a practice in oral rehabilitation

It is appropriate at this point to evaluate the management of a practice in oral rehabilitation. Certainly, it is not my intention to discourage the beginner in the field of full-mouth rehabilitation, but one must recognize that a desire to do this type of dentistry is not enough. Many factors make it very difficult to render this service, not the least of which are the financial considerations.

FEES

It is impossible to set an average fee for this work. The fee can be worked out only after we have some idea of what it will cost us to render the particular service. Unfortunately, there are few patients who will go along on a cost plus basis. Most want to know approximately how much they will have to pay. It is difficult for the beginner to estimate what it is going to cost him to render the service. Only after some experience with similar cases will he be able to make an approximate evaluation. Even then, contingencies can arise to alter the picture.

In arriving at a fee that is fair to patient and practitioner, one must consider the ramifications of this type of practice.

LEARNING THE TECHNIQUE

The very first hurdle, of course, is learning the philosophy and technique necessary to perform this service. Until quite recently, it was difficult to do this, for it had to be learned at a preceptoral level. There are now several organized courses in gnathology at both the undergraduate and postgraduate levels. Thus there has been some progress toward making the study of these principles less remote. Much remains to be done in this direction, for the obstacles to learning the technique are still considerable. With this textbook I am attempting to help the student overcome some of these obstacles.

PERSONNEL

Having surmounted the first hurdle and acquired the know-how, the dentist will find that it is not economically sound to do all the work himself. He must hire a technician. But technicians trained along these lines are not readily available; therefore he must train his own. This has certain implications. Considerable time and money are invested in the training of a technician. Further—and this is a serious consideration—the dentist must protect himself against the loss of that technician after he has trained him.

It should be explained why this type of work requires a technician on the premises. Let us assume that there is a technician competently trained for this work, but that he is not located on the premises. Considerable preparation on the dentist's part would be necessary before the technician could begin to proceed. The making of casts cannot always be deferred until the end of the day. Face-bow transfers cannot safely be shipped or carried from one place to another. Constant supervision is required if an appliance is to be brought to a successful completion.

Having trained a technician, the dentist must provide space in which he can work and equipment with which to work. This involves additional overhead. Until recently, it was impossible to obtain the necessary equipment. Now it is available, but a further investment is required.

It is also important for the dentist to have a competent chair assistant to facilitate his work. She should not have to leave the chair to answer the telephone or act as a receptionist because this wastes valuable time.

LABORATORY PROCEDURES OF THE DENTIST

In considering the economics of this type of practice, one must take into account those laboratory procedures which the dentist himself should perform—specifically, the setting of the articulator. This is an extremely important step, as important as anything he may do in the mouth. It is the foundation upon which all other treatment rests. This procedure is also tedious and time consuming—and time to the dentist is a valuable commodity.

ADVANTAGES TO THE DENTIST

Let us look at the other side of the ledger.

With this type of treatment it is possible to do most of the work in the laboratory. The number of chair hours generally needed to adjust or construct something in the mouth is reduced to a minimum. One dentist can easily keep several technicians busy and still have a good deal of free time. In this respect, there is no limit to the economic possibilities of this type of practice.

It is possible for the dentist to have enough work prepared to enable him to take time out to attend meetings without having everything in his office come to a standstill. He can schedule his work so that long vacations are feasible, confident that he will return to an office which has the next step ready for him.

CASE PRESENTATION

In the beginning when one establishes a practice of this kind, careful case presentation is a must. As the years go by and satisfied patients refer others for this treatment, the case presentation becomes simple and routine. Referred patients generally come prepared for what to expect in the way of treatment and also have some idea of the financial investment that will be required of them.

Case presentation is an art and a study. Some men have made careers of it; others have disregarded it completely. As with most things, a happy medium should be sought.

Let me try to describe the case presentation as it is made in my office.

Having decided, after a complete diagnosis utilizing roentgenograms, study casts, and clinical examination, that complete reconstruction is indicated, the dentist is ready to present the case to the patient.

Begin by explaining to the patient what has been found. The condition of the gingiva is pointed out; the mobility of the teeth is demonstrated; the destruction of bone is called attention to in the roentgenograms. All these factors are then correlated to the function of the masticatory apparatus—first on the articulator with mounted study casts and then in the mouth. Give the patient a hand mirror to use as his attention is drawn to the conditions in his mouth.

Now, with casts of similar completed restorations, demonstrate what one plans to do for the patient—the objective of treatment. Next explain what this treatment entails—removing existing restorations, making preparations for restorations on the remaining teeth, replacing missing teeth, etc.

The patient is interested in knowing how long the procedure will take. Therefore, tell him how appointments are scheduled and how much work is anticipated during each visit, estimating the approximate number of visits and the time lapse from the beginning of the procedure to its completion.

Only briefly (unless pressed for details) touch on the materials to be used. This is done so that there will be no misunderstanding when the patient sees entire occlusals of gold restorations for the first time.

Explain to the patient the treatment to be performed on the supporting structures—whether extensive or routine. Acquaint him with the importance of proper home care and frequent re-examination.

The patient will want to know what he can expect after the treatment is completed. *It is most important that one makes him clearly understand exactly what one hopes to accomplish by these procedures!* He should be made to understand that the dentist is endeavoring to restore the mouth to proper function so that the remaining supporting structures may equally share the stresses encountered during function. Further, that by so distributing the functional stresses, we hope the supporting structures will maintain a state of health for a long time. The dentist should also mention that some of the dentistry may have to be replaced in time—that the objective is to maintain the health of the supporting structures for as long as possible.

At this point, most patients will be anxious to know how much all this is going to cost. When an approximate fee is quoted, a patient may ask, "Wouldn't it be cheaper to have all my teeth removed and dentures made?"

Here we must specifically describe what is involved in the transition to dentures—immediate restorations and their maintenance, the second set of dentures and the constant servicing required, the psychological adjustment, which is a big factor, etc.

When all these factors are considered, the patient will realize that over a long period of time he will have to invest as much money for dentures as he would to save his teeth. In short, he will end up without his teeth and with his money spent. It is a choice, actually, of expending a sum of money all at one time for a good investment in better dentistry or of spending the same amount gradually for artificial dentures.

Each practitioner must speak for himself, but I can say without hesitation that my decision over a decade ago to pursue this type of dentistry has never been regretted. It has provided me with a comfortable professional income; it has challenged such skills as I possess; it has given me the satisfaction of rendering lasting service to my patients.

CHAPTER 29

Practical hints from everyday experience

Full-mouth rehabilitation based on gnathological principles is not a procedure which the beginner should immediately undertake. Too many considerations—and complications—are involved. It is not simply a matter of deciding that this is *the* way to practice dentistry and then doing it. There must be a gradual transition from general practice to one in which most of the work will be done gnathologically.

This is to say that one should not mix gnathology with general practice. It just is not possible to jumble the two—to sandwich gnathology between general appointments.

How then can it be handled?

PREPARATION FOR A GNATHOLOGICAL PRACTICE

The beginner must set aside a day or part of a day each week during which all his attention will be focused on gnathological procedures and nothing else. Within this scheduled time he will acquaint himself with the various procedures described in this textbook. Each chapter for the most part is a complete entity, and thus it is possible to concentrate on one phase at a time. The different instruments should be used in sham in order that the beginner may become thoroughly familiar with all their strange nuts and bolts.

Perhaps the greatest stumbling block is the wax carving procedure. This is something that can be worked on at intervals—several hours at a time as a break from some other procedure.

Considerable time should be spent practicing the setting of an articulator. The writing apparatus can be assembled on an articulator, and practice writings can be made. A control of the articulator can be changed, and the effect of this can be compared with the writing just made. In this way the beginner becomes acquainted with the controls and their effect on the movements. By reversing the procedure and making the stylus move in a direction consonant with the existing tracing, he learns how certain controls have to be moved in order to duplicate the patient's movements.

Some of the procedures may be used in general practice, e.g., the use of the face-bow to make conventional mountings of study casts, the taking of centric interocclusal records, and the relating of units of a simple bridge to master the remount procedures.

When all these steps have become so familiar to the beginner that he can do them almost automatically, he is then ready to attempt his first patient. At the rate of one day a week of diligent application, the period of preparation should take about six months.

SCHEDULING PATIENTS

In choosing his first patient, the beginner should be sure to select a patient whose treatment will not be too complicated. He should pick a cooperative patient, one who needs extensive dentistry, but who does not have a bad joint or a severe periodontal problem. In short, he should give himself a break by selecting a rather easy patient—and give the patient a break, too, so that he will be no worse for the treatment!

The patient should be scheduled for the day that is normally set aside for gnathology, and there should be no other appointments. Thus, if something does not go as it should, the dentist can repeat the step without having to worry about the clock and another patient to see.

The first case will be an education in itself. Tying together the various steps will reveal the reason for each procedure. There will be many mistakes—every possible mistake will be made at least once. To make every possible mistake once is permissible; to make the same mistake a second time is just plain carelessness.

After treatment of the first patient has been successfully completed, the dentist is ready to start another. From here on he should schedule the patients so that they will dovetail with the laboratory steps. In other words, he should not begin to prepare three or four patients at one time because, once the teeth are prepared, the laboratory procedures will pile up. This makes for confusion. A logical plan would be to start the preparation of the second patient after the restoration for the first patient is in the laboratory. Then by the time the second patient is prepared, the laboratory work on the restoration for the first patient is near completion. The appliance for the first patient is now ready for fitting and remounting. When these procedures are completed, the second appliance can be carved in wax and prepared for casting. The acrylic work, if any, is done on the first appliance between carving and casting the second one. The third patient is prepared while the appliance for the first patient is temporarily inserted and the second appliance is carved.

The registrations are planned to dovetail with the other procedures. Although the registrations should be taken as a diagnostic procedure, they can be taken at any stage prior to carving the appliance. Occasionally it is advisable to wait until the teeth have been prepared before taking writings of the patient's jaw movements. This has advantages and disadvantages. After the teeth are prepared and temporarily covered, the patient may lose his adverse proprioceptive reflex and thus give a good writing with greater ease. On the other hand, the temporary restorations may loosen and cause the dentist some difficulty in stabilizing the clutches. They are liable to be loosened in removal of the clutch, necessitating their replacement. Actually, these are not really serious considerations; therefore, the writings can be taken at the convenience of the dentist. Again, they should be planned so that they will not tie up an articulator which is needed for some other procedure. Remember, the articulator has to be set before it can be freed for another appliance. Consequently, the dentist should not plan a remount on the same day for the articulator on which he is going to put a writing. Either the writing apparatus or the face-bow will have to be stored until the other is free. These instruments do not store well and can be easily distorted.

Eventually, as more patients are handled, the dentist will probably have several instruments with which to work. Here again, careful planning will prevent the setting and resetting of instruments before any work is completed. For example: Appliance 1 is ready to be carved. It is mounted on articulator 1. Writings are taken from patient 2 and are mounted on articulator 2. Appliance 3 is ready for adjustment (remounted) and is mounted on articulator 3.

Three articulators represent a sizable investment, but with intelligent planning on the part of the dentist they are adequate for a good deal of work.

If appliance 4 is ready to be mounted for carving, it would not be wise to use articulator 1. The reason? Because the carving procedure is time consuming. It is worked on for a time and then set aside. Several weeks might easily go by before the appliance is completely carved, and it would be foolish to have to change the settings repeatedly during this period. The same is true of a writing. Several days may pass before it is completed, and the articulator is tied up all this time. A little thoughtful planning, however, will enable the dentist to work out a system that will best suit the facilities of his laboratory.

Another consideration is the scheduling of appointments so that the patient will not be too greatly inconvenienced. Patients must be kept comfortable during these procedures. The dentist should not schedule appointments around the vacation of his patients and office staff. He should plan the work so that it does not sit in the laboratory at a time when it cannot be worked on.

Because all the teeth must be prepared before the appliance can be started, the preparations should be scheduled without long intermissions. The dentist should schedule the patient for one long (2-hour) appointment each week. At this rate, the average patient is prepared in four or five weeks.

Long appointments are more efficient. It takes but a few minutes more to prepare four teeth than it does to do two. Usually one injection will produce anesthesia for several upper teeth. The lower jaw is anesthetized with one block injection. The impressions, if rubber or hydrocolloid, can take four teeth as well as one or two. The temporary coverage for four teeth can be made in the same time it takes for two. All in all, it is more efficient to prepare a quadrant at a sitting.

TEMPORARY RESTORATIONS

Good temporary restorations are essential to the successful treatment of reconstruction appliances. They should be made of good scrap gold. They do not necessarily have to be perfect in function (although for a patient with a joint disorder, it is very important to have temporary restorations that function). They do not have to fit perfectly. They should be so constructed that the teeth do not move, are protected from decay, and are kept comfortable. Temporary restorations are made in quadrants (soldered) to facilitate their removal and replacement and, at the same time, to maintain the status quo of the prepared teeth.

Good temporary restorations are well worth while because they allow the dentist ample time in which to work out the permanent restorations and to do so at his convenience. Many of the problems of a permanent appliance come to light in a temporary prosthesis, e.g., the parallelism of the abutment teeth, the finishing line of veneer crowns, the shades of veneer work, the amount of gold displayed, etc. If an appliance does not have to be rushed, other work may be better dovetailed in the laboratory. Good temporary restorations permit a dentist to enjoy a lengthy vacation while laboratory procedures are carried out. It is rather easy for one dentist to prepare sufficient work to keep a few laboratory men busy for several weeks. In short, the laboratory can be productive in his absence.

Most important of all, good temporary restorations allow enough time for healing of the tissues—periodontal or temporomandibular. They enable the patient to forget any acquired abnormal reflexes, as, for example, closing the jaws in an eccentric position.

VENEER CROWNS

When veneer crowns are involved, the windows should not be cut to the edge of the occlusal surface until the first remount has been made. The occlusal edge should be left relatively thick until after the occlusal adjustment has been made. Then the dentist should trim the gold to a thin occlusal edge.

This is a safeguard against cutting through the functioning edge of the veneer while the adjustment is being made. If the function should end up on acrylic, there will be trouble later from wear and separation of the veneer from the crown.

TEMPORARY CEMENTATION

When a restoration is to be temporarly cemented, the dentist should be rather selective about the cementing medium to be used. It should be slightly sedative, thin enough to permit accurate seating, and strong enough to retain the restoration, although still permitting easy removal when desired.

There are several temporary cements which I use in my work, each having a specific purpose. When restorations are placed temporarily for the first time, I like to use a cement that will facilitate removal. Pulprotex* or Moyco's† temporary cement, mixed with a fair amount of petrolatum, permits easy removal. (The patient is warned to be careful.) If one of the restorations should come loose, it can be recemented with the same material, without the petrolatum. This will hold more tenaciously. If the retention is still inadequate, I will try Ackerman's‡ liquid impression cement and one of the powders, such as Moyco's or Ward's§ fiberless, with petrolatum. If I really want the restorations to stay to place, I then use Ackerman's without petrolatum. If this does not hold, I know there is something wrong with the fit, the articulation, or both.

For a patient with extremely sensitive teeth and/or mutilated gingival tissues, Ward's WondrPak seems to work to advantage. Here one must be sure to have a thin mix in order that the restoration can be seated. WondrPak, however, must not be left in place for more than three weeks because its asbestos fibers absorb moisture and will make the teeth more sensitive and encourage the additional hazard for secondary decay.

For the most sensitive patients, a small amount of finely powdered silver nitrate may be mixed with WondrPak. This must be handled quickly since the silver nitrate will hasten the set of the WondrPak.

With a temporary cementation, it is important not to dry the teeth! As the cement sets, moisture is absorbed. If the teeth are dry, moisture will then be removed from the dentinal tubules, with disastrous results. Any free blood on the preparations, however, should be wiped off with a cotton pellet.

The temporary cementation procedure has several advantages. Obviously, it facilitates the making of any necessary changes. In addition, the teeth become less sensitive as time passes, and when the appliance is ready to be permanently cemented, the teeth are quite comfortable. However, if they are still sensitive, anesthesia must be used. A patient in pain can prevent the dentist from seating the restorations properly. A well-executed appliance can be ruined by careless cementation.

Another advantage of temporary cementation is that it enables the dentist to be sure that the restorations are correct as to fit and function. If the temporary cement does not wash out after three months, it is reasonably safe to conclude that the restorations fit well and are functioning properly. On the other hand, if the temporary cement washes out before three months, permanent cement will not hold either. It will last a little longer, but it will eventually wash out.

One of the greatest temptations is to complete an appliance quickly. It is also the greatest mistake a dentist can make. Changes do take place in the relations of the teeth as they assume their new function. Whereas it is a simple matter to

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*The L. D. Caulk Co., Milford, Del.

†The J. Bird Moyer Co., Inc., Philadelphia, Pa.

‡Ackerman Dental Co., Santa Monica, Calif.

§Westward Dental Mfg. Co., San Francisco, Calif.

make necessary adjustments when the appliance can be remounted, it is a heartbreaking experience to have to make corrections on an appliance that is permanently cemented. There is no harm in keeping a prosthesis temporarily cemented for six months or a year longer than anticipated so long as it is checked occasionally for any washout.

REMOVAL OF TEMPORARILY CEMENTED RESTORATIONS

There should be removal buttons on all individual resorations. These are little projections which are waxed in place prior to casting. They should be small enough not to annoy the patient unduly, yet sufficiently large so that they may be grasped by the tip of a crown remover. The lingual areas—interproximally wherever possible—are best suited for these buttons because they seem to cause less annoyance there.

In removing a restoration, I first try the Bachaus towel clip,* using an orangewood stick as a fulcrum. This seems to be less distasteful to the patient. If the towel clip does not work, I next try the crown remover. There are several types available—one for the removal buttons and one that can be used interproximally on a bridge. For difficult-to-remove fixed bridges, I may use a technique that was demonstrated to me by Dr. Earle B. Hoyt.† A piece of dental floss, about 5 feet long, is doubled several times to make a short, strong length. This is passed through the interproximal aspect of the bridge, near the middle if possible. The floss is then tied into a loose loop, and an orangewood stick is placed in the loop. Now, while the assistant pulls on the handle of the orangewood stick, the dentist uses the crown remover interproximally. It is amazing how readily a stubborn bridge can be removed by this trick.

CLEANING RESTORATIONS

Until recently, the cleaning of restorations that had been cemented with a zinc oxide type of temporary cement was a nuisance. Today, however, thanks to Jel-Sol,‡ a fine cleansing agent, it is a simple procedure.

The restorations are placed in an acid-heating dish with some Jel-Sol. The solution is brought almost to a boil, and the restorations are allowed to remain in it. After a short time—10 to 15 minutes or longer if one is busy doing something else—the temporary cement can be brushed off very easily. The restorations are in no way harmed, the acrylic veneer is not damaged, and the restorations are as clean as when they were first constructed.

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*Friedman Specialty Co., Chicago, Ill.
†Dr. Earle B. Hoyt, New York, N. Y.
‡J. F. Jelenko & Co., Inc., New York, N. Y.

CHAPTER 30

The future of dentistry in the space age

There is a sort of finality about putting one's ideas into print. It is like a summing up or a consummation of yesterday and today. Yet, with this chapter I am placing my toe in the door of tomorrow to keep it from closing on me. I hope it will serve somewhat as a link to the newer developments that are sure to come with the future.

From the preceding chapters, it might be concluded that gnathologists go to extraordinary pains to perform dentistry with a purpose. We appear to work with great accuracy. Actually, we do not! The precision attachments on our removable prostheses are as exact as presently possible, but what would a machinist have to say about their alleged accuracy? True, they are so much better than clasp appliances. But how much better should they be?

Our methods of instrumentation are amazing when compared with those of the past and, indeed, to the majority in use today. Yet, in this Space Age they are really prehistoric.

The materials we use and handle with such care leave much to be desired. Our plasters, stones, investments, casting techniques—all lack that fine degree of accuracy which they should have. We cannot even make a solder joint without causing some change in the soldered parts or in their relation to each other.

We are actually dealing with gross considerations instead of microscopic ones. We adjust an articulator to duplicate a patient's movements and use lines to dictate the setting of the instrument. Do we realize how many layers of cells could be piled one on top of another to make up the thickness of a line? Our treatment should be directed toward preventing the crushing of these cells in function. We should be dealing with microscopic entities. As it now stands, we can only prevent the crushing of thick layers of cells.

Periodontal treatment is valuable for many mouths. In a good number of patients periodontal surgery is necessary and beneficial. But why should patients be allowed to reach a condition in which surgery is the only solution? Certainly there must be a better way!

The responsibility of the dental schools is tremendous. They have done a good job, but they must do more. It is unfortunate that much of the dental research in schools is carried on by men who really have not been trained for scientific investigation. Teachers are not necessarily qualified for research work; therefore it is reasonable to expect that our dental schools would have on their faculties some men who are thoroughly trained in research procedures.

So too should our schools have men who have been trained to teach. Teaching is an art as well as a profession, and few practicing dentists have the special training and temperament to qualify them for this work. Although it is desirable for a school to engage several practicing dentists as consultants to balance the theoretical aspects with the practical, it is regrettable that the faculties of many dental schools are made up largely of part-time instructors who maintain the school connection for their own benefit. The day or so that they devote to the school is easy for them and a diversion from their busy practice. This is well and good, but the students are the losers.

Men who are essentially teachers should not have to augment their income by private practice. Their salary should be commensurate with their training, experience, and ability. They should use their spare time to familiarize themselves with the newer methods continually being developed. Too many schools are still teaching procedures that are thirty or forty years old—not because those methods are better, but because their teachers have not had the time to learn anything else.

To recognize these conditions is one thing; to remedy them is something else. The expending of additional funds for dental schools is only part of the answer, for this in itself is no guarantee of excellence. Some of the abuses we have mentioned exist in schools with heavy endowments. In the final analysis, what is needed are strong, wise, dedicated administrators who are as zealous in raising the intellectual standards of their institutions as they are in raising funds. To settle for less is to settle for mediocrity.

In recent years there have been some exciting developments in the field of dental research. Electromyography has opened new vistas for understanding the function of the masticating mechanism. Some of the mysteries of muscle function have been solved. The effects of various treatments can now be evaluated and compared. Cinefluoroscopy belongs in this category. Mandibular movements can be carefully examined and studied, and statistical analyses of the variations in movement of the structures involved are now possible. This new research medium is already responsible for much valuable information.

Of how much value electromyography and cinefluoroscopy will be in the practical treatment of patients is not yet clear. Still, the information that can be gathered will certainly help to illuminate some of the present darkness.

The electronic field in general holds more promise in answering some of our practical problems. The work of the Air Force with tiny resistors that can be placed in dentures is extremely interesting. Before long, many controversies will be settled decisively. When we learn the answers to what is really required of a masticating mechanism, we can then direct our wholehearted efforts toward fulfilling these requirements.

Soon to be realized is the electronic recording of patients' mandibular movements. These recordings could in turn duplicate the movements on a suitable instrument. Properly activated circuits could then develop the surfaces required for a particular patient. Such a plan has already been submitted to the patent office.

These are some of the dreams of tomorrow. So long as we strive to realize such dreams, it is not conceivable that the Space Age will leave dentistry behind.

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