# Practical Procedures in Oral Rehabilitation

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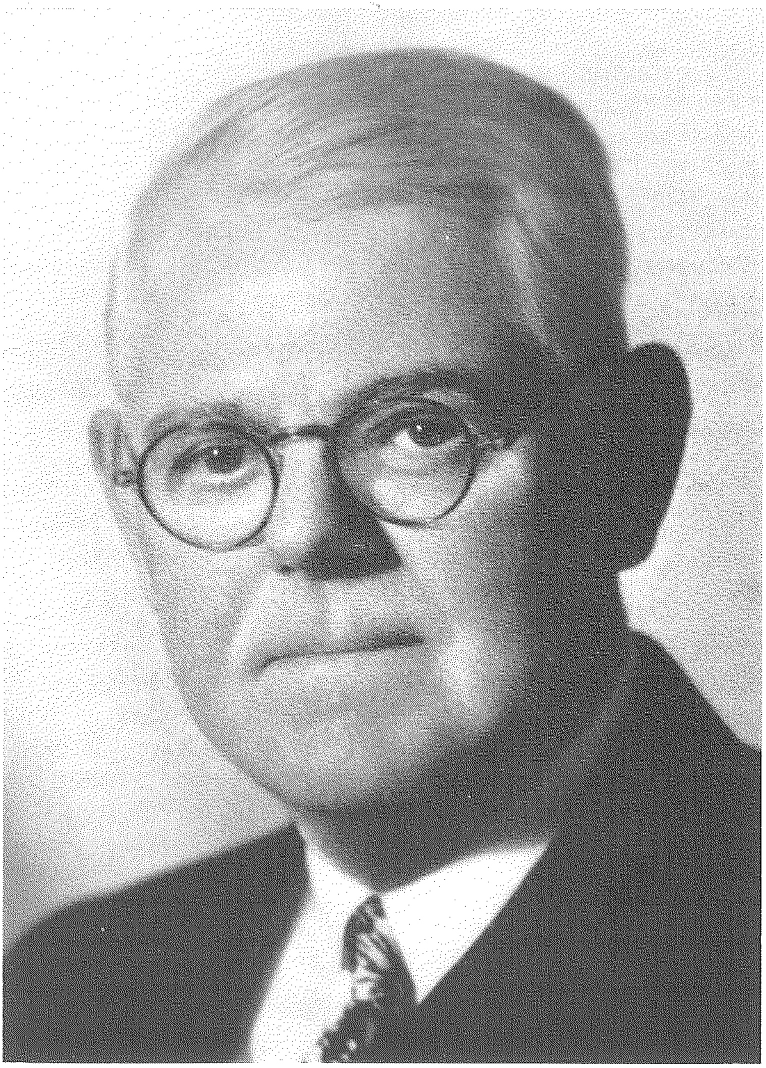


*Dedicated to*
BEVERLY McCOLLUM, D.D.S.

# Preface

This book was written in response to many requests for a textbook for students and practitioners. As rehabilitation has assumed a more prominent place in dental thinking, it has created a greater desire for knowledge of the technics and the instrumentation that are associated with and peculiar to the problems of dental rehabilitation. A knowledge of anatomy, physiology and periodontics is essential to a full understanding of the problems, and it is assumed that this knowledge already has been obtained from a study of these essentials. It is assumed also that the reader already is familiar with the routine procedures of crown and bridge, and of denture prosthetics. In this book we are concerned primarily with technical problems of full mouth treatment.

The fact that these procedures are the technics of rehabilitation does not mean that they are applicable only to those limited cases in which all the teeth are being reconstructed. The principles that make for successful rehabilitation can be applied every day to better solutions of routine problems. The principles of centric bites, hinge relations, check-bites, remounting and treatment are the same whether a routine denture, a periodontal problem, an extensive bridge or even oral surgery is being considered. Most of these principles apply with equal force to orthodontic treatment, although some of the technical means will be different. In short, this is not a book for a limited field: it covers the application of technics to dentistry as treatment and the integration of the mechanical devices of dentistry as a true part of oral medicine.

Most of this text has been devoted to a description of how to do oral rehabilitation, since there is a great need for this information. It is hoped that the application of these practical technics to many practical problems will be apparent. So far as I am aware, this is the first time that these have been assembled as related procedures which, when put together, unite all the structures of the oral organ—teeth, supporting structures, joints and muscles—in physiologic co-ordination.

The fact that I have not quoted from the writings of others does not mean that all this material is original. There is no such thing as true originality in this field. The only innovation lies in putting together and setting down in orderly fashion the ideas gathered from many others over many years, mostly from personal contacts and discussions.

The man who deserves the most credit for whatever help this book may provide is my old friend and counselor, the founder of the Gnathological Society, Dr. Beverly McCollum. Without his guidance, inspiration and teaching I never would have been made aware of most of this material and spurred on to learn more about it. It has been discouraging at times to hear men with little minds try to undermine his greatness because of personal jealousy over who deserves credit for what. In recent years it has been most heartening to see principles for which he fought and was damned accepted calmly as fact. It is the misfortune of dentistry that more men have not been privileged to know the greatness of his mind.

Without the untiring devotion of Dr. William Maxwell, who is responsible for most of the illustrations, this book never would have become a practical reality. Indeed, I think it is fair to say that the time and the energy required for illustrating it exceeded that required for the writing of the book. I am in-

debted to Dr. Dan Isaacson for writing and illustrating the chapter on Correction of Occlusal Disharmonies; to Dr. William Palankey for illustrations on mounting and check-bites; to Dr. Robert Simpson for illustrations on complete dentures; to Dr. Robert Kaplan for the chapter on Periodontal Consideration.

It would be impossible to list all the friends from whom or through whom I have gleaned the information here assembled. The fact that I can name but a few does not mean that I would slight any of them. I would have to go back to my school days and name teachers for whom I had too little regard at the time. Many others to whom I shall be eternally indebted crowd into the picture. To name but a few: Dr. Dan Grubb (deceased) and his coworker Mr. Russell Jones; two old friends and associates, Dr. Ray Garvey and Dr. Clem Bird; Dr. Lester Burket and Dr. Milton Rode of the University of Pennsylvania, who had the understanding and the fortitude to incorporate oral rehabilitation in undergraduate teaching; Dr. Don McQueen of the Gnathological Society for lending an unselfish and understanding mind; Dr. John Thompson for friendly disagreements leading to fruitful understanding; Dr. Robert Moyers for a better understanding of muscle physiology; Dr. George Coleman for a constant helping hand; Dr. William Dykins for many discussions on mucostatics—even Mr. Harry Page for ferreting out what Dr. Carrol Jones christened "mucostatics"; Mr. Tom Nicoll and Mr. James Stern for helping hands many years ago; and, most of all, my father and the previous generations of dentists who passed on to us the fruits of their labors.

The list could go on and on. Suffice it to say that without the knowledge acquired from these others this book never could have been written. In every profession progress is based largely on the learning that others have generously passed on. If this book aids in that professional service it will have been worth the effort.

E. R. G.

# Contents

*Chapter* 1

# Rehabilitation

During the past decade, full mouth treatment has stepped from an obscure seat of questionable respectability to an accepted position in dental practice. High-speed preparation and elastic impression materials, coupled with unprecedented public acceptance of dental treatment, have created a fertile field for expansion. But our technical ability to undertake full mouth reconstruction has advanced much more rapidly than our knowledge of how to treat the mouth. Much of the full mouth treatment today is not really treatment: it is merely reconstruction of teeth in groups. The physiologic considerations in the reconstruction of an entire mouth are quite different from those in the restoration of individual, unrelated teeth. Rehabilitation is establishing a harmonious relation of teeth, supporting structures, joints and muscles: a physiologic activity to aid in maintaining a healthy organ. Though it frequently does require reconstruction of many or all of the teeth, it does not imply that reconstruction of teeth is rehabilitation of the mouth.

It is relatively rare to be presented with a mouth requiring extensive restoration which does not also require some consideration of periodontal problems. Even in the young patient, whose tooth loss may have been due solely to dental caries, the changed relationship and the increased stresses on the remaining teeth may lead to periodontal problems which otherwise would not have existed. The purpose of restorative dentistry is not only the replacement of lost chewing surfaces. Important though this is, of equal importance is the preservation in health of the remaining structures, and this applies likewise to full dentures, so that the restoration will not hasten the loss of its own supporting structures.

For many years clinical experience has pointed to a relationship between functional movements in the temporomandibular joint and pathologic processes occurring in the jaws. The patient's ability to accept and tolerate restorations and the end-result of our treatment are dependent on many factors, but we cannot ignore this one. Mere acceptance and tolerance by the patient is not the criterion of successful treatment. Our ability to treat and save mouths is directly related to our ability to capture and transfer jaw function to the restoration.

## PERIODONTAL CONSIDERATIONS

Periodontal disease and dental caries are complex pathologic states which do not result from a single simple cause. Successful solution has so far evaded us because histologic, biochemical, bacteriologic, genetic, functional, and psychosomatic stress and even evolutionary factors are involved. Many single investigators and larger groups of scientists have attacked these conditions from a variety of angles. Much has been learned and applied to clinical treatment, but there are so many closely interrelated factors involved, and so many different sciences concerned, that up to now it has not been possible to disentangle the various processes which go on, and decide on the relative order or importance of each.

When the problem is attacked from the viewpoint of any one of these sciences, facts emerge which are a part of the picture, but a part only. When enough facts from these, and possibly other yet unknown sciences, have been accumulated, it will become possible for a broad general synthesis of the various ideas to be made. The various parts of the puzzle will fall into place, and the methods and the mechanism for the prevention of dental disease will become clear. However, as in the cases of cancer and arthritis, the synthesis has not yet been made. Lacking this knowledge, in dental disease we must rely on symptomatic treatment and the use of those methods which have been found to be clinically and empirically effective.

Although we do not know the cause of dental diseases, we do know a considerable amount about them. We know, for example, that diet and endocrine factors play an important part in the breakdown and the repair of dental tissues. Yet they alone are not the cause, or all tissues would present the same problems. They do profoundly affect the ability of tissues to sustain stress. As a result, in some instances they alone can provide enough favorable balance to swing the scales. But, likewise, a better distribution of stress alters the metabolic picture. Each of these factors is relative to the other. Convenient though it would be, we cannot pin our hopes to some one magic cure-all. Treatment of occlusion is not, per se, periodontal therapy. Even though we do not know the histologic mechanism of the relation between pathologic changes in the supporting structures and occlusal stresses on the teeth, we have considerable clinical evidence that such a relationship does exist. This does not imply that occlusal stress is *the* cause of, or *the* treatment for, periodontal disease. It does not mean that treatment of occlusion replaces the need for periodontal therapy. It is not as simple as that. It does indicate that treatment of occlusion is an essential part of, or an adjunct to, the successful treatment of the pathologic processes that occur in the supporting structures and constitute a sick mouth.

Rehabilitation involves more than tooth reconstruction. Although this is frequently necessary from the standpoint of the teeth themselves, it should be viewed also as a part of the treatment of the whole mouth. Restorations must be viewed from both aspects: their relation to the teeth themselves and their relation to the whole mouth. More often than not, the chief purpose of a restoration is to place the tooth in a proper functional relation to the mouth. Much of the full mouth treatment today is tooth reconstruction rather than rehabilitation. Primarily, rehabilitation involves the treatment of occlusion. This is because the simultaneous reconstruction of many teeth in one mouth is vastly different from the reconstruction of the same number of teeth in many different mouths. The difference lies in the alteration of nature's protective mechanism, the proprioceptive reflex.

## NEUROMUSCULAR RELATIONS

Some years ago, in discussing this problem, Harry Sicher pointed out that, in full denture construction, a hinge axis mounting and a centric bite are essential to stable occlusal relationships. Yet many people are able to go through life in comfort and health with a set of natural teeth which do not meet in centric relation. Lack of centric relation occlusion is not per se abnormal to the individual. This is because, as his cusps start to interdigitate, the proprioceptive reflex activates the muscles to move the mandible to a position which will not traumatize the tissues as the teeth come into contact.

Loss of teeth changes the proprioceptive reflex. There is no longer the same signal to tell the patient where to close. As it grows, the dentition develops proprioceptive reflexes as nature's defense mechanism against self-inflicted injury. Movements of the mandible which bring the teeth into contact are brought about by the musculature but are controlled by the temporomandibular joints. The muscles provide the means of motion, but the paths which the mandible can follow in tooth contact are determined by the temporomandibular joints. In young, healthy dentition, proprioceptive reflexes enable the muscles to guide the mandible to the positions that are least injurious to the supporting structures of the mouth. As long as these positions are harmonious with the joints, a state of functional equilibrium is maintained.

These proprioceptive reflexes are brought bout by tooth contact or by pressures transnitted by food between the occlusal surfaces. Loss of teeth, tipping of teeth, excessive vear, or rapid equilibration all can alter these eflexes and interfere with the normal adapive mechanisms. When the occlusal surfaces re all destroyed at one fell swoop, as in ull mouth reconstruction, the proprioceptive eflex immediately is destroyed. This is why econstruction of all the occlusal surfaces in ne mouth is not the same as reconstruction f the same number of unrelated teeth in eparate mouths. Now the temporomandibuar joint takes over as the guiding factor. The nuscles still provide the power, but the joints letermine whether or not the teeth are in a armonious relationship. Thus new occlusal urfaces, lacking proprioceptive reflexes to uide them, must likewise follow the paths f motion of the temporomandibular joint to void lateral stresses and injury. Except in he very young, new reflexes cannot develop o cope with the damage, unless the teeth re harmonious with the joint. Teeth contructed without regard to the functional aths of the joint cannot be compensated by he musculature. In voluntary closure the nuscles can adjust the mandible to any posiion dictated by the teeth. But during the nvoluntary functions of chewing, they canot permanently adapt the mandible to any osition not harmonious with the joints withut injury to some part of the system: teeth, upporting structures, joints or the muscles hemselves.

Rehabilitation, then, should be an attempt to restore a harmonious relation of hese structures, to avoid self-destruction by lashing teeth, joints and muscles. Recontruction of the mouth without consideration f these factors is not rehabilitation. Undertanding rehabilitation depends upon undertanding the temporomandibular joint.

## THE TEMPOROMANDIBULAR JOINT

There are still those who speak of this s a loose, sloppy joint, incapable of direcion, subject to the dictates of occlusion. This joint is unique in that it is not held together by ligaments. Muscular action holds it together; the ligaments merely limit the range of its movements. That is why Lammie terms centric relation "ligamentous centric." It is the posterior limit of the ligaments. At rest this is a loose, sloppy joint, particularly when severe malocclusion has subjected it to abnormal stresses, which can stretch the capsule. But when muscular force is applied to close the mandible against resistance, the joint is drawn tightly together, the condyle being braced on the pressure-bearing area of the meniscus seated against the glenoid fossa. The mandible is lifted bodily before any other functional movements take place. The hinge axis is lifted to brace itself so that the mandible can rotate as it closes against resistance. Muscular force holds the joints together; the ligaments merely limit the amount of motion. Thus, when the muscles are at rest, in tonus, the joint likewise hangs loosely, held together by the ligaments. It should be apparent that a closure from rest position to tooth contact can never be a hinge closure. As a matter of fact, there is nothing easier to demonstrate in practice. But it does constitute a major problem of recording maxillomandibular relations. The so-called unstrained relations are the one thing that we do not want. But they should not be relations forced upon the patient by externally applied force. They should be the relations that the patient will use by the application of his own muscular forces.

Although the nonfunctioning joint is loose and sloppy, functionally it bears an extremely precise relation to the occlusal surfaces of the teeth. These surfaces do not exist merely to make the teeth rough and sharp, like glorified rasps. They are formed so that efficient biting, shearing and masticating surfaces can maintain a harmonious relation to the joints and the muscles. There is nothing haphazard or sloppy about any of these structures in form or function.

The temporomandibular joint exists for the purpose of guiding the mandible to positions of tooth contact which will enable the cusps to mesh and glide past each other without injury. To form such related surfaces requires the use of mechanical aids to both diagnosis and treatment. There are many reasons why the mouth itself cannot be used as the articulator in full mouth treatment. Although it appears sensible and logical that the mouth would be the best articulator, this is a technical impossibility. An articulator reproduces the functional relation of the teeth to the paths of motion of the temporomandibular joint. No instrument can reproduce the anatomy of the joint but, to be effective, it must reproduce the relation of this anatomy to the form of the teeth. Construction of teeth is a mechanical procedure, but that does not mean that it cannot be a physiologic remedy. Since the function of teeth is chewing, it is the chewing paths of the joint which the patient executes with his own musculature that must be recorded and reproduced. Rotary motions which close the mandible to tooth contact are brought about by rotation in the lower compartment, but the position of the mandible at the time of contact depends upon where the meniscus lies on the condyle path. The patient in mastication never closes in centric. He closes in lateral excursion and returns via the Bennett movement to and through centric. He does not stop suddenly at centric as though he had run into an obstacle. As with any muscular action, there is a natural follow-through. The teeth glide past centric, up onto the balancing cusps, as the mandible opens and returns to lateral for the next stroke. Maxwell has pointed out that centric is where the condyle changes from a closing rotation to an opening rotation, and so brings the lingual balancing cusps on the working side into contact. Not for mere prosthetic bilateral balance. Since the patient cannot move one compartment of the joint without simultaneous action of the other compartment, he cannot make a functional closure in centric. Centric is one position of the lower compartment, but, since the patient cannot make a centric closure during the involuntary act of mastication, the mere location of this position of the axis and a centric bite, without recording the paths of the joint, is of little functional value. Cusps of the teeth must follow these paths of motion, not guide the mandible in a clash with the joints and the muscles. So instruments used to form these cusps must likewise reproduce the actual functional paths of the joint.

## FUNCTIONAL PATHS

In mastication the mandible opens to move into lateral excursion preparatory to closing on the bolus. The nonchewing condyle moves down, forward and inward in a circular path about the rotating working condyle. Therefore, the working condyle is rotating in three planes simultaneously. It is an established fact of physics, mathematics and mechanical engineering, embraced in kinematics, that, for a solid body in space to rotate in three planes simultaneously, the axes of those planes must be at right angles and must coincide at a point center. It is the relation of the teeth to this point center in each condyle which enables the cusps to pass each other without colliding or bumping.

The condyles are irregular bodies, and the mandible is asymmetrical. They are all rigid bodies, and a rigid body cannot rotate simultaneously around two parallel axes. To enable these irregular bodies to rotate around point centers, there are interposed between the rigid condyle and the glenoid fossa the movable meniscus and synovial membranes and fluids. In the closing rotation which brings the teeth into contact, both condyles are rotating. The rigid mandible rotates to closure around an axis formed by connecting the point centers in the two condyles. This is the hinge axis. Since the patient is not closing in centric, the contacting positions of the teeth are the positions of the hinge axis on the condyle paths. The position of the axis on the condyle path does not depend on the condyle path alone, but also upon the position of the center of rotation (vertical axis) on the working side. Since the three planes on the working side must intersect at a point, if we locate the axes of two of these planes (i.e. the hinge axis and the center of rotation), we automatically have the axis of the third plane, the sagittal axis, and the point centers of rotary movement.

These axes can be located readily, and their paths of motion recorded, by means of a suitable pantograph, using the patient's own muscular action and chewing strokes. Needless to say, in order to reproduce them in the restoration, the articulator must be fully adjustable to the patient's three-dimensional chewing. To be effective, occlusal rehabilitation must reproduce the results of this three-dimensional action in the cusps, without stress and trauma to any part of the stomatognathic system.

## GNATHOLOGY

These are the objectives of gnathology. Strictly speaking, gnathology means the study of the jaws. The study provides the diagnosis upon which to base treatment-planning. Gnathology is the study of the patient as an individual to determine his individual requirements for treatment. It uses instrumentation and technics as the means for practical accomplishment—these instruments and technics are not themselves gnathology. They are only the tools, the means of treatment, but this does not imply that they are the only means of treatment. Increased understanding must bring with it better instruments and technics. It is our hope constantly to improve and change our instruments and technics, with increased understanding. But the philosophy is unchanging. It is a philosophy of the treatment of the patient as an individual. It is not an attempt to force upon the patient some preconceived, standardized form of treatment. Diagnostic and treatment procedures may be standardized, but their application must be tailored to the patient's need. There is more than one technic for performing an appendectomy but, whatever the technic, the end-result must be the removal of the appendix.

Gnathology is far less arbitrary in its approach to treatment than conventional reconstruction; it is much less radical in its prescriptions. It has far less potential for harm. It permits much more latitude in adapting the treatment to suit the problems. It does not require that every case be treated by a mouth full of crowns. Fundamentally, it is conservative in its belief that treatment should be designed to create a benign harmony of action; it is not just a hope that some adaptive mechanism will tolerate our treatment.

The only dogma of gnathology, if you would call it that, is the basic tenet of all the healing arts: treatment of the patient as an individual. Treatment based upon a true diagnosis of his particular problem, and an understanding of what is needed to make the dentistry an actual treatment—not the technics, not the instrumentation. Treatment of the patient lies in the use of whatever tools, physical and intellectual, the knowledge, the skill and the understanding of the operator can apply to the end that his reconstructions will become true restorative remedies.

Much dispute has arisen over the question of acceptability. Twenty years ago the mere mention of the hinge axis was a cause for name-calling and emotional outbursts. Yet today one hardly can attend a dental meeting or pick up a dental journal without seeing a reference to it as an accepted fact. Acceptance of the new and the different is always slow when established systems of action and thought are challenged by new approaches. This is a healthy reaction. Acceptance of the new and the different, merely because they are new and different, is not sound progress. New ideas must prove themselves before they can become integrated into practice. But it is unfortunate when such progress is retarded by a lack of meeting of minds, by emotion and prejudice. One has only to read comments in the literature to realize how great are some of the misconceptions which widen the abyss.

Gnathology does not present any rigid treatment for the patient. It studies the functional problems to enable the operator to select the treatment that he believes to be best suited to the problem. The technics and the instruments described here are presented as a means to that end.

*Chapter* 2

# Functional Relations of the Temporomandibular Joint

## JOINT RELATIONS

The seemingly erratic behavior of the temporomandibular joint frequently obscures the actions in the joint which make this behavior possible. The almost infinite variety of joint relations exhibited by varying muscle forces tends to make it appear to be a loose, sloppy joint subject to the whims of muscular control. Rehabilitation of the whole mouth and intelligent handling of the instruments used for this purpose depend upon being able to separate the actions taking place in the joint which make this behavior possible. Occlusal relations of the teeth are the result of precise actions in the joint, with various patterns of muscle activity. We must understand the nature of these actions and the manner in which they combine to be able to use this seemingly erratic behavior in treatment. The usefulness of an articulator depends upon how well the operator can transfer these actions to an instrument and, in turn, how well it can produce all the irregularities of functional relations.

The restorative dentist faces two problems. He must create tooth forms which are harmonious for the relation of the cusps to the supporting structures and, at the same time, bear a relation to each other which is correct for the joints. Since it is the relation of the cusps to the joints which permits them to function in harmony without stress, the joint must be the first consideration in tooth form and relation.

We are accustomed to speak of the temporomandibular joints as though each of them were one joint. But, as a matter of fact, each of them is two separate and distinct joints, inseparably linked yet with totally different functions. They are true double joints, and this is quite widely recognized today by anatomists who have devoted serious study to the problem. What are spoken of as the lower compartment and the upper compartment are in reality two joints, held together by a single capsule. Much of the past confusion undoubtedly has arisen from the fact that, although they are separate, distinct joints, in function they always act simultaneously. In functional action, the individual cannot move one compartment of a joint without moving the other. The important fact is that he can and does use them in an infinite variety of combinations. When we consider the fact that he has two temporomandibular joints, linked inseparably by bone, which must always move together, so that in reality he has four joints all moving at once in various combinations, it does appear hopelessly complicated.

If we can forget the mental hazards engendered by these apparent complexities, and break the problem down into its component parts, it becomes amazingly simple. The so-called lower compartment or lower joint is the joint of the condyle on the meniscus. It is a complete joint in itself, with its own synovial membrane and fluid. Within any possible functional range of tooth contact, the condyle rotates on the meniscus around the axial (not axle!) center. It possesses all the anatomic characteristics of a pressure-bearing joint. The meniscus, which forms the socket, is a dense fibrocartilage. The socket area upon which the condyle rotates is devoid of blood vessels and nerves.

urrounding this pressure-bearing area is a upply of blood vessels and nerves, which ourish the disk and show that the condyle ; designed to rotate, but not to glide upon it. n passing, we might note the fact that it is ıe forced movement of the condyle on the ıeniscus, caused by improperly related usps, which impinges on the nerves and reates joint pains.

The upper compartment of the joint is ɔrmed by the meniscus on the glenoid fossa. t also is a complete joint in itself, but is ɔtally different from the lower compartment. Iere the action is solely the gliding of the ıeniscus. Since the condyle must remain in osition on the pressure-bearing area of the neniscus, as the meniscus glides on the fossa he whole lower joint moves as a unit on he fossa. So the temporomandibular joint is omparable with any ball-and-socket joint, xcept that the whole ball and socket can e moved to various positions in the glenoid ossa to bring the teeth into changing conact. The upper teeth are in constant fixed elation with the upper joint, the lower teeth n constant fixed relation with the lower ɔint. Thus, the relation of the upper and he lower teeth to each other must be deternined by the relation of these two joints to ach other.

As already pointed out, these two joints lways move simultaneously. As the condyle otates on the meniscus, the meniscus glides n the fossa. But they can be moved in an nfinite variety of combinations. Various roations in the lower joint can be combined vith various gliding paths in the upper comartment to produce an endless variety of aths of the mandible. It is probably this act which has caused so much confusion in he attempts to study this joint. Small wonder hat superficially it would appear hopelessly omplicated! This wide variety of paths is kewise the reason why it is hopelessly imractical to use the mouth as an articulator. Iowever, if we do but two things—locate the pening-closing axis of rotation of the conyle and reproduce the paths which it follows—then we can recombine them to reproduce every path of motion of which the mandible is capable.

## AXES OF MOVEMENT

It is evident that we must locate this opening-closing axis of the condyle before we can trace its path. The vertical-sagittal component of mandibular movements takes place around a horizontal axis known as the hinge axis. The horizontal-sagittal component of mandibular movement is around a vertical axis (center of rotation) which intersects the hinge axis in the condyle. It is not at some imaginary place behind the condyle. The vertical-horizontal component of mandibular movement is around a sagittal axis which intersects the hinge axis at the same point as the vertical axis does.

Since the mandible is capable of being rotated in three planes simultaneously, the point of intersection of these three axes is the center of the rotary movements of the mandible during function. This center of rotation moves during function and, as we will see later, one of the requirements in "transferring the patient to an articulator" is to locate this center and record its possible paths of motion during function. Because the mandible makes both right and left lateral excursions, which are three-dimensional, there are two centers of rotation, one in each condyle. Connecting the point centers in the two condyles by an imaginary line creates the hinge axis of the mandible and locates the center of rotary motion of the mandible in the sagittal plane. Since the hinge axis is located in the mandible, the hinge axis goes wherever the mandible goes and is the center of the rotary component of the arc of closure around which the mandibular cusps are moving when they meet the maxillary cusps in every tooth-contacting position of the mandible.

The center of rotation is the point around which the working condyle rotates in lateral excursion. It is the relation of the cusps to the center of rotation which enables them to

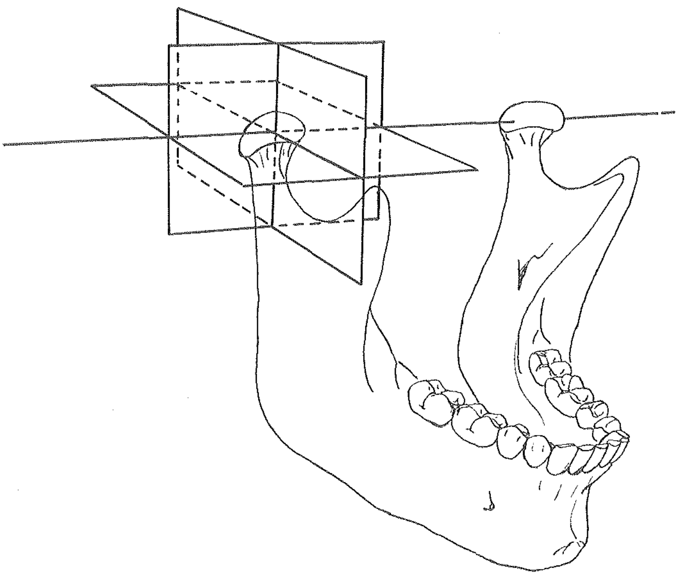


FIG. 1. The condyle can rotate in 3 planes simultaneously.

travel around each other in a circular path so that, as they pass, their contacts do not create lateral stresses. The center of rotation travels with the mandible and is the center about which horizontal motion takes place in every movement of the mandible, including every level of mandibular hinge opening. The Bennett movement is the path of travel of the center of rotation across the glenoid fossa, as the condyle is rotating while it is gliding across the fossa. In other words, as the condyle and the meniscus on the balancing side return along its path to its starting point, the working condyle is gliding across its fossa, likewise returning to its starting point. This path of the working condyle is the Bennett movement. It has nothing to do with the opening or the closing of the mandible, since they are brought about by rotary motion in the lower ball-and-socket compartment while the Bennett movement occurs in the upper gliding compartment. Thus, the center of rotation can follow the same path across the fossa at any mandible opening, with or without tooth contact.

The Bennett movement is a bodily side-shift of the mandible, accompanied by rotation of the working condyle, as the balancing condyle moves down, forward and inward. The chewing stroke is a return path, with the teeth closing in lateral and returning to and through centric. As a result of this side-shift, the path of the balancing condyle is different than when it is straight protrusive. The balancing path is usually, though not necessarily, steeper than the protrusive path. The difference in these paths requires a "broken axis" on the articulator. A broken axis is necessary because the movement of the center of rotation usually is not in the direction of a straight projection of the hinge axis during lateral excursions.

The difference between these paths, coupled with the side-shift, constitutes the path of the Bennett movement. The amount of the Bennett movement—that is, how far to the side it shifts—is likewise a determining factor.

Most important is the timing of the Bennett movement, that is, the rapidity of the side-shift with relation to the backward or the return movement of the balancing condyle. The effect on the teeth of a given path and amount of Bennett movement will depend upon whether the side-shift occurred close to centric or required the full lateral excursion to complete it. Usually the Bennett movement occurs rather rapidly, close to centric, during the lateral excursion. But, in any case, the Bennett movement cannot be

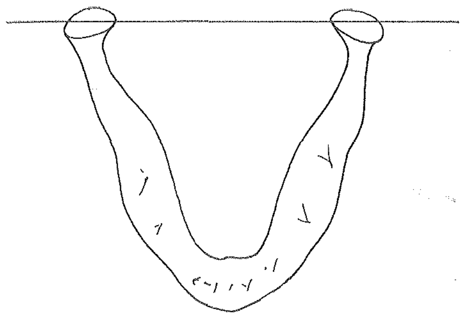


FIG. 2. Connecting the centers forms the hinge axis.

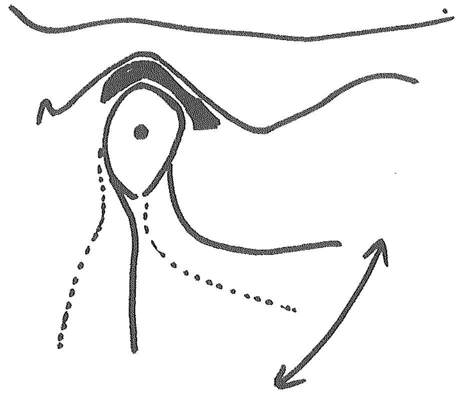


FIG. 3. The hinge axis is the center of the closing rotation.

considered only with relation to the path of the working condyle. It must be related to the paths and the timing of both condyles.

## PATHS OF MOTION

As the working condyle rotates and glides across the fossa, the mandible is passing simultaneously through three planes. To accomplish this, as Hjortso has shown in his film on this joint, the condyle must be rotating around three axes at right angles to each other. Because this is a simultaneous action, these three axes (shown in Fig. 1) must coincide at a point center. As shown in Figure 2, connecting these two centers—one in the right condyle for right lateral movements and one in the left condyle for left lateral move-

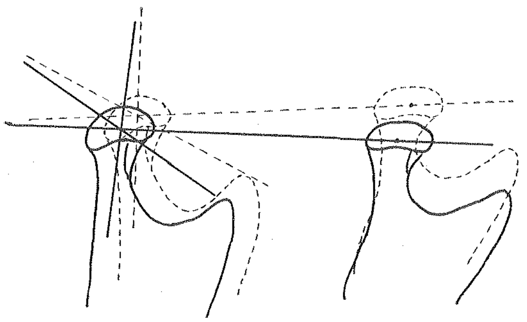


FIG. 4. The hinge axis in lateral excursion.

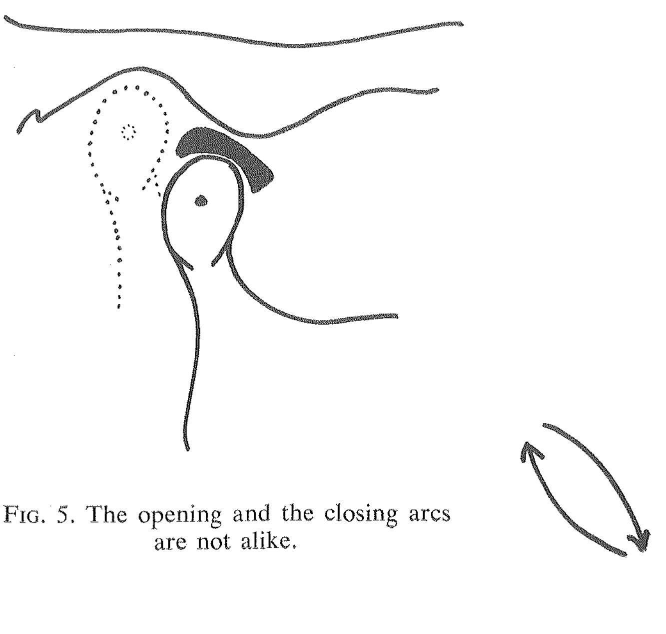


FIG. 5. The opening and the closing arcs are not alike.

ments—with an imaginary line forms the hinge axis of the mandible. Closing rotation to tooth contact (Fig. 3) takes place around this axis. The action takes place by rotation of the condyle on the meniscus. The condyle and the meniscus are joined by the capsular ligament and are moved simultaneously by the external pterygoid muscle. So, wherever the mandible moves the axis moves with it (Fig. 4) and is the center of the arc of closure in every tooth-contacting position of the mandible.

This rotary closing action is always combined with gliding of the meniscus. As the condyle is rotating the meniscus is gliding (Fig. 5), so that the resultant path of the mandible is a parabolic curve. These combined two actions produce an axis at the angle of the mandible. This is the axis upon which Monson based his repositioning of the mandible. This combination is always different in any two successive openings, so that Monson's axis changes with each opening. It is not a fixed, locatable axis. More important, the closing path is not the same as the opening path. On closure, the action is reversed. This is what produces the classic "tear drop" pattern of the chewing cycle. On the return stroke, the axis would be at some imaginary position in space above the skull.

These paths are not successively alike because the human mandible does not have a single fixed path of motion. Varying amounts of rotation can be combined with various paths of the meniscus. Rotation with relatively little lateral movement of the condyle would result in a path with more vertical component. Lesser rotation with more lateral movement would result in a more nearly horizontal path. This great variety of irregular paths, resulting from various combinations, creates the need for cusps on teeth which will be harmonious for any combination without inflicting injury.

The lower teeth embedded in the mandible are in constant fixed relation with the lower joint with its hinge axis. The upper teeth and the glenoid fossa, which control the paths of the meniscus, are fixed in the skull. Thus,

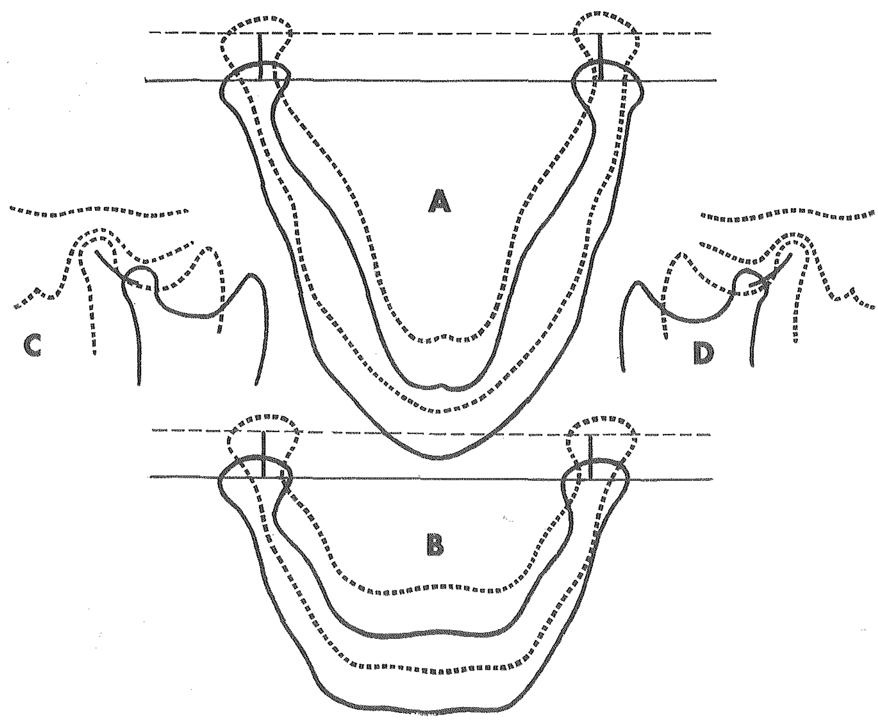



FIG. 6. The protrusive path of the hinge axis.

the relation of the upper and the lower teeth to each other in any position of the mandible is determined by the relation of these two compartments of the joint to each other.

Positions of the mandible which bring about these changing tooth contacts, as the condyle rotates to closure on the axis, result from three basic paths of the condyles. In a simple protrusive path, as seen in Figure 6, viewed from above at "A," both condyles move forward. Seen from in front at "B," they also move downward, because, as seen at "C" and at "D" in the sagittal plane, the slope of the eminentia carries the condyles down a curved path over the tubercular eminence. This protrusive path has resulted in changing positions of the hinge axis, as shown by the dotted lines.

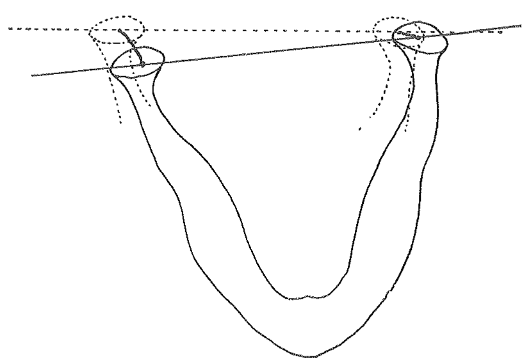


FIG. 7. In lateral excursion the working condyle moves out.

## LATERAL PATHS

In lateral excursion, one condyle, referred to as the working condyle because this is the chewing side, is rotating, while the other, the balancing condyle, again moves forward and down. The working condyle, as shown in Figure 7, is not only rotating; it is also gliding across the fossa in a different path. This lateral path of the working condyle is the Bennett movement. We must remember that what Bennett observed was this combined action of rotation and translation. Like the opening path, this is a combined action which, for any given stroke, would result in a center located somewhere in the skull behind the condyle. But, as with the opening action, it is different for each lateral movement, de-

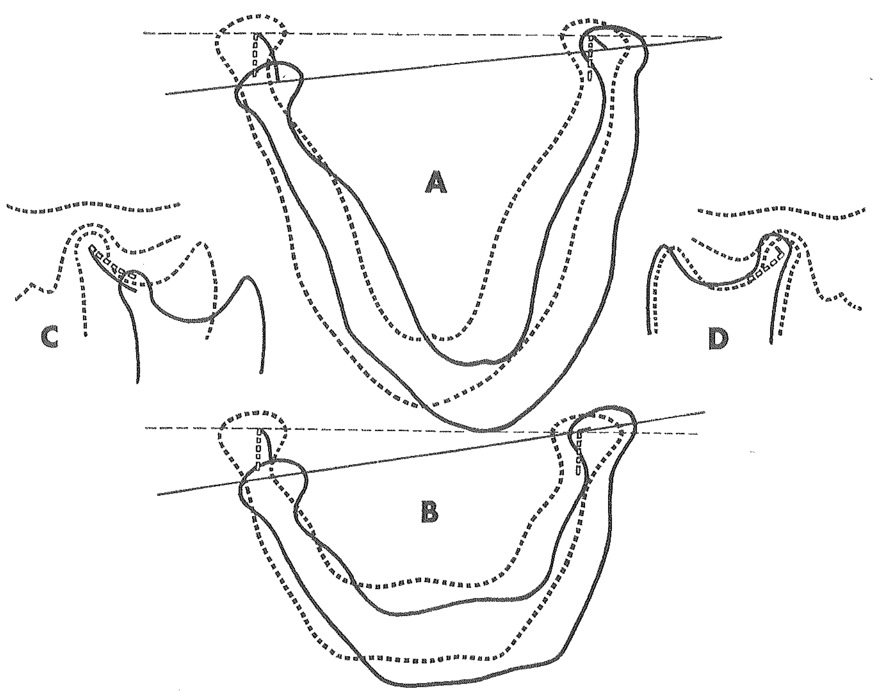



FIG. 8. Lateral paths of the hinge axis.

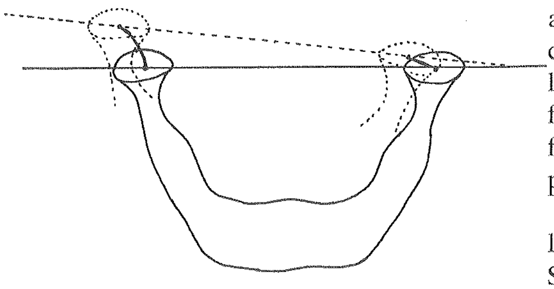


FIG. 9. The balancing path of the condyle is usually steeper.

pending upon the degree of rotation and the amount of translation. As before, it is merely a changing relation of the two compartments, and, as before, it can be reproduced by locating the center of rotation and the path which it follows. Technically this would be referred to as a part of the condyle path, but it is convenient to express it in separate terms as the Bennett movement since it has a different result on the form and the relation of the occlusal surfaces of the teeth. This Bennett movement enables the cusps to pass between and around each other without bumping and colliding. As the working condyle moves laterally, the balancing condyle, as it comes forward, must also move inward along a different path from the one that it followed in protrusive excursion.

As seen in Figure 8, the hinge axis now follows different paths than it did in protrusive. Seen from above at "A," on the working side the axis has moved laterally and has rotated at the same time. On the balancing side, it has come forward and medially. However, as seen from in front at "B," when the working condyle moves laterally it usually does not move straight out on the line of the axis in centric. As it moves out, it also may go up or down. As a result, the balancing condyle, viewed in the sagittal plane at "C," follows a different path than it did in protrusive. This difference results from the Bennett movement. Usually, although not invariably, as seen in Figure 9 from in front, this balancing path is a somewhat steeper path of similar curvature. The amount of the Bennett move-

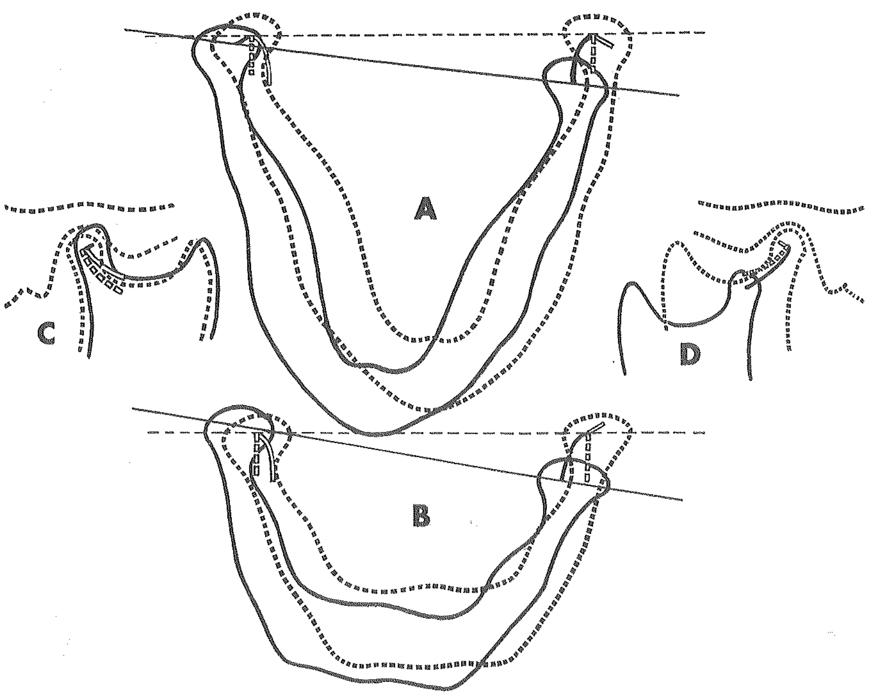



FIG. 10. The paths of the hinge axis are not the same in the other lateral excursions.

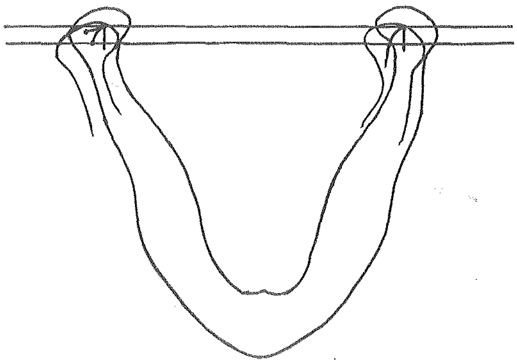


FIG. 11. An intermediate lateral protrusive.

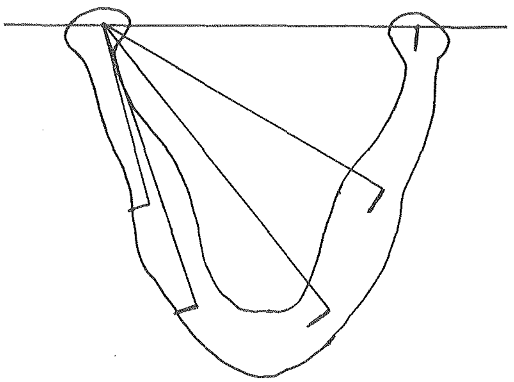


FIG. 12. The paths of the cusps around the center of rotation.

ment is limited by the ligaments and the inner wall of the glenoid fossa on the balancing side.

When the action is reversed, the other side becomes the working condyle. The actions are similar, but the paths are always different. The two sides are never symmetrical, nor are the paths ever identical. Figure 10 shows all these paths from centric. At "A,"

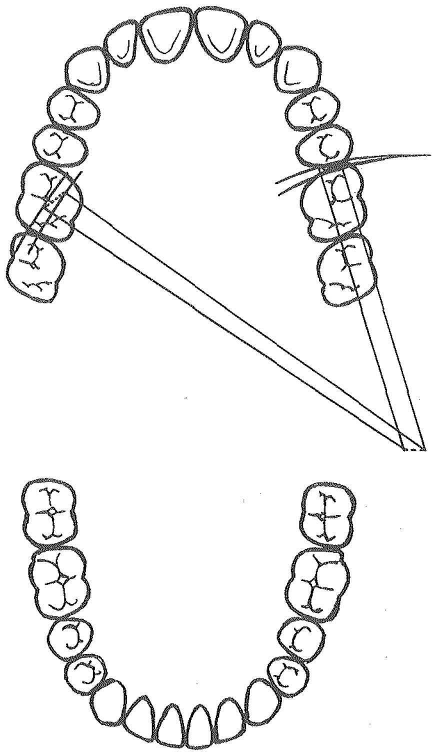


FIG. 13. The Bennett movement changes the center of rotation.

from above, the condyle which was the balancing side in the previous illustration, has now become the working condyle. As it moved laterally, it followed a different path than the other condyle did when it was working. As it moves laterally, it may also go back or forward. At "B," from in front, this results in a different vertical path of the mandible. Likewise, at "D," in the sagittal section, this results in a balancing path different from that on the other side.

To recapitulate, every path of the mandible results from combining these three basic

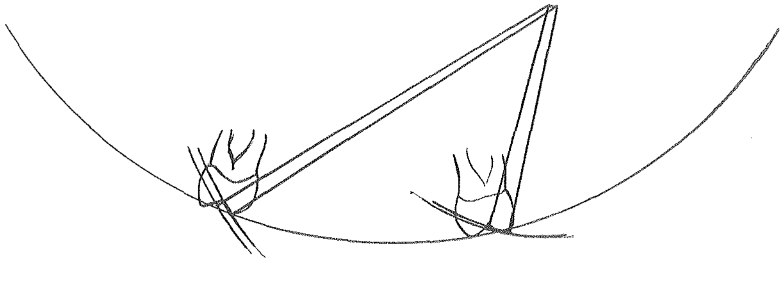


FIG. 14. The vertical effect of the Bennett movement.

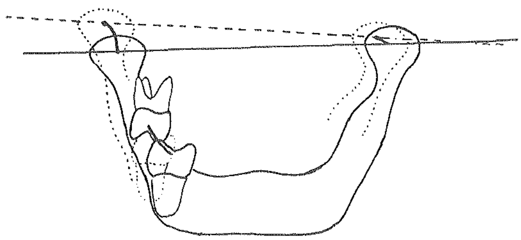


FIG. 15. Relation of the balancing path to the cusps.

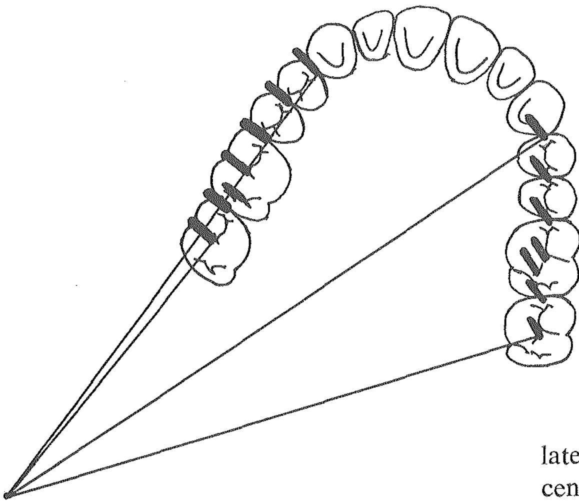


FIG. 16. The paths of motion of the lower cusps on the upper teeth.

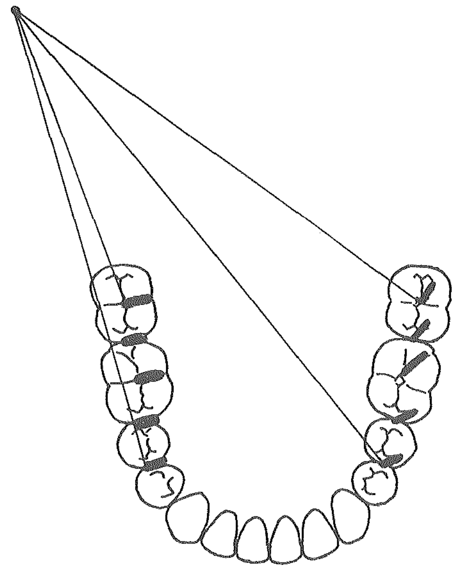


FIG. 17. The paths of motion of the upper cusps on the lower teeth.

paths of each condyle with the varying degrees of rotation in the lower compartment. Extreme lateral protrusive is a path intermediate between an extreme lateral excursion and a pure protrusive path. Any lateral protrusive would result from both condyles moving forward (as shown in Fig. 11) and at the same time shifting to one side in a full Bennett movement.

## PATHS OF THE TEETH

The horizontal paths of the cusps, as the working condyle rotates, are seen in Figure 12. On the working side the cusps travel buccolingually; on the balancing side the upper lingual cusps pass distolingually (Chap. 16). In order to pass without colliding (Fig. 13), they must be properly related to the position and the path of the center of rotation in the Bennett movement. Simple rotation, as shown by the center of rotation in its medial position, would result in a path from that center. Rotation in the extreme Bennett movement would result in a path from the center in its extreme lateral position. The cusp must be able to follow the path shown by the dotted line, which results from the movement of this center.

The vertical relation of the Bennett movement is shown in Figure 14. The slope of the cusps must be such that they do not ride up on each other. The lines of travel shown on the working side are the sides of the cusps as they pass each other. When this now becomes the balancing side (Fig. 15), the balancing cusps, rotating around the working condyle as the balancing condyle moves down and forward, travel around each other.

The horizontal path of the lower cusps (Fig. 16) shows how they pass between and around each other. On the working side, the tips of the lower buccal cusps glide across the marginal ridges and through the sulci of the upper teeth. On the balancing side, the inner slope of the lower buccal cusps slides past the inner slope of the upper lingual cusps. Meanwhile (Fig. 17), on the working side, the upper lingual cusps pass across the marginal ridges and the sulci between the lower lingual cusps.

It is the co-ordination of these paths of motion of the teeth with the paths of motion of the joints which determines whether the teeth are physiologic remedies or pathologic foreign bodies. This is discussed in further detail in Chapter 16 on Articulation of the Teeth and Chapter 17 on carving.

## PRACTICAL SIGNIFICANCE

The practical significance of all this lies in its application to the use of an articulator as a prosthetic tool. It possesses no magic powers to do anything for anybody. It is devoid of blood supply and muscles. It is as good a tool as the knowledge and the skill of the operator, and no articulator automatically will create the functional tooth contact of the patient merely by having models mounted in it by any method, hinge axis or no hinge axis. We cannot deal with one compartment of the joint and ignore the other. Because failure to obtain a correct centric bite must lead to complete failure, no matter what else is done, many have come to believe that a good centric bite is all that is needed. It is quite true that the results of a good centric bite can be quite breath-taking compared wtih the hopeless results without it, and it is an absolute essential to real treatment, but it does not follow that it alone is adequate.

The object of any articulator mounting is to establish on a mechanical instrument the same relation of the teeth to its axes that the teeth in the mouth occupy to the axes of the condyles. Since the condyles and the axes are part of the mandible, the axes and the condyles of the articulator must be part of the lower bow. The Bennett movement is the path of the axis or the center of rotation of the working condyle as it is rotating while its meniscus glides across the fossa. It is the power movement of tooth contact, and the center of rotation is likewise in the condyle. Thus, the intercondylar distance must be adjusted to reproduce the relation of the centers of rotation to the mandibular teeth so that they can pass without colliding.

The paths of the meniscus on the glenoid fossa are constant to the upper teeth regardless of the position or the opening of the mandible. The object of any articulator setting or adjustment is to reproduce on a mechanical instrument the paths of motion of the axes of the patient. So the condyle paths must be an integral part of the upper bow of an articulator. These paths must be adjustable to reproduce the angle, the curvature and the lateral paths of the glenoid fossa, which are never alike in any respect on the two sides. They must, of course, be adjustable to the intercondylar distance and to the Bennett movement of the mandible.

Such a genuine anatomic joint articulator can reproduce every contacting position of the teeth and guide the cusp forms and relations that are necessary to maintain stability of the teeth, be they periodontally involved natural teeth or a full artificial substitute. With working models made from a single impression accurately mounted on such an articulator, which will reproduce the actual anatomic relations, the operator, figuratively speaking, can put the patient on the laboratory bench. Then he can delegate to the technician a major part of the work so tediously and unnecessarily performed at the chair. The economy, and the time and the energy conserved by the intelligent employment of a genuinely anatomic articulator far, far outweigh the relatively insignificant time and energy required to master its use. It can make true rehabilitation a routine dental practice.

*Chapter* 3

# Biomechanics

Dentistry in general (and periodontia in particular) today stands acutely in need of a practical, rational philosophy based upon a biologic concept of the whole mouth, a biomechanical basis for dental practice. This is not some abstract academic problem, but a practical one that a dentist must solve if he would avoid confusion and failure.

Philosophy should comprise an understanding of the causes leading to any given effect. We are not concerned here with the technic for performing any given operation, but rather with what operations are required to make dentistry a healing profession. We seek an understanding of the relation between the mechanical procedures of dentistry and the biologic phenomena occurring in the tissues of the jaws, to the end that the dentist may in a very real sense be a physician to the mouth rather than a repairman dealing with a lot of static, unrelated pieces of inert matter.

The lack of such a philosophy is the most acute, far-reaching defect in dental practice today. It casts its lengthening shadow over the entire future of dental practice, colors all the future planning for dentistry and tinges our relations with allied professions. Because of its lack, dental thinking wanders aimlessly from one technic to another, from one material to another, in an endless search for a cure-all, without ever visualizing the real problem. Technic and materials are the tools of dentistry: they are useful only as a means of fulfilling our biologic objectives.

Scientific discussions and research in dentistry concern themselves very largely with dental caries. Clinics and papers on restorative dentistry concern themselves largely with the problems associated with the "fit" of dental appliances and with caries. Dentists in actual practice think and act largely in terms of fit, and, from the standpoint of preventing loss of teeth from caries and from lack of fit, our knowledge today is adequate. If the problem of maintaining healthy mouths were simply a question of dealing with dental caries and proper-fitting replacements, we could prevent the loss of most teeth that are affected by these factors alone. Failures in this respect are due largely to carelessness or to the operator's not using the knowledge we have. If, tomorrow, we were suddenly to discover the cause of and how to prevent dental caries, we would still have to deal with diseased mouths and loss of teeth, but the majority of dentists would not know what to do.

The fact remains that, even with dental caries as widespread as it is today, more teeth are lost from periodontal disease than from caries. Therefore, it is readily apparent that the real problem of the practicing dentist is not dental caries, but the preservation of the supporting structures to prevent the inroads of periodontal disease. And those measures which, taken in time, could prevent the breakdown are the same measures which the periodontist must take if he would bring about the cure of a sick mouth so that nature's own metabolic processes can maintain that mouth in a state of health.

Fundamentally, of course, we are dependent upon nature's metabolic processes to maintain the health of the mouth. But there is a direct and definite relation between the mechanical procedures of dentistry and the metabolic activity of the adjacent structures. So, first, let us try to view dentistry as the treatment of a dynamic, living mouth.

Bacteria are not the cause of periodontal disease. If they were, all of us would be sick all the time. Bacteria produce the symptoms

: various diseases. In the mouth, they pro-
ıce the symptoms which we call periodontal .sease. By symptomatic treatment, the imination of the local irritating factors, the se of various antibacterial measures, and hysical therapy with the toothbrush and milar devices, we can produce the appear-
ıce of health in the tissues. But the loss of one and the formation of a pocket were hat brought about the local irritating fac-
ırs. Unless we deal with the original causes ır the formation of the pocket, even though e combat the symptoms of infection and ıaintain the appearance of health, the teeth ill be lost. That is what we mean by treat-
ıent of the whole mouth.

## METABOLIC ASPECTS

Fundamentally, the health of any tissue epends upon the ability of the nerve and ıe blood supply to fill its metabolic require-
ıents. But here is the important corollary: ıe metabolic requirements of any tissue are etermined by its functional demands. Therein es the crux of our functional problem. 'he ability of the body to maintain any tissue ı a state of health is related to function. Iere is the answer to occupational disease nd physical therapy, and the basic reason ır the existence of any specialty of medicine. : is the peculiarities of the functional prob-
ıms of dentistry which set it apart from the ther specialties.

The relation between metabolic ability and ıetabolic demands is a factor in the course f disease. If the functional demands are ı excess of the metabolic level, tissue disease ıay follow. That is the kernel of the func-
onal aspects of the dental problem. That ; the basis of various occupational diseases, nd, in a very real sense, dental disease is n occupational disease. When a large num-
er of people are engaged in an occupation 'hich requires constant use of some part of ıe body, some of those people will develop, ı varying degrees, an occupational disease 'hich is peculiar to that trade. The reason, f course, is that the metabolic requirement created by the functional demands upon that particular part is beyond the metabolic ability of some of the people concerned. The varying degrees of metabolic deficiency determine the varying degrees of the occupational disease. The changes in metabolic activity that come with age determine how long the functional demand can be maintained without disease. For the same reason that not all people engaged in the same occupation develop the same occupational disease, not all mouths in the same function develop the same periodontal disturbances.

This provides us with an explanation for many puzzling things that we have all seen: Some mouths in very bad malfunction do not break down while others with much less malfunction break down badly; the most careful tooth-grinding in the world can never be wholly successful, yet various methods produce varying results; dietary treatment has varying results; there are many hazy systemic factors; fairly simple restorations of function sometimes produce favorable results; we obtain varying results with even the best function; the effects of bruxism are variable.

Every dentist knows that a very important determining factor is the amount of bone that is left around the tooth. Have you ever stopped to wonder exactly why that is true? If it is not a problem of function, then what difference could the amount of bone make? There is no other possible explanation: whether we realize it or not, it has been firmly established that the problem of maintaining healthy supporting structures requires a consideration of function. In the sense that it is related to the metabolic problem, the man who seeks relief in external factors is partly correct, but that should be kept in its proper perspective as a means of treatment.

Theoretically, there are three courses open to us. We might use any one or all three. First, we might invade the field of endocrinology and try to produce a more favorable balance in metabolism. There are many reasons why that is too dangerous a course to consider as a routine practical measure.

Second, we could try to build up the metabolic constituents of the blood. That is perfectly practical, within the limits of our present knowledge of what those factors are. Indeed, we must give it all possible consideration. Obviously, anything which affects the health of the entire body will be reflected in the mouth. We cannot deal with dental problems as though they were entirely separated from the general health. But, by that same token, the metabolic constituents of the blood enter into our consideration only to the extent that they influence all the tissues. The degree of success that we can attain by building them up is limited by the amount that metabolic ability falls below functional demands. And they would be useful to us only to the extent that they are required for the health of the whole body. But what about the vast majority of people whose metabolism is just not equal to the excessive functional demands of the mouth? Here we can get into an endless discussion about what we conceive to be health, or if there is such a thing as a perfectly healthy person, which is very likely to throw a smoke screen over the whole picture. If we can look through to the heart of the problem we can see that we have but one logical approach: our constant aim, the basic consideration upon which all our technical procedures must be predicated, must be to create and maintain the best possible function. We know that the more perfect the function, the less the metabolic requirement. In spite of our best efforts, the metabolic ability is bound to fall as a person ages. But the more perfect the function, the lower it can fall and the longer it will be before functional demands exceed metabolism.

There is much more that could be said on this subject, particularly with regard to the relation of functional disease, to growth physiology, maintenance physiology, age changes, psychosomatics and a host of other aspects. We have only scratched the surface. We are only attempting to show that there is a connecting link between the mechanical procedures of dentistry and the health of the supporting structures. But that does not answer our problem. On the contrary, it only shows us why it is so important that we learn the correct answer to the real problem: What is the most perfect function? If we can recognize the fact that the health of the mouth is directly related to the function of the mouth, that the better the function, the longer metabolism can maintain it, then surely we must see that our real dental problem does not lie in the field of medicine, but rather in the mechanics of function. We must first understand what is theoretically perfect function and then make our compromise approach as close to that as possible within the physical limitations imposed upon us, in the hope that nature's metabolic processes will provide the necessary tolerance.

## ORAL PHYSIOLOGY

The most difficult problem that we face in any discussion of dentistry as treatment for a sick mouth is the lack of a general concept, by dentists as a group, of the relation of oral physiology and anatomy to our actual practices. Anatomy is usually shrugged off as something we learn in college and then promptly forget. Besides, what in the world has it to do with patching holes and bridging spaces? Frequently we hear from the lecture platform high-sounding phrases about the physiologic factors of the mouth. The speech is always above us, but we all derive a glow of satisfaction and pat ourselves upon the back because we are members of a learned healing profession. But when Mrs. Jones comes into the office as a patient, we forget all about it, for it has no practical application to our routine daily work.

Anatomy is the dynamic form and the relation of parts which make physiology possible. These two must always be considered in their inseparable relation to each other and to the practical problems of routine daily practice.

Unfortunately, not only do dentists generally not possess the know-how of oral physiology, but most of them do not even understand what we mean by the term. When dentists speak of biologic factors, they generally start talking in terms of the general emistry of the body as it applies to all the aling arts. They think about such things as ɔod counts, urinalyses, calcium metabolism d similar medical problems. It is quite true at all these factors can and do exert an in-ence upon the health of the mouth, par-ularly with regard to diet and avitaminosis. We cannot ignore these factors. The mouth a part of the body and, obviously, any-ing which affects the health of the whole ganism will be reflected in the mouth. that same token, the degree to which ose factors can enter into the health of the outh is subject to the same influences that termine how much they will affect any her organ of the body. And that is where r problem differs from the general medical oblem: there begins the biologic problem ich is peculiar to the practice of dentistry. ose dentists who merely try to ape the ysician with drugs and diets and vitamins n never bring about a permanently success-l result, because these things are not ough. The degree to which these can help determined by the physiology of the mouth. is the relation between these factors and e mechanics of tissue pathology which con-itutes our routine daily dental problem.

Our ability to save teeth that under less illful treatment would have been lost has sulted in the anomalous condition that in alarmingly large percentage of cases we e actually doing the mouth more harm than ɔod. For what we are doing is preserving ɔmfortably diseased teeth, which are a slow, sidious menace to the health of the patient. ideed, so accustomed have we become to iversally diseased mouths, and so little do e know about them, that, like the common ɔld, they have become a part of our daily ves. Not until pathology has become gross d the disease well-nigh beyond hope does e dentist give it serious consideration. One the strange reasons for this lies in the fact at dentists themselves do not genuinely ap-eciate the importance of the mouth as a tal organ of a healthy body. We pay lip rvice to it, but deep down in our hearts we e not truly conscious of it in our daily ork.

Broadly speaking, with respect to the part that teeth play in mouth function, we have two opposing schools of thought. On the one side we have those who believe that the teeth themselves rule the entire organ and, at the other extreme, those who believe that they exercise no control. I personally believe that the teeth are simply a harmonious part of the machine, working in conjunction with it as equal partners in a co-operative enterprise. They are neither the masters nor the servants of the temporomandibular joint; they share equal responsibility and equal control. In short, we cannot put whatever teeth we like into a mouth and expect that mouth to adapt itself to them, but neither can we neglect to create tooth forms which will exercise the measure of control in function that is neces-sary to the proper co-ordination of all these parts. The teeth must all share this control equally and in complete harmony with each other as well as with the rest of the organ.

The functional forces involved in chew-ing with cusps are the biologic factors which are peculiar to the practice of dentistry, which set it apart from the other specialties of medicine. They are true biologic factors because they constitute the functional de-mand which determines the metabolic level required to maintain the tissues of the mouth. They determine whether dental treatment is a restorative remedy or a foreign body to be thrown off; whether or not our mechanical devices are biologically sound.

## BIOMECHANICAL PROBLEM

Our problem then is biomechanical. Den-tal treatment by its very nature must be mechanical, but that does not mean that it cannot be biologic. The surgeon, the oculist, the physical therapist all employ mechanical means, but always with the biologic objective of restoring and maintaining function. The problem we face is much more intricate than theirs. All mechanical replacements must exert leverage of one type or another on their supporting and opposing structures. Since it is a fact that by the time treatment can be undertaken some degeneration usually has taken place, it is all the more important that

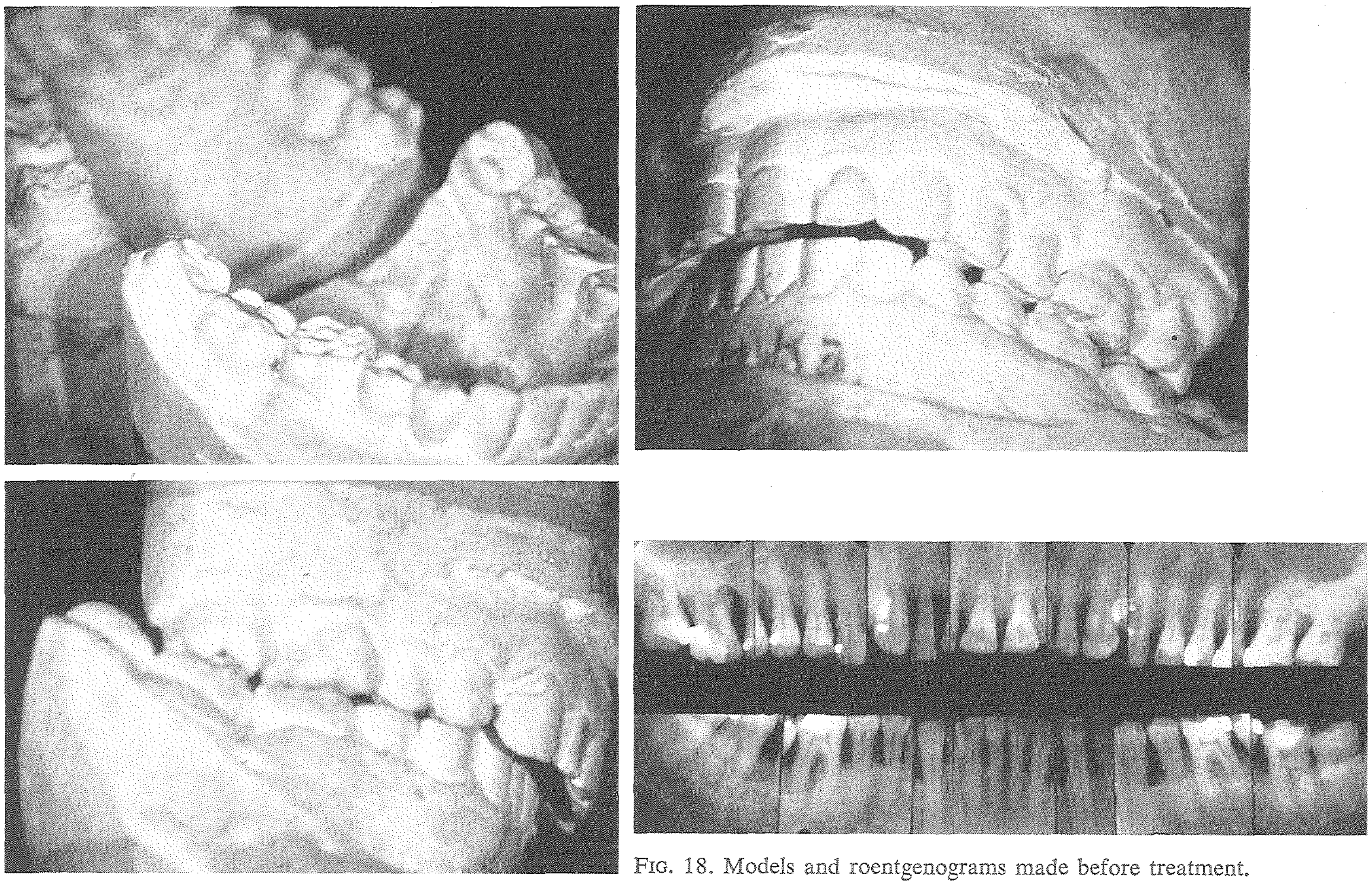


Fig. 18. Models and roentgenograms made before treatment.

FIG. 19. Restoration of the case shown in Figure 18.

replacements be in biologic harmony, so that nature's healing process can come to our aid. We may be able to correct deformities, to supply some of the things which nature has failed to supply, but we can never neglect the maintenance physiology of the body as the basic requirement of a healthy mouth. Here then must be our basis of dental practice, if we would create and maintain healthy functioning mouths and avoid the otherwise inevitable set of full artificial dentures. Whatever mechanical procedures are indicated in a particular mouth must always be predicated upon the maintenance physiology of the individual. In whatever oral treatment the diagnosis shows to be necessary—tooth repair or tooth replacement or tooth removal—we must be guided in our prescription by the mechanics of tissue function that are required to permit that maintenance physiology to operate. Unless the mechanics of tissue pathology receives adequate attention, the degenerative process will continue, with the ultimate loss of teeth, regardless of the local condition of the soft tissues.

For many years, discussions among dentists who have devoted serious study to the mouth have centered around the relation between form and function. On the one side, we hear arguments to prove that form creates function and, on the other side, equally logical arguments that form is the result of function. There is no means of knowing which is correct and, as a matter of fact, at the moment it is largely an academic question from a practical standpoint. All of them agree that there must exist a harmony between form and function, and one clinical fact is firmly established beyond the shadow of a doubt: for the natural metabolic processes of the body to be able to maintain a healthy mouth, the form of the teeth must harmonize with the functions of the mouth. With that knowledge, there is one short sentence to be memorized: "The practice of dentistry is the science of articulating teeth." When examining a patient, look at the whole mouth; look at the woods, not at the trees. When one sees rampant decay, and chronic gingivitis, and bone destruction, and loosening abutments, and dentures that will not stay put, and tender, sore teeth, and is told of obscure facial pains whose etiology does not seem clear, one should look first at the function of the whole mouth, not at the local condition. Gradually one will begin to get a different view of dentistry, a clear, over-all picture of dental practice, the cornerstone of which is: "The practice of dentistry is the science of articulating teeth."

## PRACTICAL RESULTS

That this can be a very real factor in treatment is illustrated by the roentgenograms and the models shown in Figure 18 (before treat-

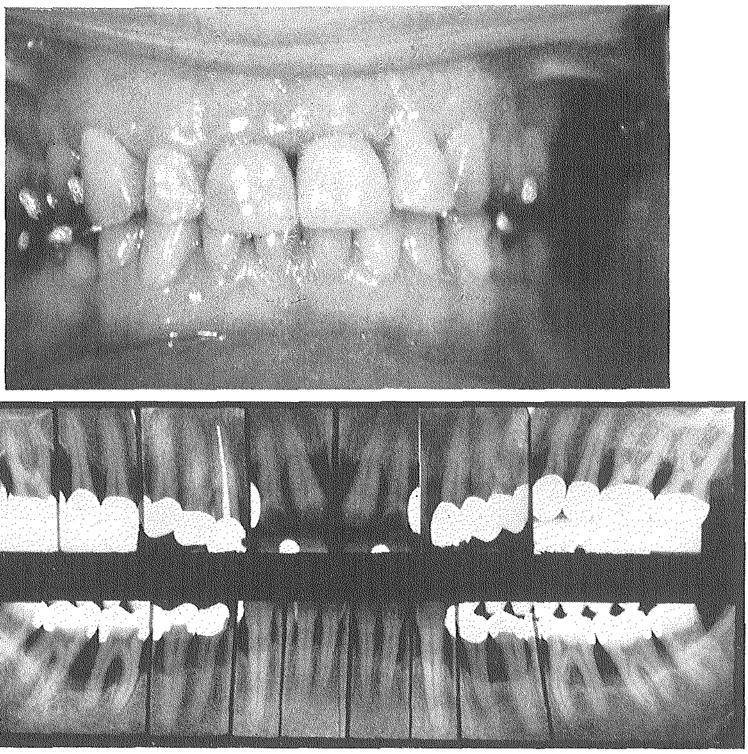


FIG. 20. Case shown in Figure 18 eight years after treatment.

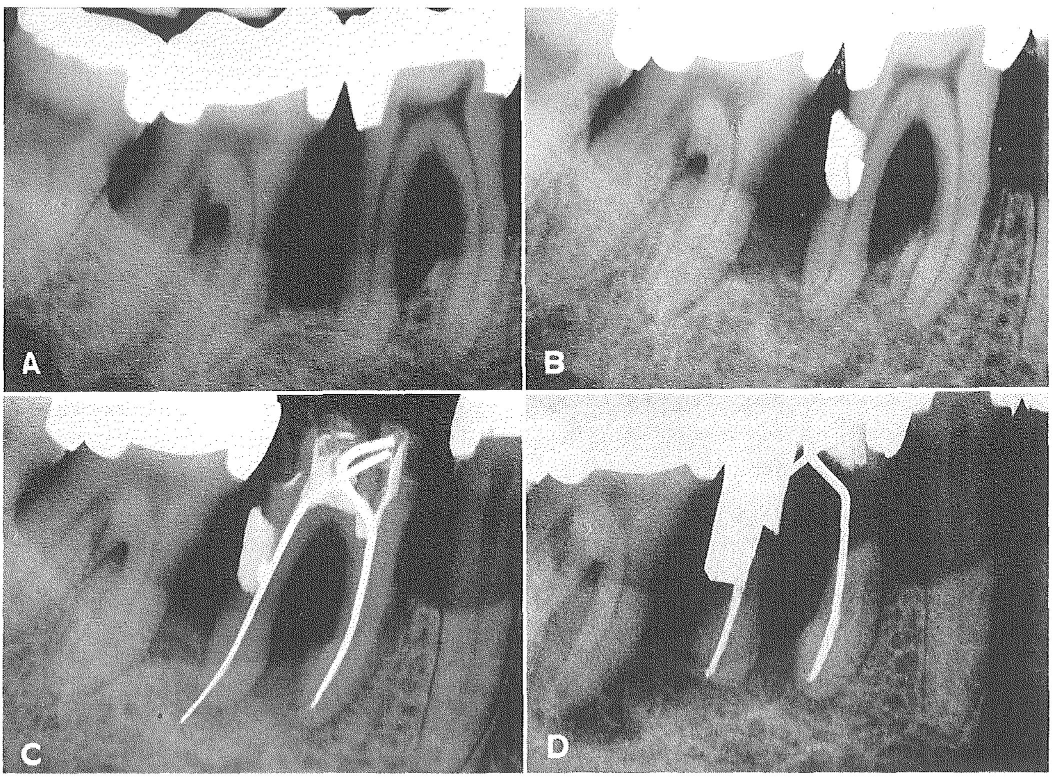



FIG. 21. Progress of the disease.

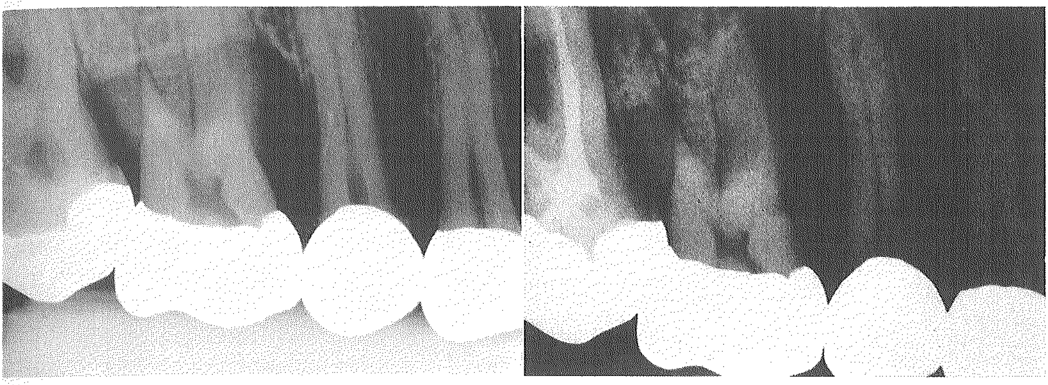
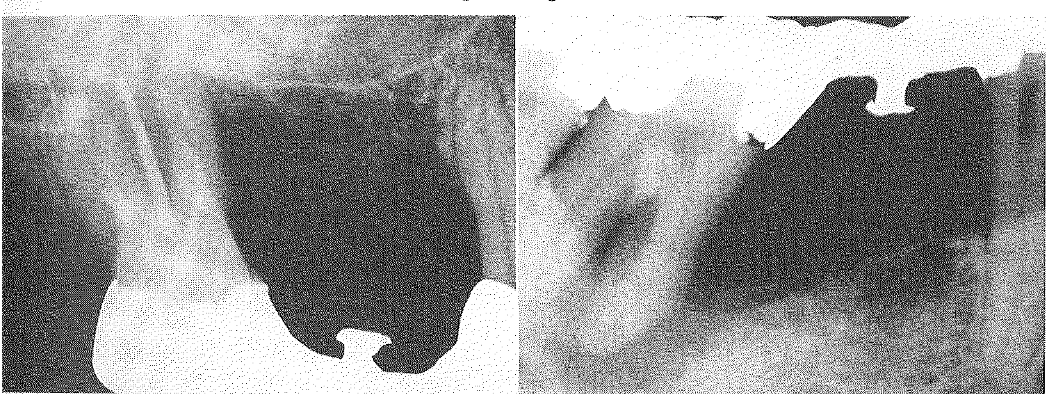


FIG. 22 (*Top*). Roentgenograms taken before and after stress.
FIG. 23 (*Bottom*). Fixed bridges using the same occlusal restorations.

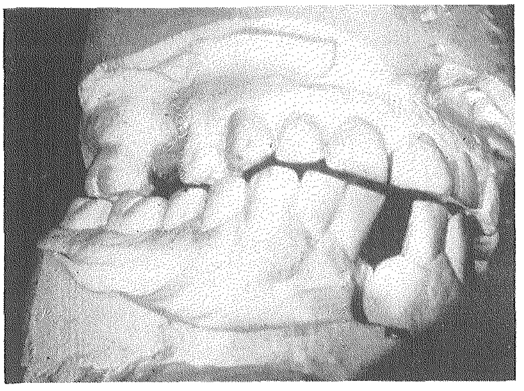


ıent). The case presents a severe perio-lontal problem with gross clinical symptoms. 3y a combination of rehabilitation and perio-lontal therapy, it was treated as shown by he models in Figure 19 (after treatment). he treatment was apparently highly success-ul, as shown by the roentgenograms in igure 20 (eight years after treatment). The one picture had improved, as evidenced by he lamina dura and the interseptal bone. Iome care and diet were both good.

Then, in 1956, there was a sudden and lramatic change in the clinical appearance. issues which for years had been firm and ıealthy became soft, spongy and bleeding. ockets opened and filled with debris. None f the habits of life had changed, yet there vas a radical gross change in the mouth. inally it was learned that the patient had een projected suddenly into a situation of reat emotional stress, which was a constant lay-and-night problem and caused much clenching and grinding of the teeth at night. The first evidence of damage appeared in the tooth least able to withstand stress, the lower left first molar. As shown in Figure 21 A, in January, 1957, there is evidence of slight resorption on the distal root. In 4 months it had progressed to the pulp (B) and the tooth required capping. This was not successful, so endodontic treatment was instituted 2 months later (C). A new restoration was placed, but 6 months later the tooth had decayed from the bifurcation up (D) and periodontally it and the second molar had deteriorated greatly.

Meanwhile, the upper left first molar had likewise undergone a rapid periodontal breakdown. The "before and after" roent-genograms are shown in Figure 22. The first molars were extracted and replaced by fixed bridges (Fig. 23), using the same occlusal surfaces.

As rapidly as it had come, the stress situ-



tional state leads to the conclusion that it was a factor, but a difficult one to evaluate in practice. There is no doubt that the emotional state influences the course of treatment. It is still too soon to tell whether or not the infrabony pocket on the second molar will fill in.

Evidence that this can occur is shown in Figure 24 (a case before treatment). In June, 1951, the patient presented for treatment. He had just lost several teeth from periodontal breakdown, and was about to

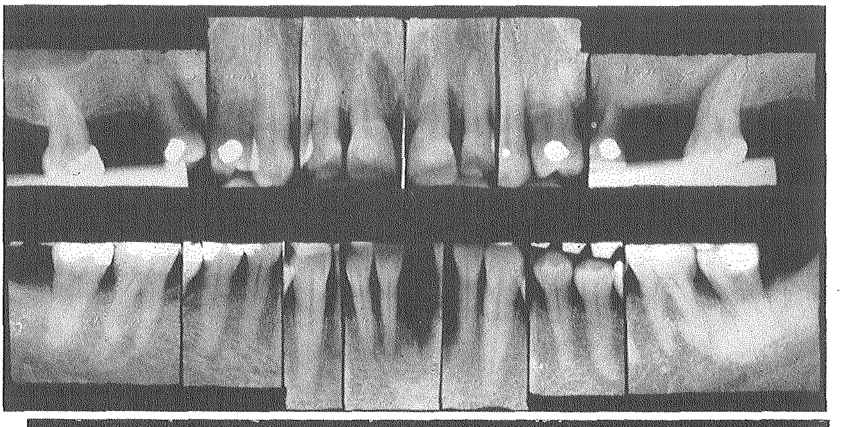


FIG. 24. Roentgenograms and models made before treatment.

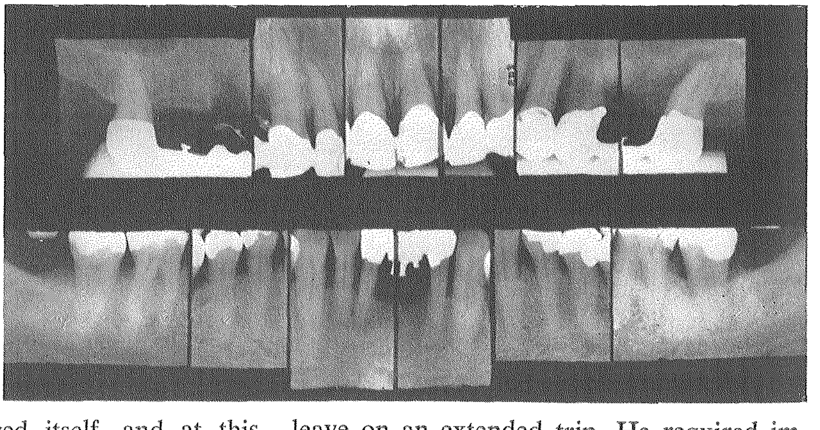


FIG. 25. Roentgenograms taken 1 year after flat periodontal splinting.

ation suddenly resolved itself, and at this writing the clinical and roentgenographic picture has returned to the *status quo* before the situation developed. The important point about this case is that, if treatment had been started during the period of stress, the results would have been influenced strongly by the functional demands placed on the teeth by the stress. The evidence that the case went up, then down, then up again with the emo-

leave on an extended trip. He required immediate temporary replacements. There was not time to follow the usual course in these cases, making registrations and carved, articulated temporaries. All the upper teeth and the lower posteriors were prepared and mounted on a plain-line articulator with a centric bite, to construct typical, flat, temporary periodontal splints. While these were being constructed in the laboratory, registra-

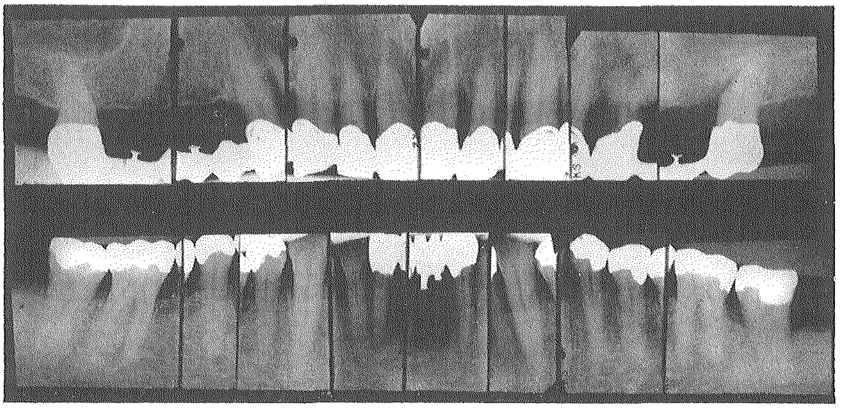


FIG. 26. Roentgenograms taken 16 months after articulated restoration.

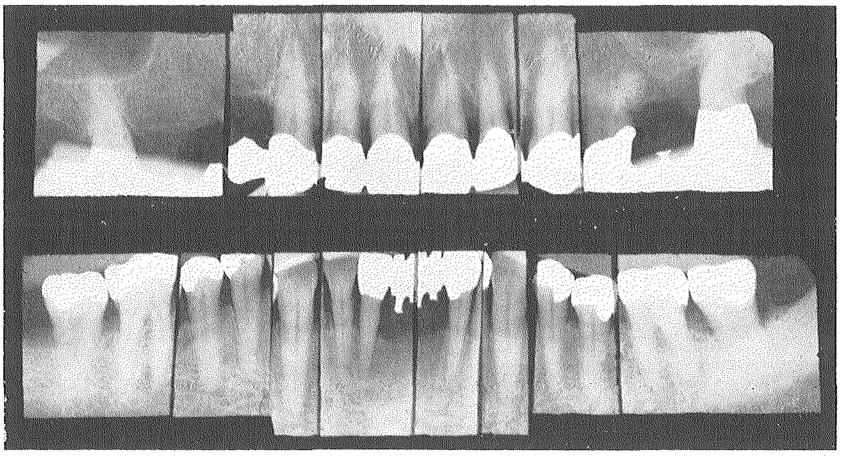


FIG. 27. Roentgenograms taken 42 months after articulated restoration.

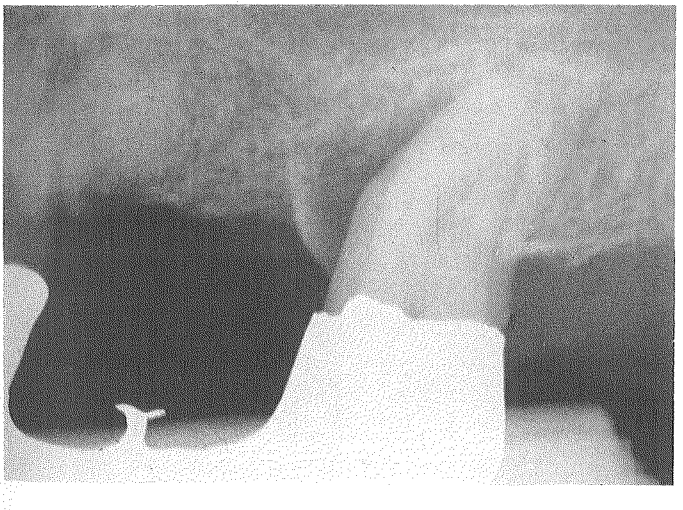


FIG. 28. A recent roentgenogram of the infrabony pocket.

tions and impressions were taken for the permanent work, in the expectation that the patient would return in September.

Exactly one year later, in June, 1952, he finally returned. It was apparent that he had undergone gross periodontal deterioration. When the splint was removed, the upper left first bicuspid came out in it. All the teeth could be depressed in their sockets. The roentgenograms shown in Figure 25 were

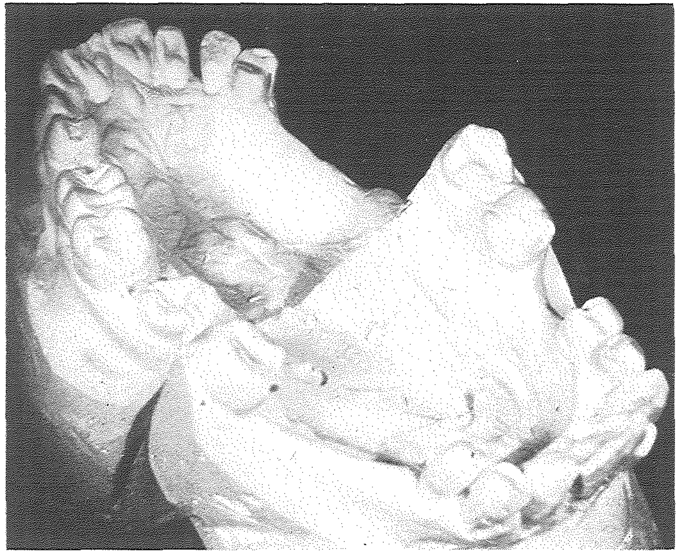


FIG. 29 (*Top and bottom*). Partial denture case and roentgenograms taken before treatment in 1938.

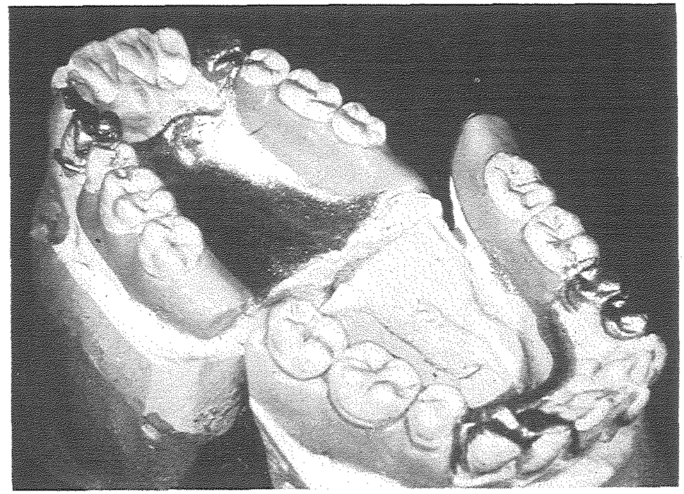
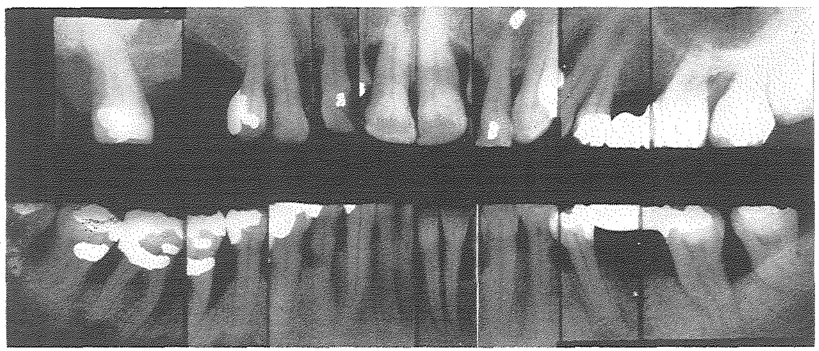


FIG. 30. A partial denture constructed with check-bites.



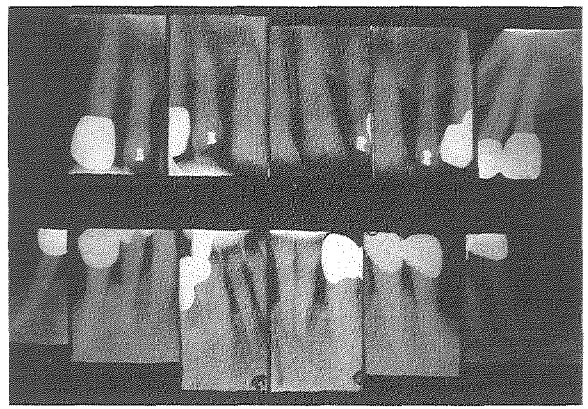
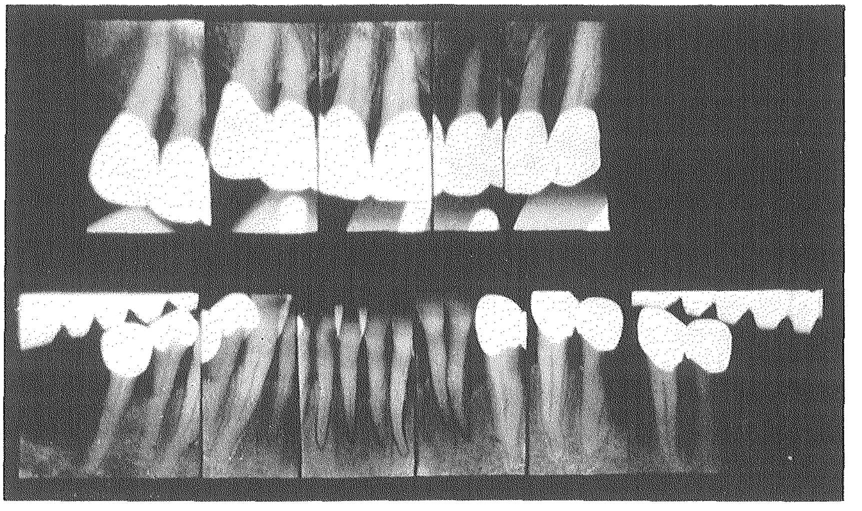


FIG. 31. Roentgenograms taken 7 years after the construction of partial dentures.

FIG. 32. Roentgenograms taken 3 years after rebuilding the anteriors.



taken, and showed that the infrabony pocket on the upper right second molar had extended beyond the apex of the tooth.

The prognosis indeed was not good, but, since the restoration had been constructed, it seemed that there was nothing to lose by attempting to save some of the teeth. It was remounted and adjusted. The teeth were so loose that even the temporary cement would depress them and prevent the restoration from seating. Although this was against good judgment, it had to be cemented with zinc oxide and eugenol so that the teeth could settle into the restorations.

Clinically the case began to improve. In November, 1953, 16 months later, the roentgenograms in Figure 26 showed a filling-in of the bone. The restoration was removed, and it was found that the teeth were much less mobile. The infrabony pocket on the upper right second molar had filled in appreciably. It was recemented with zinc oxide and eugenol and roentgenograms were taken again in 1955, 2 years later (Fig. 27). A recent film of the tooth (Fig. 28) shows excellent bone fill-in.

The case shown in Figure 29 was treated in 1938 by the check-bite technic that is described later in this book. The posterior teeth were extracted, and partial dentures with attachments were constructed (shown in Fig. 30). For physical reasons nothing was done at that time about the anterior teeth, except for conservative periodontal therapy. In 1952, the abutment teeth were holding surprisingly well (Fig. 31), but the anteriors had degenerated greatly. It was decided then to reconstruct the anterior teeth. Since this was an edge-to-edge bite with extreme mobility, it was decided to splint the anterior teeth. The results in 1956 are shown in the roentgenograms in Figure 32. Note the remarkable bone regeneration there.

All these roentgenograms were taken with a long cone, using special film holders to position them as nearly alike as possible. The exposures and the development were identical. It seems probable that, in cases of apparent bone regeneration, not all the bone is destroyed but to some extent it is "burnt out" by the radiography. Actually, what probably happens is a recalcification of bone which is still present but not evident in the roentgenogram. Nevertheless, it does appear from both the roentgenographic and the clinical standpoints that there have been bone changes as the result of changing functional demands and their relation to treatment.

*Chapter* 4

# Periodontal Consideration

ROBERT KAPLAN, D.D.S.*

The complex alterations in epithelium, connective tissue, bone and cementum that physically become recognizable as periodontal disease have been analyzed and classified by various systems and treated by a wide variety of operative procedures and medications. Dentistry has been applying itself to the study and the treatment of these tissue changes with increasing concern, in a desire to reduce the dental disease that these alterations represent and the tooth loss that all too frequently plagues the patient, even the one under routine dental care.

Our patients are conditioned to the morbidity and the mortality of the dental apparatus for those who do not seek dental treatment. However, it is becoming increasingly difficult for those patients whose faith in us had led them to accept our dental treatment to understand why they should become denture candidates in their mature years, after a steady succession of dental remedies. We are searching constantly for facts that permit an understanding of the seemingly infinite combination of signs and symptoms of tissue changes which characterize man's dentition throughout a lifetime. Surely a time will come when we will well understand the process of decay and the relationships of the mechanical, the chemical and the bacterial stressor agents with each other, with the general metabolism of the patient and with the altered local metabolism in the periodontal structures. As we accumulate these facts and apply our knowledge, the treatment of caries, periodontal disease, excessive wear of teeth, shifting of teeth, dysfunction, and problems of pain, anxiety and even orally oriented neuroses, will be on a more rational basis than is the present state of treatment in dentistry.

The change in the practice of dentistry from a pure craft to a profession whose treatment principles draw upon all knowledge, complex or simple, is slow and painful. Naturally, we are more enthusiastic in our search for simplicity, expediency and practicality and tend to turn away from the seemingly complex. If fact and truth indicate simplicity, it surely is not wise to search for the complex. But if fact and truth lie in increased complexity, our time and efforts must be spent in understanding, not wasted in denying the nature of the problem.

Can you imagine what progress there can be in physics, chemistry, electronics and medicine if the search for truth is complicated by denial of the complexity of the problem? Yet the paradox is that, with understanding of the complex, come instruments and technics that simplify and make possible solutions previously considered unobtainable.

As an example allied to dentistry, just think of an operation to correct a congenital heart defect. Nothing about it can be called practical in the conventional sense of treatment. Surely a procedure which calls for teams of highly trained physicians, technicians, nurses, thousands of dollars worth of highly specialized equipment and hours of intense and co-ordinated effort to accomplish what heretofore had been so complex as to be considered impossible, is not practical. That is, unless you happen to be the one with a now curable heart defect.

Pragmatism is the password today in periodontal therapy, but if we are not care-

* Taken from a paper presented at the Chicago Midwinter Meeting, 1961.

ful this will certainly slow down the accumulation of facts that results in the fundamental understanding of cause and effect in disease. As an example, no one can deny that teeth usually become tighter, for a time at least, if they are all bound together so that force applied in any direction on one root is resisted by many other roots. But this gives no inkling of how force can be distributed best on 14 opposing individual teeth that have overbite, cusps, interaxial contacts and other apparently unfavorable relations to each other. Philosophically speaking, one has to hope for an inseparable union of all proximal contacts to prevent drifting and mobility of teeth. On the other hand, a rational analysis would seek to find out whether or not there is an optimum co-ordination of teeth and force that might prevent the need for splinting.

## THE ADAPTATION SYNDROME

As a background for analyzing the role of occlusal rehabilitation in periodontal disease treatment, it is first necessary to re-examine periodontal disease in the light of studies made in the past decade on the inflammatory reaction. The majority of these studies have been made by physicians and physiologists and are not specific studies of dental problems. Paraphrasing the language of Hans Selye, M.D., periodontal disease can be considered a local adaptation syndrome (L-A-S) whose principal repercussions to topical stress are confined to the immediate vicinity of the eliciting injury.

> These repercussions consist on the one hand of degeneration, atrophy and necrosis, on the other of inflammation, hypertrophy and hyperplasia. This L-A-S is the sum of all nonspecific local biologic phenomena, including damage and defense.*

Transferring this quotation to dentistry demands that we consider these pathologic changes in relation to the clinical diseases of gingivitis, periodontitis, periodontitis complex, periodontosis and traumatism. All these are characterized by tissue changes classified as degeneration, atrophy, necrosis, inflammation, hypertrophy and/or hyperplasia. These tissue responses are practically the total of all supporting tissue changes, and it becomes fascinating to consider periodontal disease in the light of this co-ordinated philosophy. Surely this permits us to consider periodontal pockets as tissues which have the clinical picture they present because of both damage and defense. At present, Dr. Selye feels that one cannot separate damage and defense although he believes that the phenomena of cellular degeneration, atrophy and necrosis are predominantly injurious; on the other hand, the function of the inflammatory granulomatous barricade is fundamentally a protective phenomenon which shields the adjacent tissues against the irritant. The local adaptation syndrome is considered to be a triphasic response, all details of which undoubtedly are quite relevant to the clinical picture of periodontal disease, but the second stage—the stage of resistance—seems to be the one most appropriate to a discussion of periodontitis, gingivitis and periodontitis complex. According to Selye and others, tissues in this stage of reaction exhibit interesting characteristics with regard to what are called stressor agents or—more familiar to us—local etiologic agents. Tissues at this stage

> become highly resistant to further treatment with otherwise necrotizing doses of the particular irritant which was used to produce it, and even exhibit a high degree of tolerance to substances which normally would evoke the formation of a histologically similar type of response. At the same time, a resistance of irritants which normally would produce a different type of response is significantly diminished.†

Apparently, a response to injury of one type produces changes in the affected tissues that cause them to lose the ability to adapt

* Selye, Hans: The part of inflammation in the local adaptation syndrome *in* Jasmin, G., and Robert, A. (eds.): Symposium on the Mechanism of Inflammation, pp. 53-54, Montreal, ACTA, Inc., 1953.

† *Ibid.*, p. 60.

themselves to other purposes. In other words, the adaptation to one local etiologic agent alters the local tissue metabolism, so that it is less resistant to another type of local etiologic agent applied to those tissues. This one characteristic of the inflammatory response so sketchily presented may well help to clarify the tremendous variation in the clinical picture, the rate of progress and the consequent prognosis of gingival and periodontal disease.

With this very sketchy background, the role of occlusion in periodontal disease may be evaluated. It is clear-cut and unquestioned that improperly directed and/or excessive force on a tooth is a primary stressor agent in producing an alteration in the tissues of the periodontium, classified and described as the dystrophic changes of traumatism. It is also clear-cut and unquestioned that primary stressor agents such as calculi, bacteria, toxins and iatrogenic agents can evoke the specific responses of gingivitis and even a localized marginal periodontitis. The questions then become: Do you believe that the adaptation of periodontal tissues to bacteria, calculi, chemical toxins or iatrogenic agents leaves them ill-equipped to resist the primary stressor agent of excess and/or improperly directed mechanical forces? Or do you believe that the adaptation of periodontal tissues to mechanical force leaves the tissues ill-equipped to resist bacteria, calculi, chemical toxins or iatrogenic agents? In any case, both these questions require consideration.

Any gingivitis or marginal bone disease has many unpleasant aspects and harmful toxic effects systemically, but, from the standpoint of tooth mortality, it is the progressive apical advance of the disease that is serious. It is control in one area, yet advance in another, that is serious. It is the apparently controlled marginal disease that in a few years becomes an advanced bone loss problem, following operative dentistry or a prosthetic appliance, that is serious. It is in this context, in its relationship to the progressive nature of periodontal disease, that the consideration of mechanical forces, as expressed in occlusion, becomes of paramount importance.

In rational therapy, the approach that does not seem to be in keeping with the current concepts of inflammation or with clinical observation is that no consideration of occlusion is necessary at any stage. Consideration of occlusion is given, if at all, only in the terminal stages of the disease, or after the application of some formula as to how much mobility teeth must exhibit, or how much bone loss has to occur, before one dares to consider the mechanical force factor on the dentition to be a part of the clinical picture and to allow for it in the treatment plan. The approach that does not seem to be in keeping with the current concepts of inflammation is to treat only the occlusion without removing the other primary stressor agents responsible for inducing the marginal tissue reactions.

## ROLE OF OCCLUSION

An occlusal reconstruction can now be discussed from the viewpoints of its objective and its characteristics. In a gnathologic sense, the aims of reconstruction are the same as those of optimum orthodontic therapy. They are to create the maximally harmonious relationship that is possible between teeth, musculature and temporomandibular joint, accepting as fixed those anatomic relationships that are not amenable to change, and reconstituting and rearranging, by changes in tooth contours and position, those factors that permit alterations. The ideal is philosophically similar to that in orthodontics. If temporomandibular joint dysfunction is not present before treatment, then it must not be present following therapy. If it is present before treatment, then the occlusal reconstruction should be so arranged that it will rule out tooth relationships as a factor in the disease.

If muscle spasm and tenderness, referred pain, and limited and un-co-ordinated movement are absent prior to occlusal reconstruction or orthodontics, they must be absent following therapy. If they are present before reconstruction therapy, those aspects of the problem related to malarticulation must be absent following therapy.

If teeth are shifting position because of vectors of force created by the existing malarticulation or the favored patterns of mandibular movement, and if excessive or uneven wear of teeth has also occurred, an occlusal reconstruction should create contacting relations which resist wear and restore the efficiency of function by permitting those movements that naturally result from uninhibited muscle-joint relationships.

If bone loss has been progressive before occlusal reconstruction, it should stop following occlusal reconstruction. Inherent also in an occlusal reconstruction is the necessity for repairing the ravages of decay, and removing existing dentistry which is causing marginal disease, not creating a marginal disease problem attributable to the new restorations at the same time. This must be done in a manner that is esthetically acceptable to the patient. Of course, it should follow that the patient will have fewer problems with the entire oral apparatus, that the prognosis of all areas of the dental apparatus is improved, and that, as time passes, the patient will be grateful for having received a needed health service.

## PHYSIOLOGIC REQUIREMENTS

With all this as the sought-for objective, there is much more to occlusal reconstruction than providing a device for bracing against traumatic forces. Ideally, an occlusal reconstruction should be an effort at attaining optimum dental health. It is dentistry's effort to secure physiologic articulation of the teeth for the patient, in the belief that a patient with a physiologic articulation is more resistant to the other primary stressor agents, has mitigated the traumatism factor and has substituted physiologic stimulation. This physiologic articulation (one which requires the least adaptation for symptom-free function) has certain characteristics. The first of these is a tooth arrangement which permits the condyle-disk assembly to seat itself upward during function. This tendency to seat itself during function is simply an effect of the vectors of force resulting from the relation of origin and insertion of the temporal, masseter and internal pterygoid, the open position of the mandible, and the forward and downward position of the condyle at the start of muscular activity. Closely related to this is the necessity for having tooth relationships which permit the condyle-disk assembly to maintain this seated relationship while executing the full Bennett movement, combined with a unilateral descent and return of the condyle in both right and left working excursions.

A physiologic articulation of teeth harmonizes with these relationships by having its lowest vertical of occlusion in this terminal hinge relationship, and maintains this lowest vertical of occlusion during a border excursion in both directions. In other words, the cusps pass each other in this relationship. Teeth which are positioned in such a way as to interfere with this function in the condyle seat become the crux of dysfunction and traumatism problems. This is so fundamental that all other considerations of tooth form, cusp length, width of teeth, length of clinical crown, overbite and overjet, plane of occlusion, curve of Spee, and all other mechanical considerations are secondary to it.

A patient showing clinically satisfactory gliding relationships, with the teeth in contact, will show entirely different tooth relationships when analyzed in relationship to these seated condyle paths. This is the crux of gnathologic diagnosis and treatment. A physiologic articulation must at least permit incision and shearing by the anteriors, without posterior interferences that would prevent these activities or would prevent a braced relationship along the condyle paths. But the border path contacts must be so efficient as to discourage anterior thrusting movements automatically. A physiologic articulation should not make demands upon the proprioceptive mechanism to modify the optimum condyle relationships described above by modifying neuromuscular activity.

Much has been made in recent years of

this neuromuscular mechanism of proprioception as a defender of the dentition. Of course, one would have to acknowledge that such a mechanism does exist. But clinical observation would lead one to believe that, like most bodily defenses, it is capable of exhaustion, or is ineffective in the face of either increasing demands on it by changing occlusion or decreased capacity of the body to adapt generally. To understand this we have only to look at the practically universal evidences of tooth contacts and traumatism in adulthood. To predicate the treatment of a weakened dentition on the assumption that the patient can and will maintain this adaptation for a lifetime seems a calculated risk.

A physiologic occlusal reconstruction recognizes that the natural tooth form of the molars, the bicuspids, the cuspids and the incisors, if properly co-ordinated to one another and to the orderly movements of the musculature and the temporomandibular joint, is the ideal method for reducing the functional demands on the supporting apparatus. Thus, changing the excessive demands of dysfunction to the stimulating and beneficial effect of physiologic function permits, in addition, increased resistance to the other local stressor agents present in the mouth. Of course, as has been pointed out, optimum periodontal therapy would be that therapy which permits physiologic function and removes all local stressor agents, thus permitting the supporting tissues to return to health.

This has been a look at periodontal disease—occlusion interrelationships. To do real justice to it would require experience yet to be had, experimental evidence yet to be obtained, additional years to observe past efforts, an objectivity which a practicing dentist does not have. Even then, the role of occlusal corrections in the treatment of periodontal disease will never be the same to all. The complex nature of the alterations in epithelium, connective tissue and bone that physically become recognizable as the symptom complex called periodontal disease can be approached from many different aspects, all with some degree of success. But the entire picture is incompletely understood and poorly delineated, so that one must possess open-mindedness to re-evaluate one's concepts and treatments constantly in the light of the slowly increasing store of knowledge.

In the meantime, we are in the era when extensive dental procedures are in vogue. The restorative dentistry, whether called oral rehabilitation, reconstruction, periodontal prosthesis or full coverage splints, and the gingival procedures, whether classified as gingivectomy, gingivoplasty, mucobuccal fold extensions or osseous resections, are treatments that, at their best, can be a valuable contribution to a patient's well-being, but, at the same time, carry the possibility of physical and emotional as well as dental havoc.

The golden rule should govern all dental treatment. Especially in this area must we decide whether or not we, as patients, knowing what we know of our own results with these procedures, would want to have the planned treatment. Even when the dental treatment becomes thus defined, further evaluation of the particular patient's total physical and emotional health often indicates the need for modifying extensive dental treatment to the advantage of the total needs of the patient.

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*Chapter* 5

# Mucostatics

Whenever sufficient natural teeth with adequate bony support remain, the fixed bridge is the restoration of choice for the replacement of lost teeth. When it is necessary to use a removable partial denture, it may be assumed that it is used in the expectation that it will receive support from the underlying mucosa.

A stable occlusion and a stable denture base, full or partial, are interdependent: one cannot survive without the other. In order to maintain stable occlusal relationships, the base must maintain what Dr. William Dykins referred to as a "tissue-base constant." The base must rest immovable on tissue. For the tissue to tolerate such a precisely fitted base, the occlusion must be completely harmonious. If the malocclusion twists and turns the base, the tissue cannot tolerate it.

Every base in function becomes a mucostatic base, but usually not before it has yielded enough under pressure to displace the tissue until it comes into contact with the whole base area: when pressure is released, the tissue rebounds and, at first, the base rests in contact only in spots. However, it is possible to make a base which will be in perfect tissue contact at all times.

## THE MUCOSTATIC PRINCIPLE

In order to draw a true picture of mucostatics, I am going to ask you to perform a really difficult task. For the next few minutes let us try to forget that we are dentists. Let us forget that we have ever seen an impression or a tray or a compound or wax. In short, let us forget all the accouterments that have grown so dear to our hearts. Instead, we are a group of scientists with an engineering turn of mind, who have been presented with a brand new problem—one we have never even heard of before. It seems that, for unknown reasons, many people today lose all their teeth. They are in dire need of some way to chew. Some men known as dentists have undertaken the making of artificial teeth so that these unfortunate souls can get along in the world. And most of them do just manage to get along. This is particularly true of the lower dentures. For some reason they seem to have a lot more trouble with those lowers. As engineers we find that rather puzzling. We are not dentists—we have never seen the inside of an edentulous mouth; we have never heard about suction and reliefs and peripheral seals and tissue compression. In our ignorance, we naïvely approach the problem with no foreboding of the terrible complications awaiting us.

## BASE STABILITY

Still working from an engineering standpoint, we must analyze the problem first. What do we want to accomplish? Why, that is very simple. All that we have to do is to make a set of teeth which will be stable in function at all times. It seems that that is the only requirement. If the denture moves or is displaced when the wearer is eating or talking or laughing or sneezing, or using the mouth in any other way, then it certainly is not stable. Stability, then, is the sole objective of a denture base. If we have stability, we automatically have retention.

Now that we know what we want, our next step is to find out how we are going to get it. We take our first look into an edentulous mouth. We see, roughly, where teeth once stood, a U-shaped formation, an irregularly rounded ridge in some spots and in others fading out entirely to a concavity with the cheek on one side and the floor of the

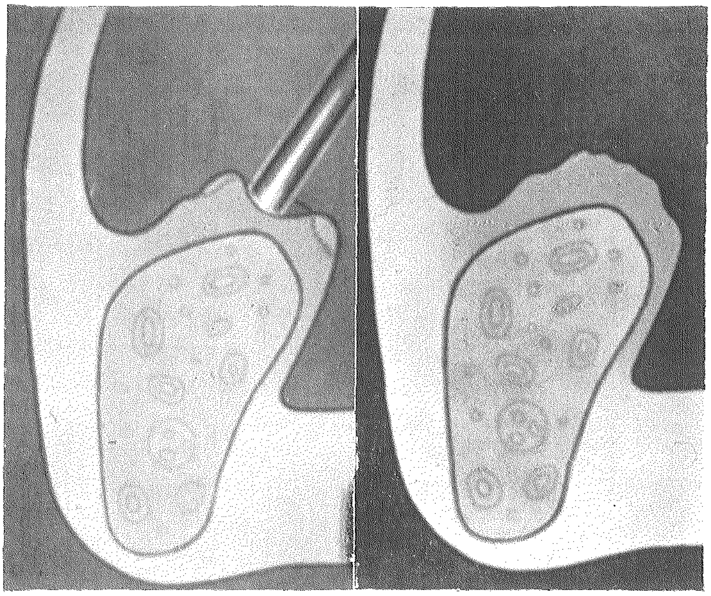


FIG. 33 (*Left*). Coerced tissue will distort but not compress.
FIG. 34 (*Right*). When released, it springs back.

mouth on the other. The whole area is covered with mucous membrane, but when we feel it with our fingers we discover that although it is quite firm and rigid in some spots—apparently because there is just a thin, dense layer of tissue over the remaining jawbone—in other spots it is all soft and mushy. Evidently, on different parts of this ridge (as we have learned that it is called), the tissues are quite radically different in their physical properties. Pouring over textbooks on biology, we learn some very interesting facts about these tissues. They are composed entirely of liquids and solids which, for all practical purposes, are incompressible. Yet, when we used our fingers to push on this soft, mushy tissue we could see it yield. Since it is incompressible, we know that when we pushed it down in one place (Fig. 33) it must have bulged in another. But it also possesses the property of elasticity. As soon as we removed our fingers (Fig. 34), it sprang right back to the shape that it had before we touched it. That does not mean that it is rubbery. Rubber is compressible, whereas tissue is not. But we can displace tissue. So, each time we pressed our fingers into it, we could displace it in one place and cause it to bulge in another. The trouble is that, in order to make it bulge in exactly the same way each time, we would have to displace it exactly the same way each time. Well, now, that is very interesting! Let's just file that in our minds for future reference and see what else we can learn from our biology texts. We find that tissue is not only incompressible, but that it cannot be stretched. It cannot be stretched because it is integumentary. That is, if we grasped this soft, mushy tissue, or the tissues of the cheek contiguous to it, and pulled the tissue (Fig. 35), then to some degree all the tissue on that ridge would have to move. But again, as soon as we release it, the tissue will return instantly to its original position. So if, when we get ready to make this base, we are compelled to pull upon the peripheral tissues, through the medium of the cheeks and the lips, then the base will have to exert an identical pull in order to fit the distorted tissues. If, while we are taking the impression, we happen to pull first in one direction and then in another, we will be in trouble—it will be impossible to produce a fit. So we have learned that we must not cause the distention of the cheeks while we are taking an impression. When we say that tissue cannot be stretched, that does not mean that its shape

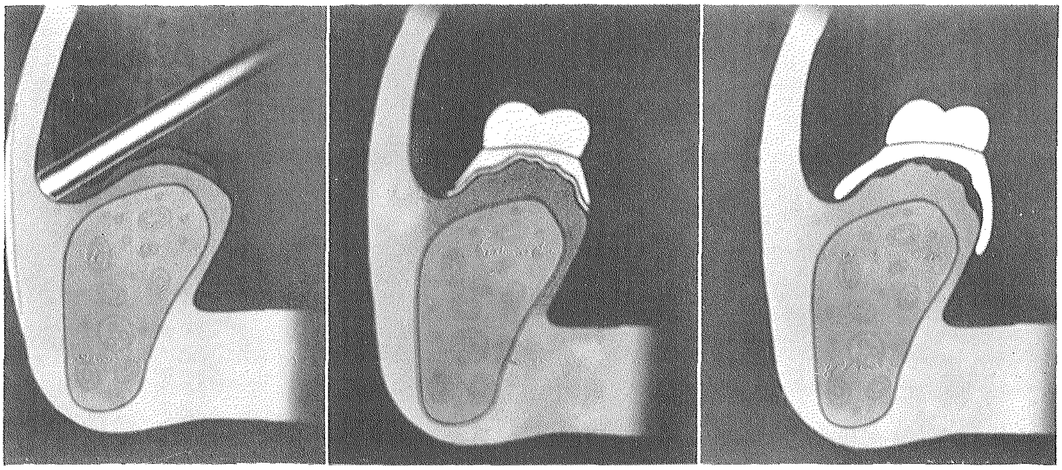


FIG. 35 (*Left*). When tissue is pulled, contiguous structures move.
FIG. 36 (*Center*). Tissue fluids are confined in cells.
FIG. 37 (*Right*). The passive base makes point contacts.

cannot be changed. We have just seen that it can be, as long as the same pull is exerted upon it.

## TISSUE COMPRESSIBLITY

As we delve further into biology, we find that this tissue is made up of minute cells (Fig. 36), each of which consists of a nucleus and a liquid that are held within a membrane. As is true of the whole tissue, this membrane cannot stretch. It can change shape under pressure, but the volume of the cell does not change. The liquid remains within it, and we cannot squeeze it out except by actually rupturing the cell. Therefore, the liquid and the solid which compose the tissue are confined within a container and cannot be compressed by any pressure we could use in the mouth.

Briefly then, we have found that the foundation upon which the base will rest consists of a material which is elastic but not rubbery, which can be displaced but not compressed, and which, after being displaced, will return immediately to its original form when released; that it is integumentary, so that when any of it moves, all of it moves; that it consists of solids and liquids confined within containers.

We started with the premise that we expect to produce an artificial denture which will be a good substitute for a natural set of teeth. As engineers, we know that the oral organ was designed to function with certain forms of teeth and that, if we wish to attain an equal degree of efficiency in function, we must replace them with similar forms and function. We know, further, that the natural teeth were embedded in bone, not floating around in soft tissue. And so, if we wish a good substitute, it also must rest solidly in place and not float around in soft tissue in function.

Now that we have acquired some facts about the problem, we are ready to consider ways and means of solving it. First, it is clear that the impression must be a microscopically accurate reproduction of the denture area. If it fits in some spots and not in others (Fig. 37), when pressure is brought to bear upon it the spots in contact will displace the tissue (Fig. 38), and the base will be depressed until it all comes in contact. But if it is all in perfect contact, none of the tissue can be displaced, and, since it cannot be compressed, the denture base will be as solid as the underlying bone. It is also apparent that the impression must reproduce the tissues in their perfectly passive form. If, during the act of taking the impression (Fig.

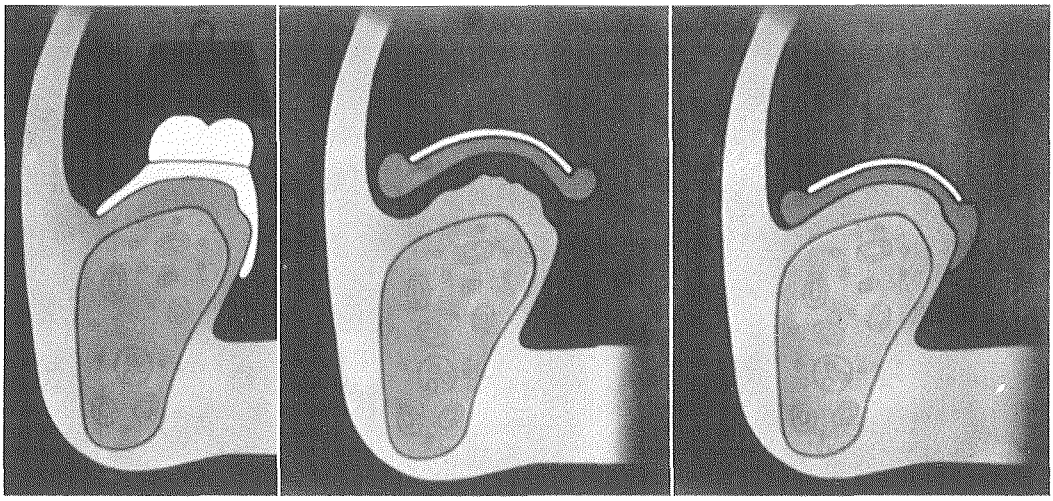
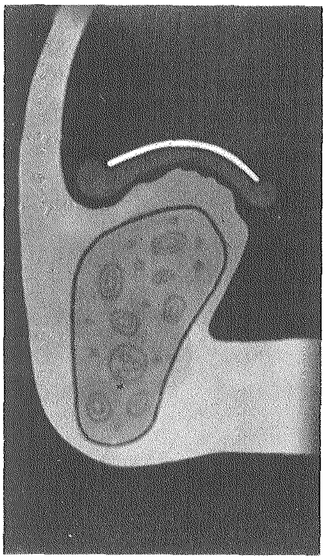


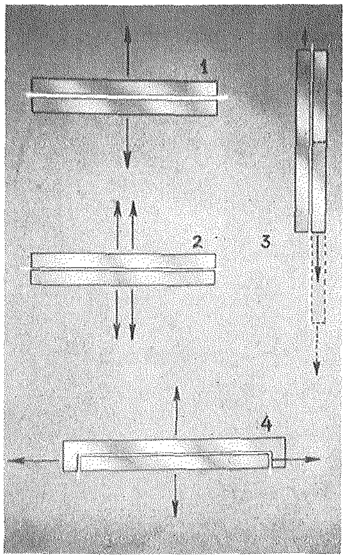
FIG. 38 (*Left*). Under pressure, tissue adapts to the base.
FIG. 39 (*Center*). An impression that requires pressure distorts tissue.
FIG. 40 (*Right*). When deformed tissue offers greater resistance, the impression material flows under pressure.

39), any part of the tissue is displaced (Fig. 40), the base made from it will not be in perfect contact with the tissues when it is at rest in the mouth. Of course, as pressure is brought to bear, it will displace the tissue just as the impression did, until it finally comes to rest in a solid position. But as soon as pressure is released (Fig. 41), the base will rebound. At first glance, this might not seem too important if the amount of displacement is small. But that brings us to another aspect of the problem, which thus far we have ignored: that part of stability which is embodied in retention. While we were pouring over those biology texts, we happened to run across a very interesting story about an old-fashioned practice known as cupping. It seems that many years ago, before medical practice had achieved its present place of eminence, many people used to go to the village barber for treatment of minor ills. If he suspected infection, it was quite common practice for him to use a little alcohol to burn the air out of a cup and then quickly invert it over the suspected area, holding it down with a tight peripheral seal as it cooled. This created a partial vacuum within the cup and over the tissues encompassed by the rim. In a short time an active hyperemia would ensue, resulting in an artificially created inflammatory process with all the classic symptoms: rubor, malor and dolor. Sometimes the process would be repeated several times wtih alternate intervals of vacuum and release—"intermittent vacuum" some call it—until finally the tissues would break down. The barber, in his infinite wisdom as keeper of the people's health, with a simple little glass cup had succeeded in making the tissues destroy themselves.

## RETENTION

Having carefully digested that, we can see that we must avoid a vacuum or suction and a sealed edge, as a plague, else the base we have so carefully produced will end up by destroying its own foundation. And, unfortunately, it is a foundation which we cannot readily rebuild. But, luckily, as engineers we have a much better solution right at hand. We know that properly utilized surface tension can be 40 times more powerful as a retaining means than even a perfect vacuum, yet perfectly harmless to human tissue. And, by good fortune, in most mouths we have a good opportunity to use it, particularly with





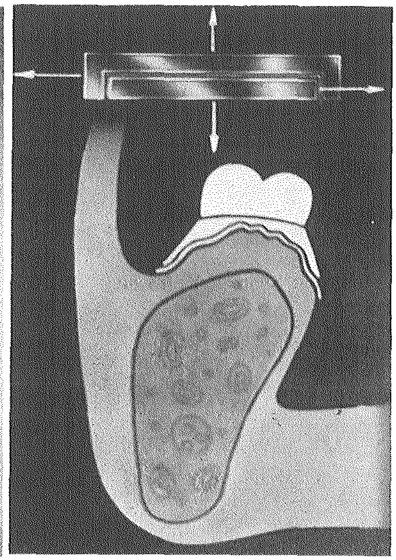
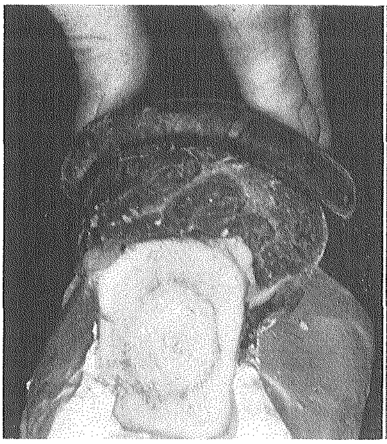



FIG. 41 (*Left*). When released, the tissue springs back, making the impression unstable.
FIG. 42 (*Center*). The thinner the surface-tension film, the greater the retention.
FIG. 43 (*Right*). Flanges prevent sliding.

the nice flat lowers which have little or no ridge to bother us. That is where we really can get a nice, solid, retentive base and at the same time nullify that great enemy, tissue resorption. But the effectiveness of this surface-tension film (Fig. 42) is inversely proportional to its thickness. The greater the space between base and tissues, the thicker the film and the less the retention. By having a flange so that it cannot slide on the tissue, the base can maintain the perfect contact that is required for surface tension to be effective. It is analogous to two glass slabs with a film of water between them (Fig. 43) and a flange on one to prevent it from sliding. Surface tension resists the pulling apart of the slabs, and the flange prevents them from sliding apart. They are stable against all forces. Now we see another reason why we must avoid any displacement of the tissues when we take the impression, even though it may seem ever so slight. If that tissue, in attempting to assume its natural form upon the release of pressure, does cause a slight rebound of the denture base, it has destroyed the surface-tension film, or thickened it to the point where it is no longer effective. That is the same accuracy of fit that we required for stability. So we see that if we have one we must have the other: stability and retention are the same. As part of our investigation, we naturally search through the literature to see what has been done in the past, and here we find two very puzzling items. For over a hundred years practically all the efforts have been devoted to attempting to create a partial vacuum between the base and the tissues. In fact, we are shocked to learn that that seems to have been almost the only thing about which the prosthodontists concerned themselves. What we have come to think of as the retentive aspect of stability they constantly referred to as suction, like that of a vacuum cup. That really does amaze us, because we know that tissue cannot possibly tolerate even a small vacuum for any usable length of time. Yet for years that seems to have been almost the sole concern of the prosthodontists; there seems to have been almost no serious effort to maintain stability so that teeth could function with an efficiency comparable with that of a natural set of teeth. We find that particularly difficult to understand because, up to this time,



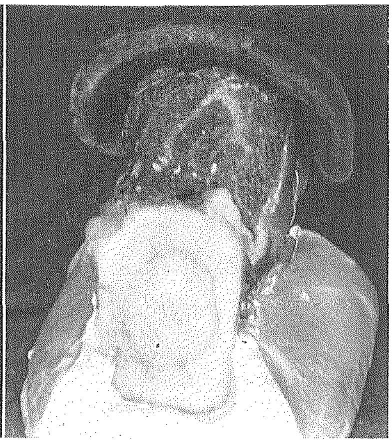


FIG. 44 (*Left*). A compound impression distorts tissue.
FIG. 45 (*Right*). Upon release, the tissue rebounds.

as engineers, we have been most careful to avoid suction for fear of destroying our very foundation and losing that precious stability. It seems strange that simple daily observation alone did not teach prosthodontists long ago that denture retention cannot be maintained long by suction; that retention is completely automatic and unavoidable if the base possesses true stability. There is nothing that anyone needs to do about it. Indeed, there is nothing that anyone can do about it except to fit the tissues just as they exist normally. We see constant references to all sorts of seals—peripheral seals, valve seals, soft-tissue seals,beaded periphery, peripheral roll, postdams, vacuum chambers, temporary vacuums, and even suction cups—that were used in an effort to obtain suction. But we know that all these things must be very short-lived in the mouth, that in a short time they end up by defeating themselves.

The other thing that puzzles us is the repeated references to the functional position of tissue or the physiologic form of the ridge. Apparently that means that, as the denture is in function, the tissues yield until they arrive at a position and a form in which they can resist the pressure being exerted upon them by the base. The fallacy of that, of course, is so obvious that it hardly merits consideration. Since the impression used to make the base distorted a lot of tissue, which sprang right back, naturally the base, when not in function, will be resting upon the tissue only in spots. As pressure is brought to bear and function starts, the base will yield until it also distorts the tissue just as the impression did. It will stop yielding when it finally comes into perfect contact with the tissue. That must be true, or the base would continue to yield until it reached the bone. But, since the tissue cannot flow out of the base and cannot be compressed, the base becomes stable at that point where it does make contact. This functional or physiologic position of the tissue is not its normal passive form; it is something which the dentist created artificially when he took his impression. So the base must be fluctuating constantly between its rest position on the tissue and the amount it must move to force the tissues into perfect contact. How can we possibly articulate a set of teeth upon such a floating foundation? Ordinary common sense tells us that, since the denture does become stable when it comes into perfect contact with the tissue, if we make that perfect contact with the tissue in its passive form, the denture will be stable at all times, instead of floating in a mass of soft tissue.

As scientists, we seem to have but one approach. Our constant aim must be the construction of a denture base that fits the patient's mouth accurately just as it is. The slightest variation from this, the smoothing out of any tissue fold in the patient's mouth, constitutes a rough jamming of the patient into an appliance, for what we are doing is making the patient fit the base. Rudimentary biology makes it clear that tissue destruction must follow. If a base will not work when it has been fitted perfectly to the patient, then it certainly cannot work when the patient has been violently squeezed into it.

Now it is clear to us why dentists have had such a struggle over these denture bases, and why artificial teeth have been such an inefficient substitute for natural ones. For years dentists deliberately have been making ill-fitting, tissue-distorting, destructive dentures in order to produce some kind of a seal or suction. Both require at least a partial vacuum inside the periphery, which can be created only by constructing a misfit denture. Otherwise, there can be no vacuum space to make a seal or suction effective. Misfit dentures are destructive dentures. All that is completely incompatible with what we have learned about the human mouth.

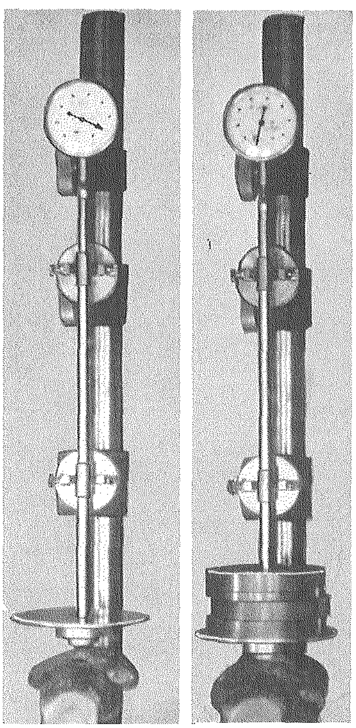


FIG. 46 (*Left*). Apparatus for testing tissue distortion

FIG. 47 (*Right*). Under pressure, the compound impression deformed tissue.

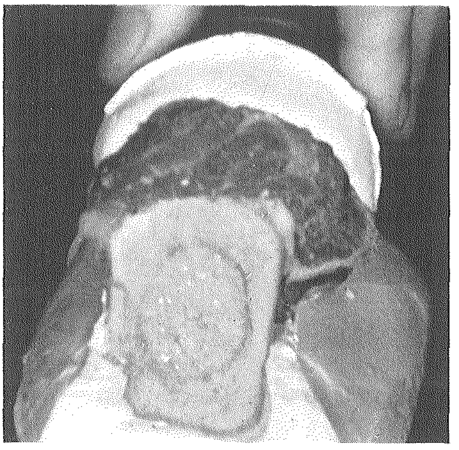


FIG. 48. A mucostatic impression of the same tissue.

## TESTING THE THEORY

To test the validity of these theories as a practical procedure, we obtained a section of shinbone from a freshly killed animal. The tissue was dissected away from the side to leave a cap of tissue, analogous to a section through the mandible. Of course, it was much larger in order to show the results more effectively. Needless to say, the quantitative conditions are magnified many times, but the qualitative results are comparable.

A soft, low-fusing compound impression (Fig. 44) was taken under conditions similar to those in the mouth. When pressure was applied, the tissue yielded, as shown in Figure 44. Upon release, it rebounded, as shown in Figure 45. To obtain a comparison of relative yield, it was placed in the apparatus shown in Figure 46. This is the kind of yield tester that is used by the Bureau of Standards to measure the yield of elastic impression materials. It was subjected to a load of 6,000 grams, comparable with the chewing force on such a denture-base area. The amount of yield is recorded on the dial gauge at the top of the column. The small dial shows the number of complete revolutions of the large dial. As we see in Figure 47, the yield was a little more than three hundred thousandths, or one third of an inch.

An impression was taken next (Fig. 48),

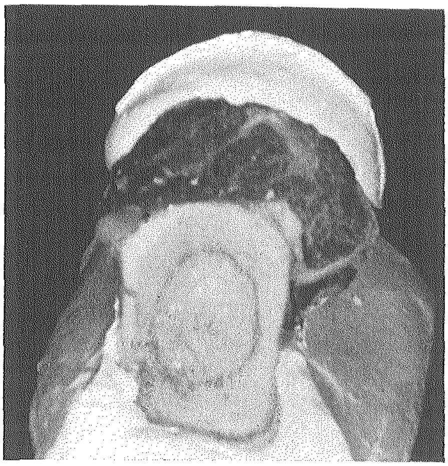


FIG. 49. Upon release, it did not rebound.

using zinc oxide paste, likewise under conditions comparable with those of a mucostatic impression. Upon release, it did not rebound (Fig. 49). This likewise was placed under a yield test with 6,000 grams. In Figure 50 we see the dial micrometer during testing. When the load was applied, there was a yield of three thousandths. There is this much yield in the apparatus itself under this much load. For all practical purposes the tissue was incompressible.

## THE IMPRESSION

We see then that, for several reasons, each operating independently of the others yet all interrelated, we must take an impression with absolute fidelity to detail of the denture area and with absolutely no displacement of the soft tissues, and reproduce it with equal accuracy in the denture base. How are we to go about this seemingly difficult task? From a purely negative approach we can see several things which we must not do. First, we must not pull and haul and tug on the cheeks, and we must not place anything in the mouth which will bulge the cheeks while we are taking the impression, because, as we learned before, the tissue is integumentary and we will displace it all the way across the ridge. So the cheeks and the tongue must be completely relaxed in their rest position and remain so throughout the impression period. Second, the material which we use to form this impression (Fig. 51) must not offer greater resistance to flow than the softest tissue with which it will come in contact. Then, in order to have enough body to be carried into the mouth but still to flow without pressure, it must have a very low surface tension. And, once in place in the mouth, it must set hard so that it can be removed without distortion and be replaced. It must be as rigid as the base, so that it can be tested for stability (Fig. 52), and sufficiently strong

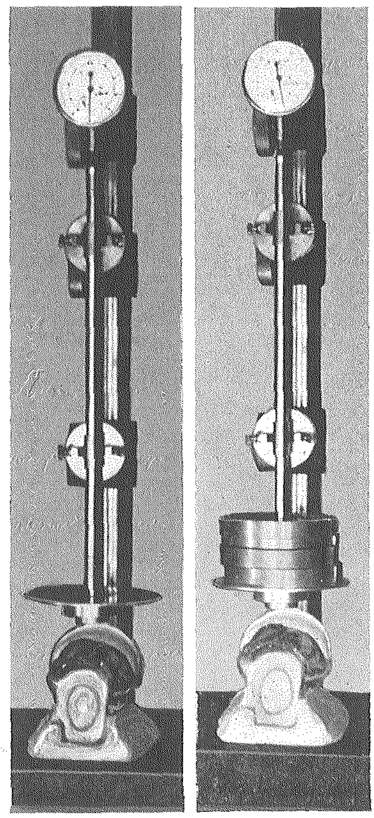
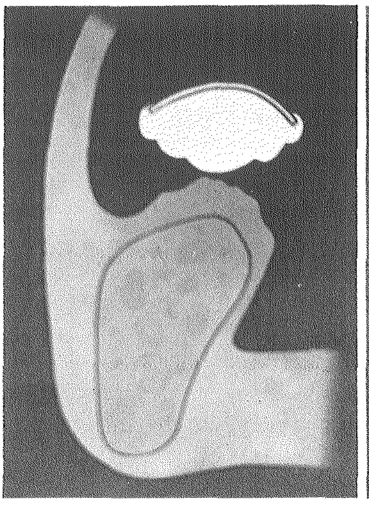


FIG. 50. Testing tissue distortion under a mucostatic impression.



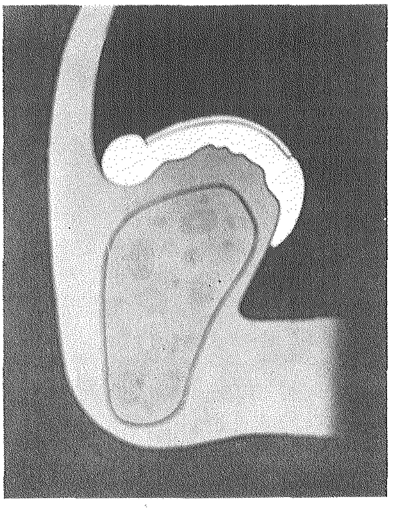


FIG. 51 (*Left*). A suitable impression must offer less resistance than tissue.

FIG. 52 (*Right*). It must set hard in the passive form of tissue.

that it will not be injured when a model of the mouth is made from it. Furthermore, since we are depending upon a thin surface-tension film for retention, we must not have any thicker film of saliva over the tissues when the impression material makes contact. Obviously, the impression material must be a thin paste of some kind, so we must have some means of getting it into the mouth. The simplest way to accomplish that would be by means of a small container, or a tray, provided that the tray is narrower than the area to be covered by the impression, that it has no handles or projections which could interfere with the lips, the cheeks, or the tongue, and also that there is enough space between it and the tissues that it could not come through the impression material and, by contact, cause a displacement of tissue. It must be light in weight. All these objectives can be accomplished best with an individually cast aluminum tray. This tray is not for the purpose of forming the impression. It is merely a vehicle to carry the impression material to its place in the mouth. Once that is accomplished, it has served its purpose.

Of course, in order to carry this tray into the mouth, we will have to retract the lips and so distort the tissues. But once it is in the mouth and the retractors are removed, the impression is not forcefully pushed into place. The patient has been coached to remain relaxed at all times and he does so while the tray is held in the mouth over the ridge. Then the fingers holding the tray are withdrawn, the cheeks and the lips are relaxed, and the material is allowed to settle slowly and gently into place over the semi-dried tissues. After the set impression is removed, it will be seen to include impressions of parts of the cheeks and the tongue, perhaps even of the tonsils. This excess material is carefully cut away, and the finished impression is returned to the mouth to be tested for stability. A certain amount of knowledge about these impressions is necessary to tell whether or not a really good impression has been obtained. The impression should not be grabbed hold of to see if it has enough suction to drag the patient out of the chair. That is really not what the patient is interested in. It may be dramatic, but it is not dentistry. The patient is interested in only one thing. Will it stay in place in function? If it responds properly to tests for stability, it certainly will have retention when it is in use.

It must be patent that all this work will have been in vain unless the denture base that is constructed is an absolutely perfect replica of the impression (Fig. 53) in every minute detail. This is possible only with a suitable metal base. There is absolutely no way to escape the use of metal. Plastic material cannot maintain the same stability and will not yield comparable results. Indeed, it even requires special precautions to make an accurate metal base, and the work should be entrusted only to those who have been properly trained to handle it.

## FUNCTIONAL CONSIDERATIONS

Once the principle is understood, taking a mucostatic impression is really a very simple procedure, requiring only a few minutes. But, before discussing technic, there is another side of this problem which we should consider briefly.

By this time the term "mucostatic base" immediately conjures up a picture of an impression taken without distortion of the soft tissues. From there our thoughts jump to compression and suction and peripheral seals and locks and all the other fallacies with which for years we have been wont to obscure the real, common-sense facts of full denture work. But there are deep, fundamental, and much more important differences than these between the philosophy of mucostatics and the various technics that have been used in previous attempts to arrive at a stable denture base.

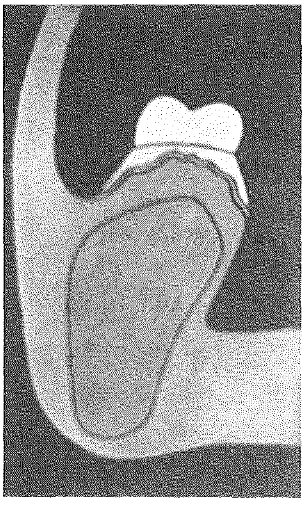


FIG. 53. The base must be a microscopic duplicate of the impression.

Until the advent of mucostatics, impression technics concerned themselves largely with various methods of "compressing" soft tissues, without regard to the fact that tissue is composed of solids and liquids, which, for all practical purposes, are incompressible. And so, what the impression really did was to push the tissues aside and distort them. But when the impression was removed from the mouth, the tissues naturally returned to their previous form. When the denture was inserted in the mouth, and pressure was brought to bear, it likewise displaced tissues, but, upon release of the load, the tissues would spring back to some extent in an attempt to return to their inherent positions. We then had a base which was, in a sense, floating upon soft tissues, in a constant state of flux. Furthermore, the ironing out of the soft tissues by the impression destroyed all the fine detail, so that such a base usually presents a smooth surface without the detail of the mucosa.

But mucostatics presents an entirely different picture. Here the base is resting in perfect contact with tissue which has not been displaced and so has not caused it to spring out of place. Since the tissue is not compressible, the base resting upon it is solid and unyielding. Here at last is the perfect denture base—as solid as natural teeth. How often the dentist has said, "Give me the perfect denture base with stability and retention and all my worries will be over!"

Unfortunately, however, the perfect denture base has led to the painful discovery—painful to both patient and operator—that there is more to the perfect denture than the base. The phenomenal success of properly constructed mucostatic bases has brought into sharp relief the real problem of successful full-denture prosthesis: articulation of the teeth. To see the reason for this we might compare the ordinary base of the past with a gymnastic performer. When he finally lands, it is into a net or onto a soft mat. Not so the mucostatic base! Here it is as though the performer landed upon solid concrete. With improperly articulated teeth, the resultant shock to the whole organ inevitably produces acute pain and discomfort. The floating base takes up the shock of malocclusion, but the solid base transmits it instantly and harshly to the underlying mucosa, causing acute suffering under the base area and initiating the process of necrobiosis, with which we are all familiar as "shrinkage of the ridge." Since the base is an accurate reproduction of the ridge tissues, with all the irregularities which we must have to obtain perfect contact, these minute roughnesses aggravate the condition.

You might well ask: If that is true, why make a mucostatic base? Why not abandon it in favor of some other method? The full lower denture always was one of the least satisfactory dental services. Mucostatics has changed that. Now it is possible to make a lower base which is actually more solid than the upper and, incidentally, in a mere fraction of the time consumed by elaborate impression technics which fail to bring about comparable results. Indeed, so secure is the lower that, when the bases are compelled to move by the forces of improper articulation, it is always the upper that skids and not the lower. It is the solid-as-a-rock fit of the lower base that presents the problem.

It is apparent then that the real problem of the mucostatic denture is articulation. But that is the problem of all dentistry. If we would create really functioning full dentures, we must first understand the natural teeth, for truly, as McCollum said: "The practice of dentistry is the science of articulating teeth." And that is equally true whether we are dealing with natural teeth or with their artificial counterparts. For counterparts they must be. Until we can learn to think clearly in terms of the entire mouth, we will never understand the part that the denture base plays in it.

## PRACTICAL CONSIDERATIONS

The object of a mucostatic impression is to obtain a negative imprint of the soft tissues under the saddle area in their completely passive form, and to reproduce every detail without distortion or "compression." It is necessary to use an impression material which has less resistance to flow than the softest tissue that it will contact. This must be carried to its place in a tray which has the shape of the saddle but is not "fitted" to the tissues. It must set rapidly in the mouth, and it must set hard and brittle so that it cannot be distorted in handling and testing. It must be dimensionally accurate and stable and must not require a separating medium. It must not change with age and, lastly, it must prevent gagging.

It is important for the operator to familiarize himself thoroughly with the manipulation of the materials before he attempts to use them in actual practice. Properly used, Ackerman's Cement is an excellent impression material. Improperly used, it becomes a source of constant trouble and failure, with the attendant wasted time and effort. The "fast" and the "slow" liquids can be mixed in varying proportions in order to suit the needs of the individual operator under the conditions of humidity and working time available. In winter, northern areas of the country, with artificial heat and low humidity, generally call for the use of only the fast liquid. Summer heat and high humidity will require the addition of some slow liquid to control the working time. The slow liquid is never used alone as it would be too slow for practical purposes. A comparatively small amount of experience will soon tell the operator how much slow liquid to add. It is good practice to purchase the material in the 8-unit can rather than in small tubes, in order to obtain a uniform material.

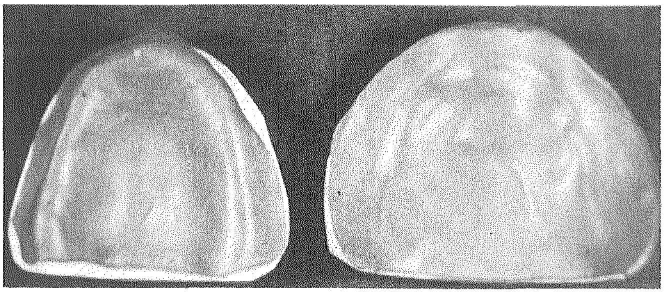


FIG. 54. Base-plate wax spacer on study models.

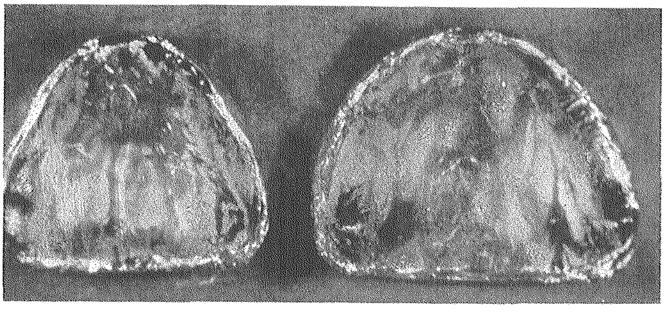


FIG. 55. Tin foil burnished over a wax spacer.

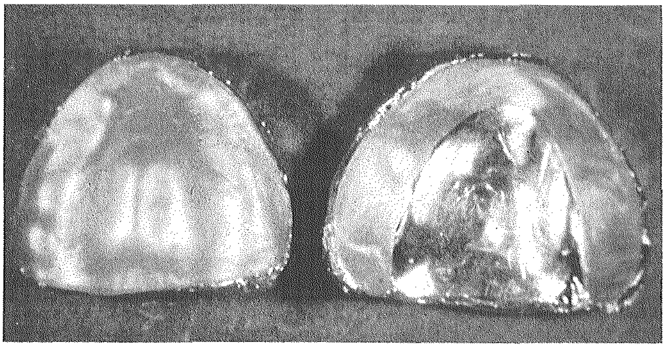


FIG. 56. Tray patterns.

The majority of failures result from an improper mixing technic. Here, only practice and experience can lead to successful results. It is absolutely essential that the operator master the mixing technic before attempting to use the material in his practice. A few dollars' worth of material expended in making trial mixes, until the operator has learned to make a smooth creamy mix quickly and easily, will pay for itself many times over.

Most mixing failures result from the operator's attempting to mix the material the way he does a dental cement, by bringing in small portions of powder at a time and spatulating each time until he has arrived at what he feels to be the correct consistency of mix. Unless he uses an excessively slow-setting liquid the material will set too fast. If he uses a liquid slow enough for that type of mixing, it will set too slowly in the mouth, and the patient is likely to distort it or push saliva between it and the tissues.

Correct mixing requires that all the powder and liquid be incorporated at one time. Since it requires a considerable amount of experience to judge the correct quantities of each, a proportioner of some kind is an absolute "must" for the beginner. A large, wax-free, paper mixing pad and a large, fairly flexible spatula are used. The correct amount of powder is placed in the center of the pad and a crater is made in the middle. The liquid is poured into this. Since the powder "wets down" rather slowly, at first no attempt is made to spatulate. The two materials are simply stirred together until they begin to

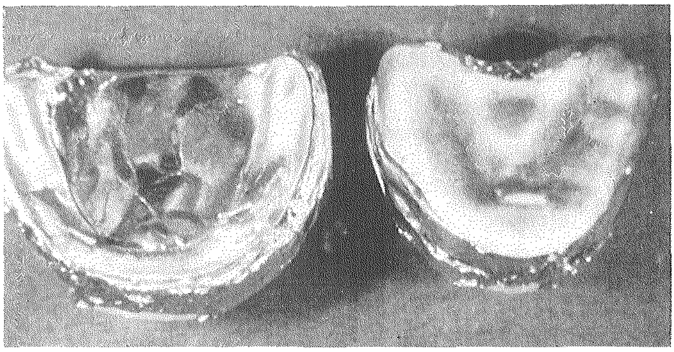


FIG. 57. Cast aluminum trays.

mix. At this stage the mixture will appear to be too thick and dry. Now it is spatulated with long, sweeping strokes, the material being spread out over the whole pad. It is then picked up on the spatula, and the operation is repeated until the mixture has a smooth, flowing consistency. Most operators tend to use too thin a mix in the beginning. It should be thin enough to fall from the spatula when lifted and flow back into the mix, but not so thin that it runs freely all over the tray. The correct quantities for an average full-denture impression are 36 cc. of loosely packed powder to 12 ml. of liquid.

The tissues usually do not require actual drying, except when an upper is being painted, but there should not be any free saliva between the impression material and the tissues. Petroleum jelly should be applied to the lips to prevent sticking.

The tray should be light, thin and rigid. It is best for it to be cast for each case in a hard aluminum alloy. Shellac bases and plastic materials are not generally advisable. The tray should conform to the general shape of the tissue but should not be closely fitted. Adequate space should be provided for the material to flow between the tray and the tissues without having to be forced out under pressure. It should be underextended, so that the material will flow beyond the edges.

## MAKING TRAYS

Snap impressions of the entire mouth are taken, using a soft, elastic impression material. The upper tray may be postdammed, but the periphery is not sealed. The object is to obtain as little tissue distortion as possible. Either an alginate or a hydrocolloid will do for this purpose. Stone models are poured and separated.

The entire base area (Fig. 54) is covered with base-plate wax for a spacer. For full-denture impressions two layers of wax are used, and for partials, one layer of wax. Over this wax spacer (Fig. 55) a sheet of .001 tin foil is burnished. Petroleum jelly is applied to the foil, and the tray pattern is formed with a single sheet of base-plate wax. The lower pattern is formed to cover the entire base area (Fig. 56), but is slightly underextended at the periphery. The upper tray is formed to cover the palate and the buccal flanges in the molar region. The labial flange is left open from bicuspid to bicuspid, the tray being carried to the crest of the ridge in that area. The flanges in the molar region should not be long enough to reach the buccal fold. If the tray is to be used for a very soft upper, which will be painted first, three sheets of wax should be used as a spacer. A doubled piece of base-plate wax about ½-inch wide is applied as a sprue at the median line of the posterior border. This is invested in a casting ring with a thin mix of any casting investment.

The wax is boiled out in hot water, and the tray is placed in a furnace to dry and heated to 800° F. to drive off all water of crystallization. Then it is cooled to 500° F. and cast (Fig. 57) with hard aluminum alloy. Clutch metal is ideal for this purpose. It is hard and strong without being brittle, and casts very easily.

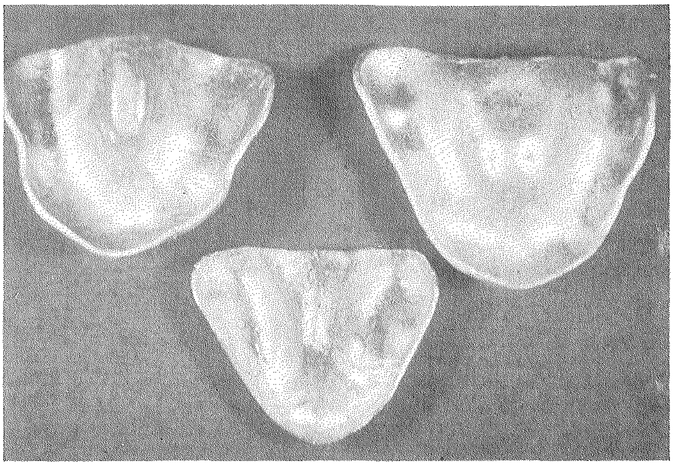


FIG. 58. Trays showing labial flange extensions.

The tray should be carefully checked in the mouth to be sure that it is not overextended on the peripheral outline. If it pushes too deeply into the buccal fold, it is trimmed with plate shears and smoothed with arbor bands.

The extension of the labial flange will vary with tissue conditions. In a mouth with firm ridge tissues, the labial flange can be extended almost to the peripheral border. A group of trays with various labial flanges is shown in Figure 58.

### PREPARING THE PATIENT

A successful mucostatic impression requires good co-operation from the patient. It is important that he be coached beforehand to understand his part in the procedure. He should be told that the object of the impression is to obtain a negative of the tissues when they are completely relaxed and at rest. While a certain amount of manipulation of the tissues is required to carry the tray to its place in his mouth, once it is seated in place, and he is told by the operator to do so, he must relax all his facial muscles and allow them to hang loosely while the material sets. He should not hold his mouth stiffly open or closed. He should just let the mandible hang. He should not swallow if he can avoid it, but let the saliva drivel and be caught in a pan. For lower impressions, just before relaxing, the tongue is pushed forward once to allow the material to settle down below it; then the tongue is carried back and its muscles are relaxed with all the other muscles. If a proper mix has been used, the period of relaxation is not hard for most patients. In the presence of saliva, the material should be sufficiently set in 1 minute that it will not be distorted by slight movements of the tongue or the cheeks, even though it is not hard enough to remove from the mouth. Of course the patient must not talk or move his head around until the material is perfectly hard.

Except when the material is being painted on the tissues with a brush, it is not necessary to have the tissues bone-dry, but there should not be any free saliva present. The mouth should be dried with exodontia sponges and then packed to absorb saliva while the mix is being made. In the lower, a sponge should be packed on each side of the tongue, covering the ridge. On the upper, a sponge should be spread over the palate and the buccal flanges. The mouth should be kept retracted after the packs are applied until the tray is in the mouth. A small amount of petroleum jelly should be applied to the lips and the adjacent skin.

### TAKING THE IMPRESSION

The tray is tested in the mouth and trimmed, if necessary. It is dried with an air blast. The powder and the liquid are poured on the slab. There is no need for haste, because the material will not start to set until it

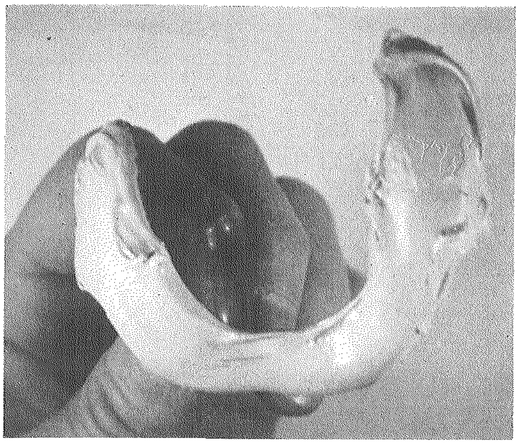


FIG. 59. The lower tray is filled with zinc oxide paste.

FIG. 60. A cone of material is placed in the upper tray.

is mixed. The assistant retracts the cheeks. The tissues are dried and the packs are applied. The material is mixed and the tray is filled. For the lower impression (Fig. 59), the entire tray is overfilled. For the upper impression, the material is placed as a cone (Fig. 60) in the center of the palatal portion of the tray. The tray is inverted quickly so that the material is hanging, and the tray is turned constantly to prevent the material from running out while it is being carried to the mouth. The packs are removed from the mouth, and the tray is carried into the mouth, but not seated on the tissues.

If it is a lower impression, the fingers are held lightly on top of the tray to prevent displacement, and the patient is told to stick out his tongue. As the tongue goes back, carrying the tray down, the fingers are withdrawn from the mouth and the patient is told to relax and remain relaxed until the material has set. The retractors are removed. At the end of 1 minute, the patient is cautioned to remain relaxed while the lip is pulled away gently so that the material may be tested to see how it is setting. If it feels hard to the point of an explorer, the patient is allowed to swallow. The impression remains in the mouth for 3 minutes, and then the patient rinses until he loosens it. It is removed from the mouth and handled carefully (Fig. 61) so that the frail, thin detail will not be damaged. If the edges are not thin and frail, it is probably not a good impression. It is rinsed in cold, running water to harden before it is tested.

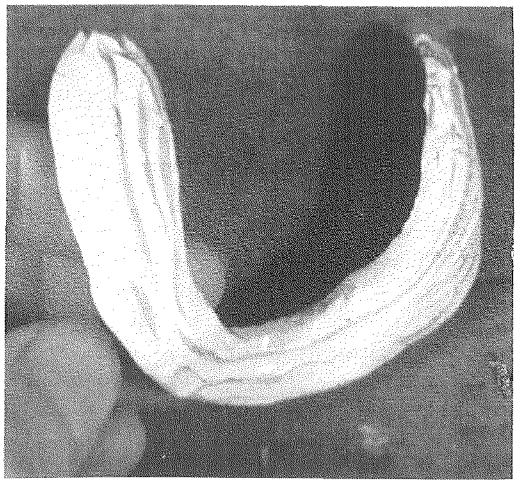


FIG. 61. The lower impression.

The upper impression is somewhat more difficult to make. The material is carried up against the palate and then gently teased up to place until it runs out at the anterior part. This must be done fairly rapidly, but without undue haste. The retractors are removed quickly, and then the fingers are removed carefully from the center of the palate, the tray being allowed to hang from the paste. In seating the tray, the forefinger is used in the center of it. Here the consistency must be exactly right or the tray will drop down, leaving a large, hollow space. There must be

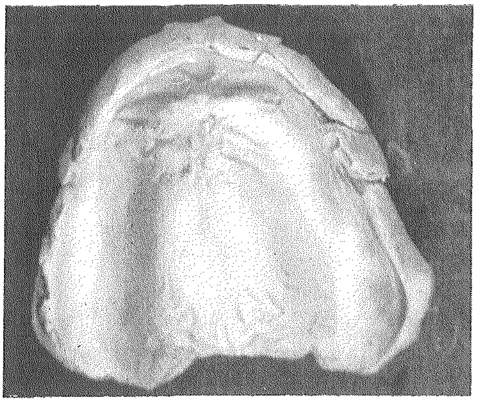


FIG. 62. An upper impression with built-up labial flange.

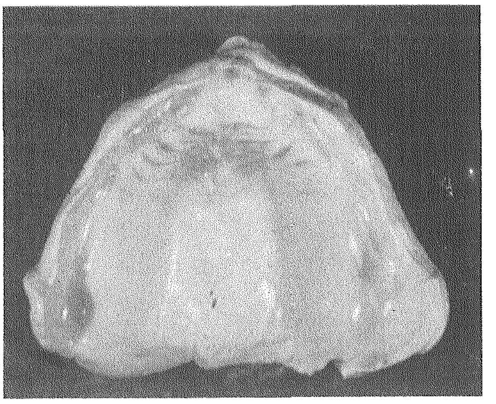


FIG. 63. An upper impression with added labial periphery.

enough working time to allow this manipulation and to have the material still flow freely after the finger has been removed and the mouth is relaxed. While this mix is setting, a second, somewhat smaller quantity is prepared for mixing. As before, the patient is told to remain relaxed, and the lip is lifted gently. A thin layer should have run up part way on the labial flange. If it is quite hard, the next step may be taken. The second mix should be of the same consistency as the first.

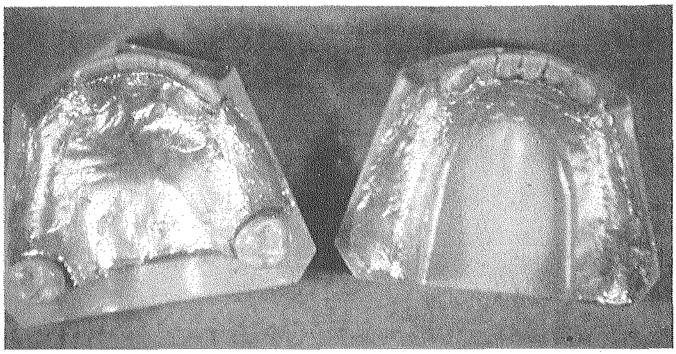
A good portion is picked up on a cement spatula, the lip is lifted, and the spatula is inserted along the inner side of one cheek. The lip is released, and the material from the spatula is spread over the buccal tissues. This is repeated on the inside of the other cheek. The patient remains relaxed until the material has set. Now, when the lip is lifted, the buccal flanges will be formed, but in too thin and frail a layer to permit removal.

A small, heavy mix of the same material is made. The lip is lifted and the surface of the set material in the mouth is dried. A thick layer of the heavy mix is applied with the cement spatula to strengthen the flange. When this has set, the patient is given a glass of cold water and told to rinse until he loosens the impression (Fig. 62). When the upper labial flange can be included in the first impression, it is necessary to make only one addition to complete the labial border, as shown in Figure 63. This is added before the impression is removed from the mouth.

Uppers presenting a lot of loose-hanging, soft masses of tissue require a painted layer before the tray impression is taken. The technic developed by Dr. William Dykins is as follows: A thin, slow-setting mix is applied to the bone-dry tissue with a bristle brush. This mix must be slow-setting so that ample time is allowed for the painting and the mix still will flow freely when the mouth is relaxed upon the completion of the application. The tissue must be bone-dry or the material will ball up when it touches the wet surface. The mix must be thin so that it can be applied readily with the bristle brush bent to an angle of 45°.

The mix is made before the tissue is dried. The mouth is retracted. A piece of fiber lint is placed over each parotid duct and held under the retractor so that neither it nor the cheek can contact the buccal flanges. First a sponge and then a heavy air blast are used to dry the tissue. The impression material is painted rapidly over the entire surface. An air blast is used to blow it all over the mouth. The retractors and the fiber lint are removed, and the patient is told to relax and wait for the material to set. As before, the material is tested gently after 3 minutes. If it is set, the surface is washed with cold water to harden it. Now a large ball burnisher is pressed gently in various areas to test for stability. If it responds properly, the tray impression over the painted layer is begun. Again the cheeks are retracted and the im-

Fig. 64. A spacer for partial denture trays.



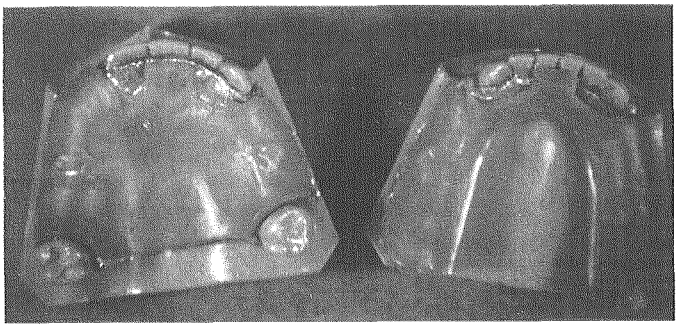


Fig. 65. Patterns for partial denture trays.

pression is blown bone-dry. The tray mix is made as usual and carried to place over the first layer just as though an impression were being taken. When it has set, the patient rinses to remove it.

### Testing for Stability

No matter how they are taken, all impressions must be tested for stability before acceptance. The impression is washed in cold water. The excess material is carefully trimmed away with a sharp Bard-Parker knife. The superficial moisture is blown off. The impression is returned to the mouth and seated, with the mouth relaxed. One spot and then another are pressed, without pulling the cheeks, to see if it yields. The first finger of one hand is pressed against the cuspid region of one side, while the first finger of the other hand is pressed against the molar region of the other side to see if there is any rock. Then the other cuspid and molar regions are tested in the same way. In a similar way, tests are made for anteroposterior stability and lateral stability. If the impression responds favorably to these tests, it is removed and stored in a humidor until poured.

The model should be poured as soon as it is convenient. A mix of Greyrock, somewhat thinner than the manufacturer's recommendation, is used. Here we are not concerned with great strength, but rather with dimensional stability. No separating medium is required. The stone is allowed to become thoroughly hardened and is then immersed in hot water (about 165° F.) to soften the impression for separation. Separation is done carefully to avoid destroying fine detail.

### Partial Dentures

An impression that is correct for the teeth is usually not a good mucostatic impression of the soft tissue. A separate impression is taken to cover the saddle area. The saddle is cast separately and then related to the teeth in the mouth. On the study model (Fig. 64) a single sheet of base-plate wax and tin foil is used as a spacer. If a plastic tray material is used, it must be thin and rigid. It should age on the bench at least 24 hours before use. A cast aluminum tray is much more reliable. The tray pattern is formed from a single thickness of base-plate wax (Fig. 65), and is cast in clutch alumi-

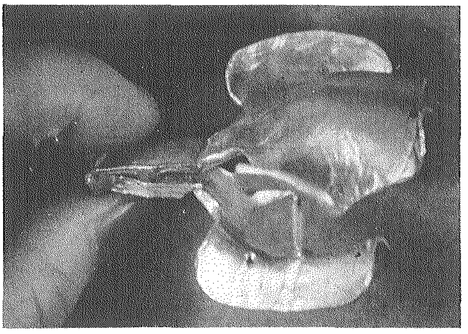


FIG. 66. Cast aluminum partial denture trays.

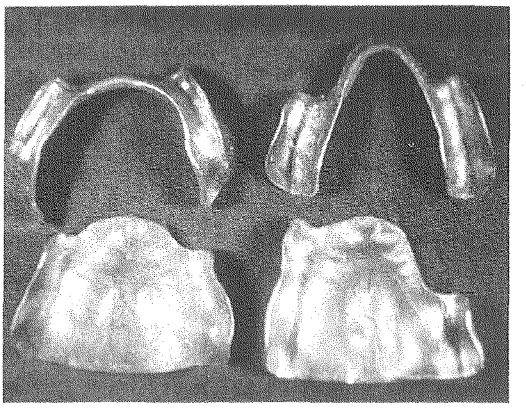
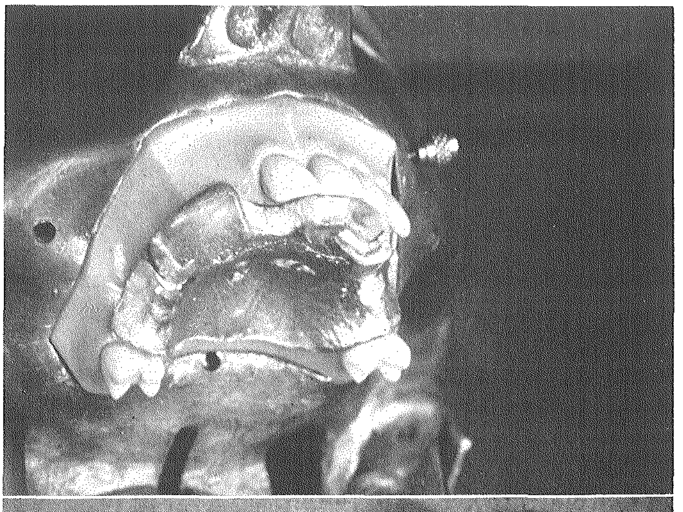


FIG. 69. Some typical partial denture trays.



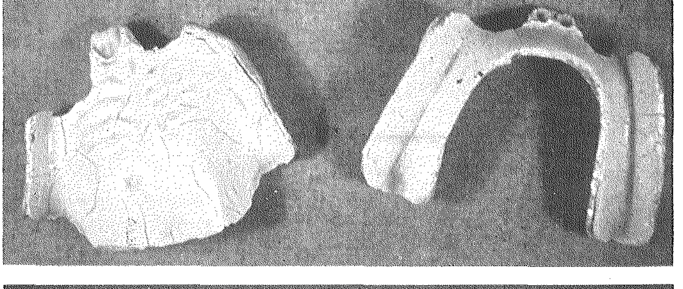


FIG. 67. Partial denture base impression.

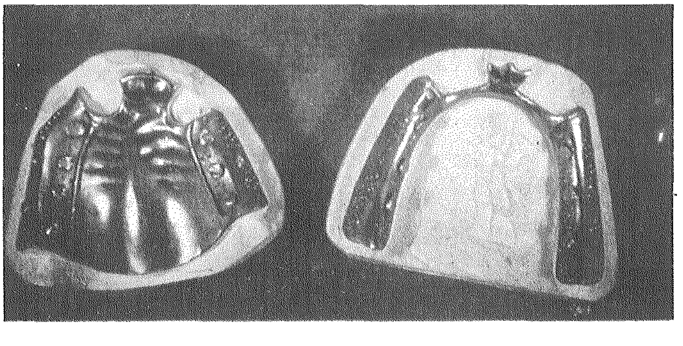


FIG. 68. Partial denture cast bases.

num (Fig. 66). It extends up onto some of the teeth that will not be used as abutments and serves as an index for positioning the base in the mouth. The impression in zinc oxide paste covers just the saddle area (Fig. 67). The excess paste which runs over the teeth is chipped away before the impression is removed. Models are poured in nonexpanding stone, and saddle castings (Fig. 68) are made to include the index. This index is used until the case is completed to check on the position of the base in the mouth. After the last remount, it is sawed off; it is not left as an indirect retainer. Some typical partial trays are shown in Figure 69. Details of assembly and finishing the case will be found in Chapter 20 on Remounting.

### Alternative Methods

Rubber base material frequently offers advantages over zinc oxide paste. One of its chief virtues is that the investment model for casting the base can be poured directly into the impression and separated without damage. This is most difficult with zinc oxide paste. In general, the procedure is the same, with some minor differences. It is not suitable for very soft, mushy tissue. The tray must be extended to the finished periphery and cover the entire labial flange. The periphery of the impression cannot be added later. Only one sheet of wax is used as a spacer under the tray, to give better support for the rubber. This tray must be rigid aluminum—any yield in the tray is fatal. Care must be used not to distort the periphery when pouring the model. When using a rubber base material, it is necessary to dry the tissue more and maintain it longer or the detail will not be good. This frequently will require the use of Vanthene or a similar antisialogogue.

A medium-body rubber base material is used, mixed on a warm slab to hasten the set. The use of additional accelerator will also hasten it to some extent and help to shorten the period of tissue dryness. It is advisable to use a rubber saliva ejector as soon as the material has stiffened enough. It is also necessary for the patient to remain relaxed for a longer period while the rubber sets, and for some people this is difficult. The chief drawbacks to rubber are the setting time and the drying problems, particularly with full lowers.

Immediate dentures (Fig. 70) are handled by making a metal base to cover the healed areas, just as if a partial denture base were being made. This is placed in the mouth, and an alginate impression is taken over the base to include the remaining teeth in the working model. These are cut off the model and the denture is constructed like any immediate denture, with the socket areas in acrylic. To rebase these areas after healing, the acrylic

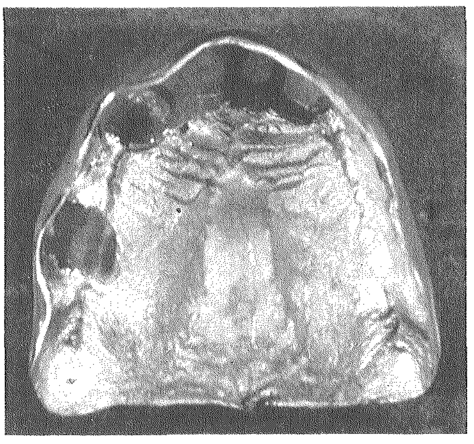


Fig. 70. An immediate denture.

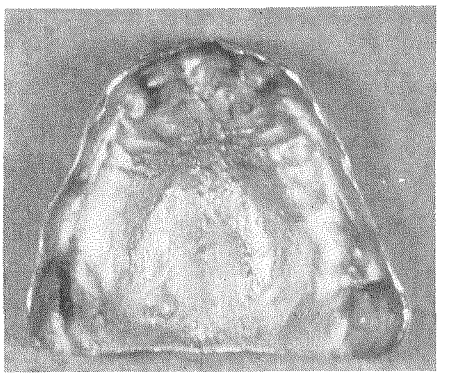


Fig. 71. The base for Figure 70 one year later.

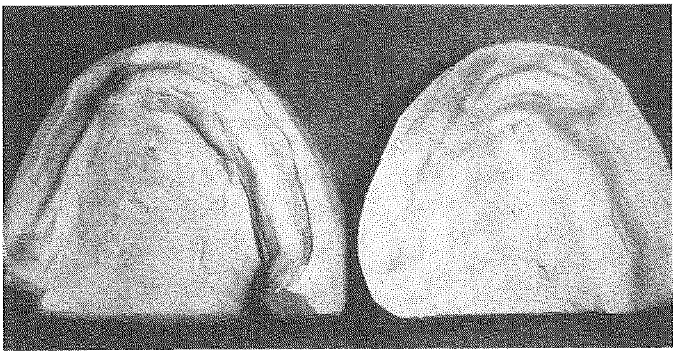


Fig. 72. Immediate lower denture models.

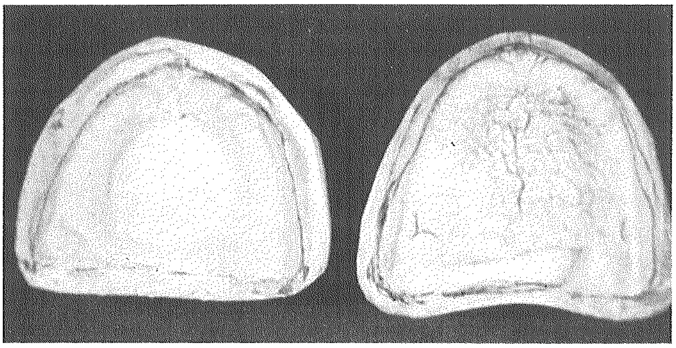


Fig. 73. Comparison of compound and mucostatic models of the same mouth.

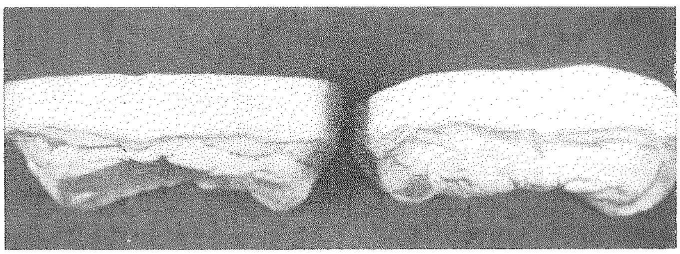


Fig. 74. Comparison of compound and mucostatic models of the same mouth.

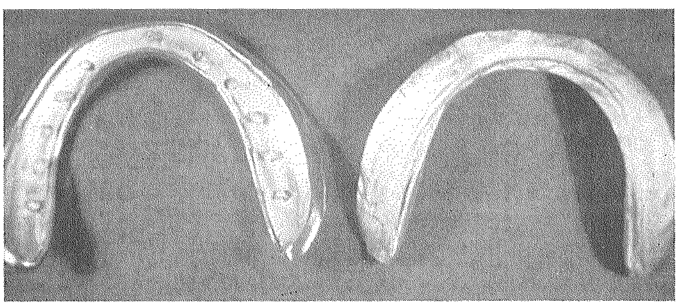


Fig. 75. Full denture bases.

is cut away from the flange, and impression material is packed in from the buccal, in the mouth. When all shrinkage has stopped—usually in about a year—a new base is constructed (Fig. 71).

Immediate lower dentures frequently do not work out as well as upper ones. When possible, it is preferable to extract the teeth, and construct the tray after initial healing. The study model and the mucostatic model are shown in Figure 72.

Comparisons of models from pressure-type impressions and mucostatic impressions of the same mouths are shown in Figure 73 and Figure 74. Soft, flabby tissue was ironed out by the force of the compound impressions.

Frequently, the first attempt will not yield

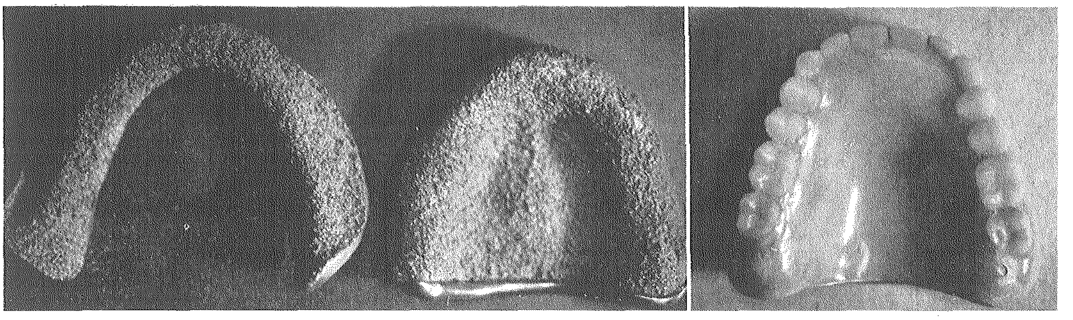


FIG. 76 (A, *left;* B, *right*). Cast aluminum bases, covered with acrylic.

a satisfactory impression but will show what has to be done on the second attempt to overcome the defects of the first one. To remove the material from the tray, the whole thing is immersed in hot water for a few minutes, and the zinc oxide paste can be pulled out as one mass. No attempt should be made to pick it out with a knife.

It should be kept in mind that the success of a mucostatic impression depends upon an accurate metal base (Fig. 75). A very light, comfortable base can be made from Alcoa D-214, an aluminum alloy made specially for this purpose. The pattern is formed from a single layer of 18-gauge wax, with fine, clear, acrylic powder pressed in for retention. On the upper (Fig. 76 A) a lock is formed across the posterior border, but there is no rim lock. The casting is covered with a thin layer of cross-linked acrylic (Fig. 76 B) to eliminate any need for polishing the metal base. Care should be used in polishing the acrylic to avoid generating heat, as this may lead to some warping.

The technic for constructing the denture will be found in Chapter 11.

*Chapter* 6

# The Hinge Axis

The mandible is related to the maxilla by means of the temporomandibular joint. At rest, the joint hangs loosely, held by the capsule and the tonicity of the closing muscles. When the muscles contract to overcome resistance, the joint is pulled tightly together and held by muscular contractions, while the condyle rotates on the meniscus to carry the teeth through the resistance of the bolus. This is not normally a simple rotary closure. At the same time that the condyle is rotating on the meniscus, the meniscus is gliding on the glenoid fossa. But, no matter what the position of the condyle is in relation to the fossa, the closing rotation is the same. The closing path is a resultant of the closing rotation's taking place at the same time that the condyle is gliding in relation to the fossa.

Because the upper teeth are in fixed relation to the glenoid fossa and the lower teeth are in fixed relation to the condyle, the relation of the teeth as they come together is determined by the relation of the condyles to the glenoid fossa. The movements of the mandible are activated by the muscles but controlled by the temporomandibular joint, and the movements as it is closing are the same with or without teeth. The joint relations do not change as a result of the loss of teeth. If, as the teeth are coming together with muscular force, they are not in correct relation to the closing path of the mandible, the joint is displaced and the muscular force is exerted as a lateral stress against the supporting structures of the teeth. This, with tissue fatigue, may lead to pathologic breakdown. When this occurs with complete dentures, it is usually the denture base which is displaced.

## PATH OF CLOSURE

The closing action that brings the teeth together is a result of rotation of the condyle on the meniscus in the lower compartment of the temporomandibular joint. This rotation takes place about an axis (Fig. 77) that is called the hinge axis. Since this axis is in the mandible, wherever the mandible moves the axis moves with it. The rotation of the condyle on the meniscus is a part of every arc of closure of the mandible, as the condyle is rotating while the meniscus glides on the glenoid fossa. The gliding action of the meniscus results in a movement of the hinge axis and brings about the changing relation of teeth, which require cusps to maintain a stable relation to the changing relations in the temporomandibular joint. The hinge axis governs the arc of closure in every contacting position of the teeth.

The mandible is never symmetrical, nor are the condyles symmetrical bodies. As a result, the mandible does not open parallel with the sagittal plane. As it opens, it deviates to the side, in addition to the lateral excursion taking place in the upper compartment of the joint. Being a rigid body, the mandible is compelled to rotate about an axis. This rotation of the asymmetrical condyles and the asymmetrical mandible is guided by the form of the surface on the meniscus. It is not a bone-to-bone contact of the condyle on the fossa. The form of the meniscus, interposed between the condyle and the fossa, and the form of the condyle surface which rests upon it combine to produce a rotation about the hinge axis. The fact that the teeth can and do describe an opening rotation of the mandible about a stationary projection of the axis on both sides simultaneously is prima-facie evidence of an intercondylar axis.

In mastication, the hinge axis is in constant motion. The patient does not normally close in centric relation. Against resistance,

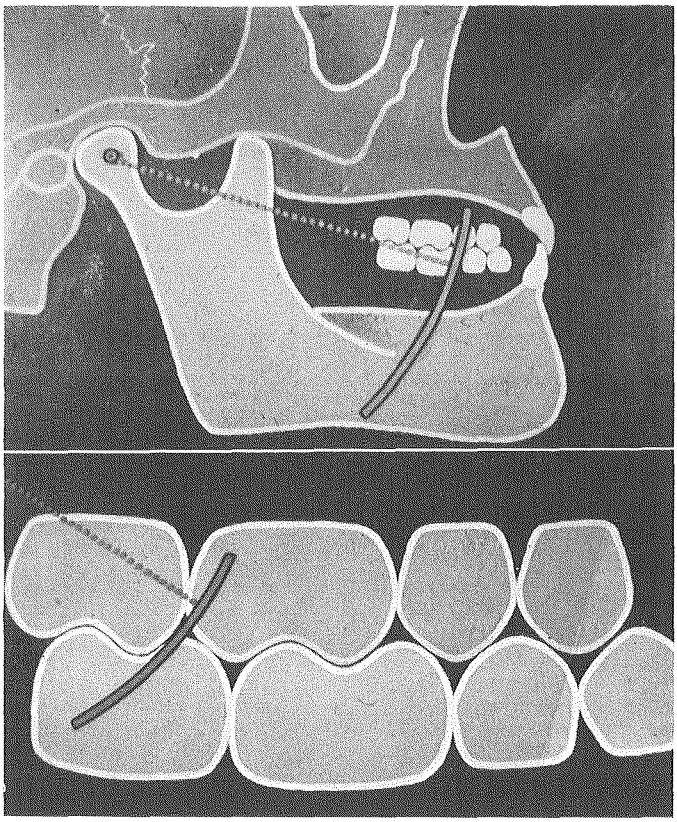


FIG. 77. The hinge axis is the arc of closure.

he closes in lateral excursion and glides back to and through centric relation. In normal relation, the rotating and the gliding actions always occur simultaneously, but in a great variety of combinations. In order to reproduce all these combinations, it is necessary to separate the two components and transfer them to the articulator, to recombine them in the occlusal forms of the teeth.

The hinge axis is only one component of the temporomandibular joint-to-tooth relations. It must be the first consideration, since it is the means of correctly orienting the teeth in the articulator and the occlusal surfaces in articulation. If the mounting is not correct, then none of the other relations can be correct. The purpose of locating the hinge axis is to provide a means of transferring the patient to the laboratory bench for the construction of restorations which will be physiologically sound. Centric relation is the most posterior superior position of the hinge axis which the patient can reproduce by his own muscular force. The paths of motion of the mandible all start from this terminal position and extend outward.

## LOCATING THE HINGE AXIS

The practical problems of transferring these relationships to an articulator are not as complex as they would appear to the uninitiated. With a small amount of experience, locating the hinge axis is a matter of a few minutes' time. The hinge bow is similar to a conventional face bow, except that for the convenience of the operator the side arms are adjustable for both length and angle. These adjustments make a relatively simple operation out of what would otherwise be a very difficult, time-consuming task. When sufficient teeth are present, the hinge bow is retained on the mandible by means of trays, called clutches, cemented to the teeth with zinc oxide paste. On the completely edentulous patient it is held by means of a chin clamp, which holds the lower base with a bite fork to attach the bow. In either case, with gentle guiding by the operator, the chin is dropped open with pure hinge motion while the stylus of the hinge bow, placed opposite the condyle, is adjusted.

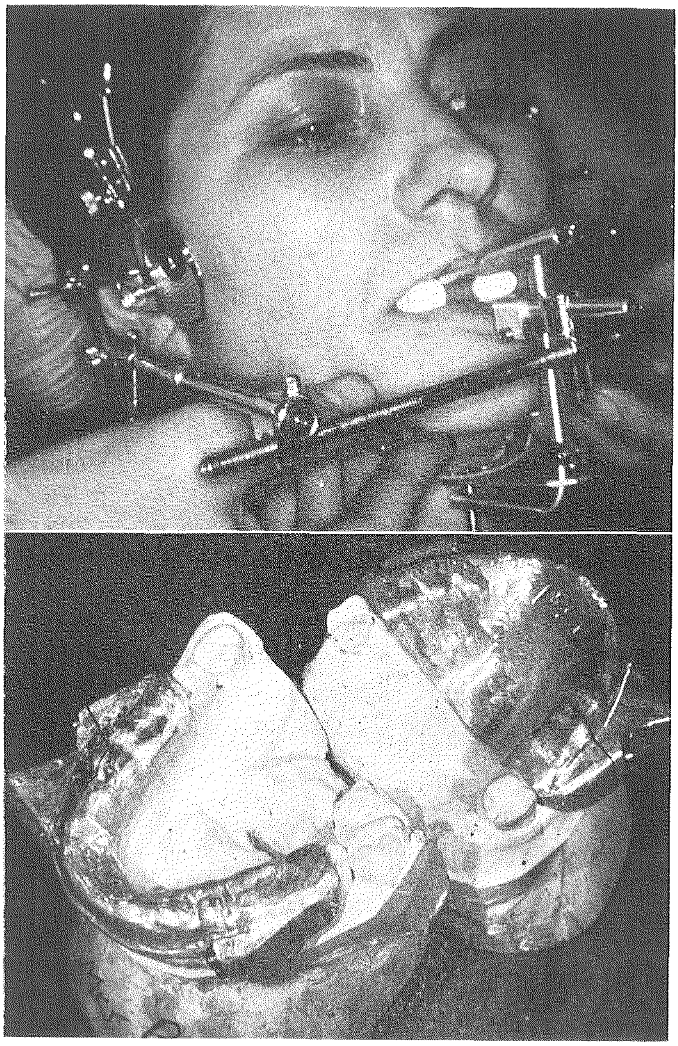
With very little practice, and a trained guiding hand, most patients will readily execute the hinge opening without gliding of the condyle. The guiding hand is essential because this is not a natural opening for the patient to make unaided. But it is not an abnormal action, because every movement which the mandible makes is a resultant of this rotation combined with any one of many gliding paths. It is not a forced, strained action. In normal opening, the patient protrudes his mandible as he opens. A guiding thumb on the chin aids him to open without protrusion. This is necessary in order to recombine this rotary component with the gliding paths that are to be recorded subsequently. If the patient always used the same combination, this would not be required, but he can and does use an infinite variety of combinations. This is the real reason for locating and transferring the hinge axis. It is not simply a mounting convenience for controlling the vertical dimension.

Without doubt, the most difficult part of locating the hinge axis is acquiring the ability to feel and control the joint action with the thumb against the chin. It must not be a forced, strained action. Rather, the thumb must be a gentle, guiding aid to the patient's own muscle action, not a compulsion to abnormal stress. It is the same action that is required for a centric bite and is different for every patient. The hinge axis must be located in the most posterior superior position of the condyle. All paths of motion take place from this position outward, and return to it to start another path. This is likewise centric relation. So a correct articulator mounting involves two considerations: the teeth must be oriented to the hinge axis, and this relationship must be established in the terminal hinge position of the condyle, which is centric relation. Articulation is the changing relation of the upper teeth to the hinge axis in paths of motion radiating from centric relation forward and laterally.

The thumb on the chin must provide just enough guidance to help the patient to overcome protrusion with opening. Since the muscle force exerted by the patient against the thumb, as he attempts to protrude, will be different for each patient, the guidance will be different each time. Therein lies the real problem of locating the axis and taking the centric bite. No mechanical device will take the place of the knowledge and the skill of the operator in this respect. It is the problem of acquiring the feel of the thumb against the chin to be able to detect pure rotation of the mandible without wavering. Too much force will do more harm than good. It will cause the patient to resist immediately with abnormal muscle action. As the patient opens and closes, the thumb is placed on the point of the chin. As the action continues, the guiding force required is determined by the force exerted against the thumb by the patient as he opens. A few minutes should be spent in practicing this action with the patient until he can co-operate easily. The operator should explain what he is trying to accomplish, but should not have the patient make a voluntary effort to aid him. This is almost sure to result in a wavering chin.

Proper instruction to the patient before placing the clutches can be of great aid. The patient should be told to let his mouth open with an easy, relaxed swing, but not to exert any force to open wide. He must not push his mouth open. The operator exerts gentle force down and back. At first the opening will be very slight. The patient is instructed not to attempt to close his mouth hard or to attempt to close his teeth all the way. The word "bite" should never be used in explaining this to the patient. He is told to make an easy closure until he feels some point of contact between his teeth, and to stop there. If the thumb is removed, he will usually slip into occlusion and thus disclose the extent of correction that is required. As

FIG. 78 (*Top*). Edentulous clamp used to stabilize the hinge bow or (*bottom*) clutches.



the action is repeated, the patient will usually open wider and wider. This is necessary for accurate location of the axis. Most people can execute an opening of an inch or more in the anterior region with comparatively little practice. This should be determined before placement of the clutch or the base plate.

## ATTACHING THE HINGE BOW

When the operator has verified his ability to control the patient, the hinge bow is attached. It may be retained by clutches, as shown here, or by the edentulous chin clamp, as explained in Chapter 11 on Complete Dentures. The skin over the temporomandibular joint is covered with a fine-ruled graph-paper card on an upper bow, sometimes called a "flag" or an edentulous cap. The attachment and the use of the hinge bow are the same, whether it is being held by a clutch cemented to natural teeth or by an edentulous bite block held by a chin clamp (Fig. 78).

A stop must be provided so that the clutches will not collide and rock the mandible. If the center bearing pin has been incorporated in the clutches, it is adjusted prior to cementation so that they will not quite touch on closure. If, as in the case shown here, the center bearing pin is on

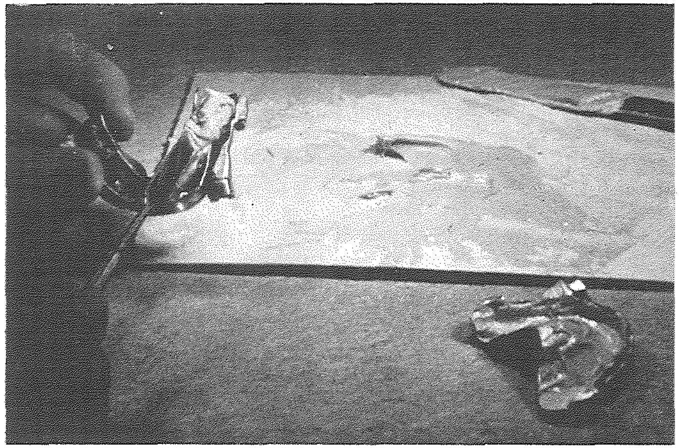


FIG. 79. Zinc oxide paste is used to cement the clutches.

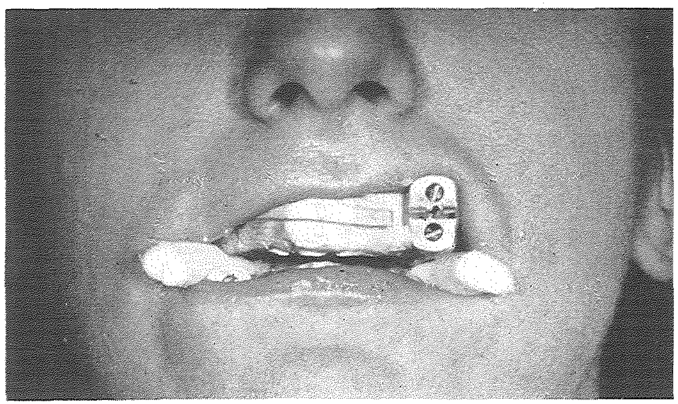


FIG. 80. The patient bites on cotton rolls.

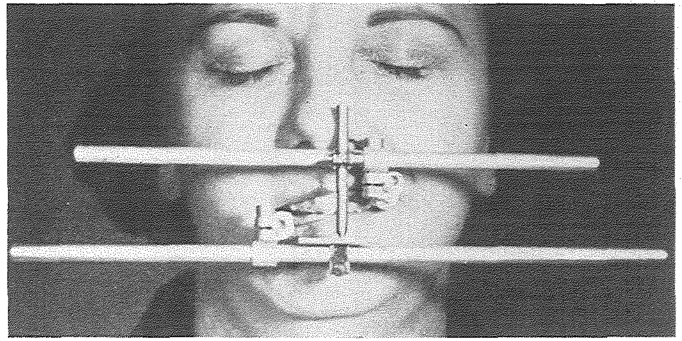


FIG. 81. The crossbars are parallel with the tragi of the ears.

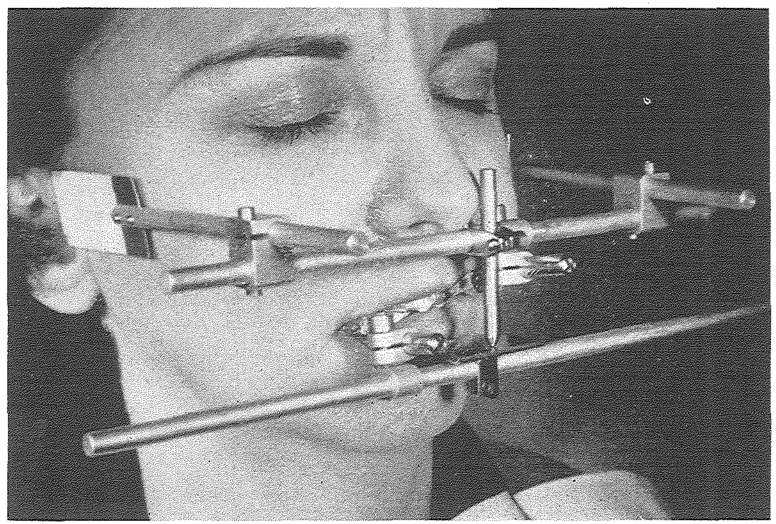


FIG. 82. The flag is placed in front of the ear.

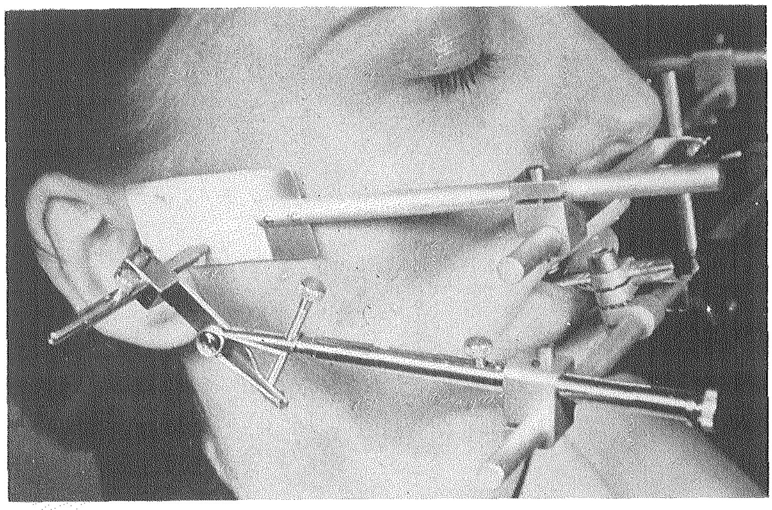


FIG. 83. The stylus is positioned below and in front of the tragus.

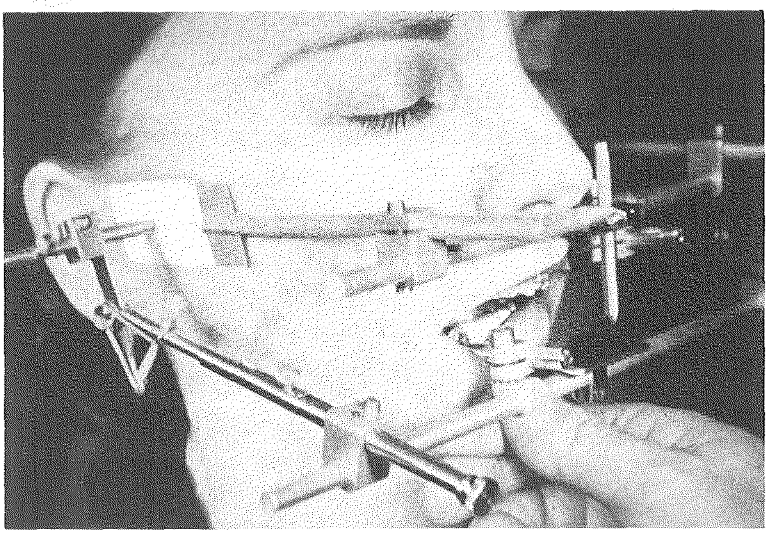


FIG. 84. The thumb guides the patient in hinge rotation.

the hinge bow itself, it is adjusted after the clutches have been cemented. A sufficient amount of zinc oxide paste is placed in the clutches (Fig. 79) so that they will be securely cemented but without gross excess which will annoy the patient. They are firmly seated, and then cotton rolls are inserted between them posteriorly (Fig. 80) for the patient to bite and retain while the cement is hardening. It is important that this cement is a material which sets hard, with no flexibility, and that the clutches are firmly seated while it is setting.

When the paste is thoroughly set, the excess is chipped away, particularly in the palatal region. The crossbars are attached to the studs so that they are parallel with the tragi of the ears (Fig. 81) and not with the pupils of the eyes. The flags with graph paper cemented to them are attached to the upper bow (Fig. 82) just in front of the tragi of the ears, and are pressed tightly against the skin. The lower, adjustable side-arms are attached (Fig. 83) so that the stylus point will be below and in front of the tragus. The stylus pin is resting loosely in the tube so that it will not drag on the paper, and the tube is about ¼ inch from the paper. All the clamps must be securely tightened, as the slightest movement would destroy the whole value of the procedure.

With the thumb against the chin, pressing

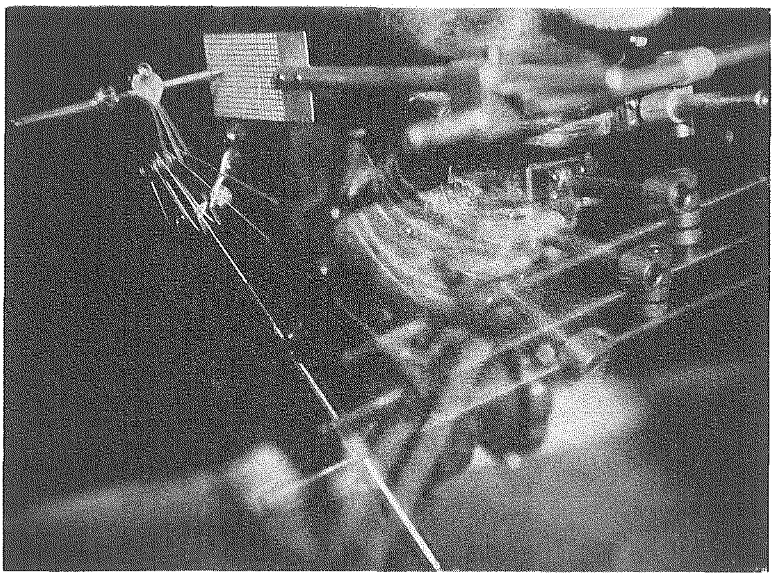


FIG. 85. The stylus arcs as the condyle rotates.

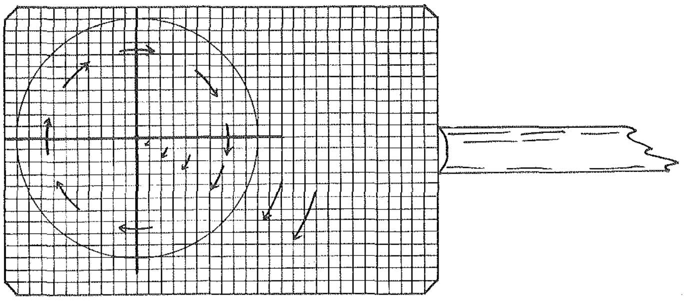


FIG. 86. The arc indicates which way to adjust.

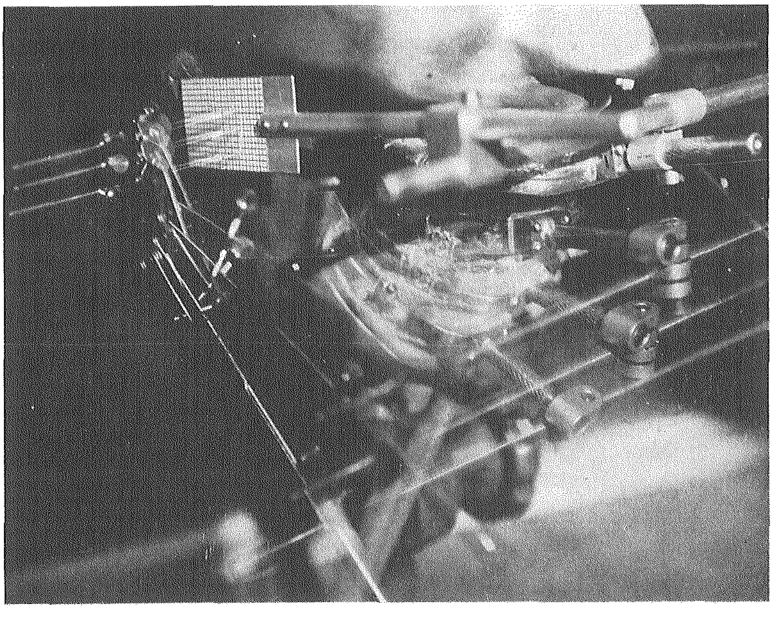


FIG. 87. The stylus point is stationary on the axis.

down and back (Fig. 84), the patient is guided in repeated hinge closures. He is instructed to let his mouth swing open, and not to make an effort to push it open. As the patient's mouth opens, the point will describe an arc (Fig. 85) similar to a compass-tracing. The hinge bow actually is a glorified compass. If, as in Figure 86, the point scribes a downward arc as the mandible opens, the operator knows he has to adjust it further back to locate the center of the arc. If it scribes a backward arc, he has to adjust it higher. During these repeated openings, many people will make an involuntary protrusion about every fourth or fifth opening. The action of the stylus will guide the operator in determining how much force is required to just overcome the patient's natural tendency to protrude the mandible each time it opens. Pressure is maintained back and down. When the patient closes, this pressure is still maintained back and down. No attempt is made to close the patient's mouth. He must close with his own muscles against gentle resistance from the operator. The trained thumb on the chin is to aid the patient, not to force him.

The point of the stylus is adjusted as the patient opens and closes, until it remains stationary with repeated rhythmic rotations (Fig. 87). The fine-ruled card aids in determining when that point has been reached. As the patient continues to open and close with guided force, the stylus is adjusted by means of the micrometer screw which extends the sidearm and the rocker-arm adjustment, until the point remains stationary, as determined on the fine-ruled card. As the stylus comes closer, the point will arc less and less. Finally, it is necessary to use a loupe or a magnifying glass. When the point appears to have ceased arcing, the operator sights along a horizontal line to see if the point remains fixed with that. Then he sights along a vertical line to see if the point likewise is stationary with that. If it is stable in

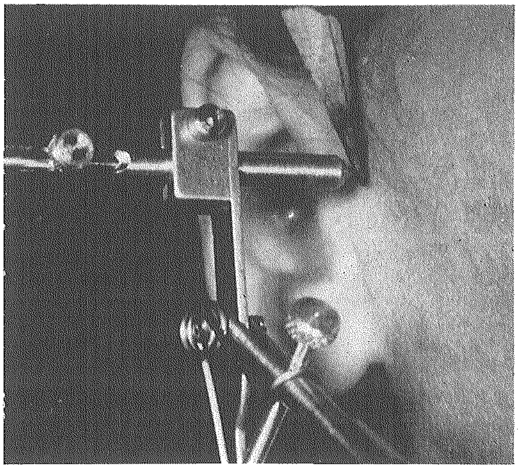


FIG. 88. Indelible pencil is applied to the stylus point.

both directions, then it is within clinical limits. The point of the stylus must not be caught in the lined card.

Only the point of the stylus will reach the stationary point on the card. The axis is not perpendicular to the sagittal plane. The stylus itself usually is not in line with the hinge axis. The point of the stylus rests on a projection of the axis on the card. The hinge bow is set up so that the styli are at right angles to the sagittal plane: the stylus does not lie on the hinge axis—only its point does. To transfer this axis correctly to an instrument, the axis must be projected out to the point of the stylus by means of a mounting frame. The stylus must not be brought in or out to meet the articulator.

When the axis has been located, the card is removed, permitting the skin to return to its natural level. The stylus point is coated by a wet, indelible pencil (Fig. 88). The patient is seated upright to avoid skin displacement by the headrest. The mandible is protruded and retruded several times to be sure that the axis is in centric relation, and the stylus is carried in to contact the skin (Fig. 89), leaving an indelible mark. Now the hinge bow is removed, and this point is tattooed into the skin (Fig. 90) as a perma-

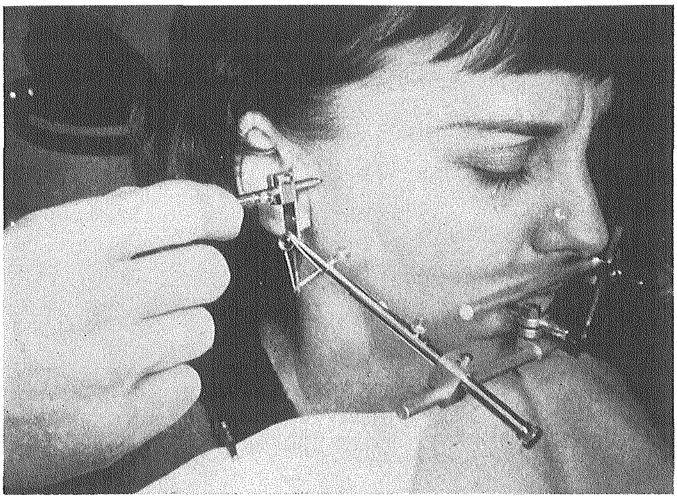


FIG. 89. Marking the skin.

FIG. 90. Tattooing the hinge axis.

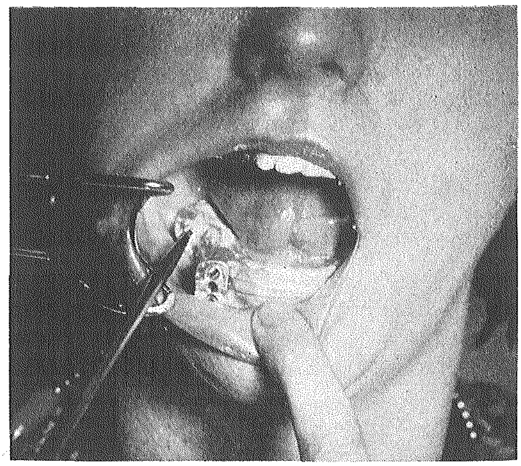


FIG. 91. Separating the clutch.

nent reference mark, since it has been determined that, if it is accurately located, it will remain as a constant guide for future mountings. It is important to minimize skin movement during these mountings.

The tattoo needle is a special 3-pronged needle, formed so that the recesses between the three points will carry the tattoo material into the skin. The three points should form a tripod. The tattoo material is red sulfide of mercury, sold under the trade names of English vermilion and cinnabar. It must be finely powdered so that it will make a smooth paste. It is mixed with just enough alcohol to make a thick paste. As large a clump is picked up on the point of the needle as it will hold. It is forced deeply into the skin—at least 1 mm. The needle is withdrawn, the handle is turned, and the needle is carried in a second time. This is repeated a third time. If it is not deeply embedded, the paste eventually will peel off and be lost. For a few days there will be a slight lump, which will leave a faint pink dot when it subsides. There is no danger of infection as cinnabar is a powerful germicide. When subsequent remounts are being made, the dot should be marked with a pencil for guidance in locating the stylus point.

The clutches are removed (Fig. 91) by

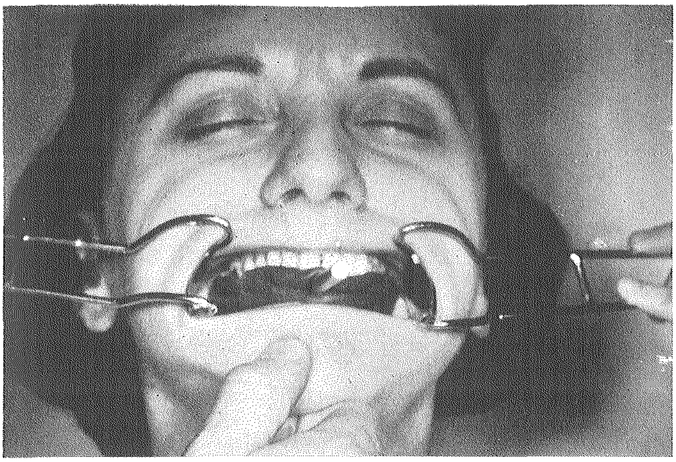


FIG. 92. Compound on the bite fork.

removing the screws which hold them together and separating them along the sawed cut. The labial section is pried off, and then the lingual half is lifted straight up.

## TRANSFERRING THE AXIS

The hinge bow is now used as a conventional face bow or transfer bow to mount the upper cast on the articulator. It is held in the mouth by a fork (Fig. 92), seated on the upper teeth with a compound bite, or attached to an upper edentulous bite block. With the patient seated in the same upright position as when the skin was marked, the styli are adjusted to just contact the tattoo marks, and are locked in position. For subsequent remounting purposes it is also necessary to establish a plane of reference at this time.

The Frankfort plane is convenient, since it also shows the correct orientation of the teeth to the facial pattern. Originally the first face bows, such as Snow's, were oriented to the ala tragus plane for establishing the plane of occlusion. Simonson developed the use of the Frankfort plane for orthodontic orientation of the teeth in the facial pattern by means of his gnathostat mountings. The plane used today is quite similar to this, differing only in the ear point, which is located on the axis. The nose point is placed at the floor of the orbit on the right side of the nose, at a point alongside the infraorbital notch. The plane of reference is purely arbitrary and may be anything that the operator chooses, but, once it has been established and the paths of motion have been oriented to it, it must be maintained in all subsequent mountings. This axis-orbital plane, as it is called, is related to the face bow and locked in position, and the assembly is removed from the face.

The stylus pin of the axis-orbital indicator is held by a spring in contact with a block, so that it is at all times parallel with the axis-orbital frame. It is spaced by the block so that the point of the stylus lies in the same plane as the point of the axis pin of the hinge bow. It must always be placed to the right of the nose, with the stylus below the frame.

The stylus is arranged in this fashion so that in subsequent mountings the three styli always will lie in the same plane as in the first mounting. It would not be possible to put the hinge bow back on the patient in the same position each time. However, placing the orbital indicator further out or further back, or further to the side, merely will project the plane further out or back. As long as the points of the axis pin fall on the projection of the axis on the face, no matter at what angle, and the stylus point of the orbital indicator coincides with the nose

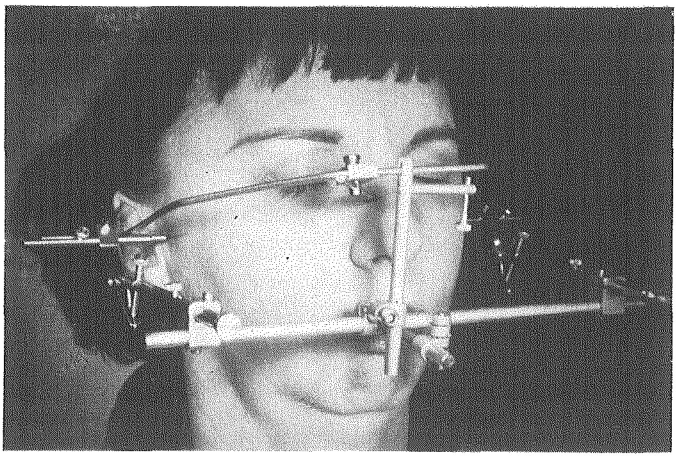


FIG. 93. Using the hinge bow as a transfer bow with the axis-orbital indicator.

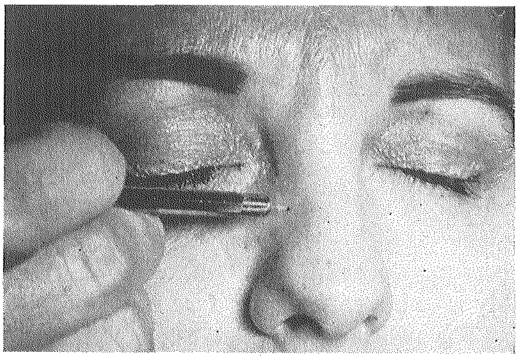


FIG. 94. Tattooing the orbital mark on the nose.

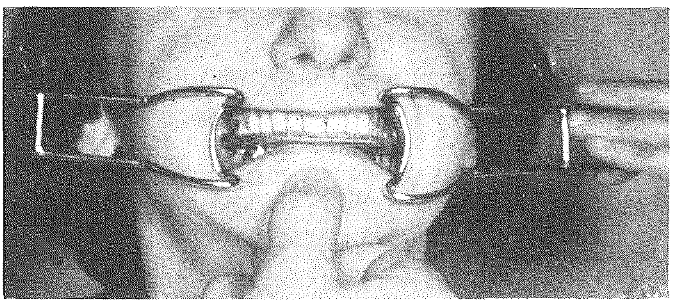


FIG. 95. Taking the centric bite.

mark, the plane of reference will be the same if the mounting frame is used to orient it to the articulator.

When the hinge bow is being used as a transfer bow, the tubes are adjusted in the clamp, instead of the styli in the tubes. This is done so that the styli can be removed, to enable the bow to be removed from the face, and then replaced in the same position. The tube clamp is loosened on the rocker arm. The stylus is set in the tube, with the thumbscrew against the bottom of the slot, and is locked. Now the point of the stylus is adjusted to touch the skin, by sliding the tube in the clamp. The tube is locked in the clamp, and the stylus is withdrawn. After the transfer bow has been removed from the head, the styli are replaced in the tubes and again locked with the thumbscrews against the bottom of the slots.

The axis-orbital indicator is held by a vertical support attached to the bow when it is used as a transfer bow. This is an L-shaped piece (Fig. 93) with a thumbscrew held by a universal clamp. The shaft is clamped outside the crossbar, to the right of the nose, so that the short shaft with the thumbscrew bridges the nose. A mark is tattooed on the right side of the nose (Fig. 94), opposite the infra-orbital notch and well to the front of the nose in the cartilaginous area. The axis-orbital indicator is placed so that the ends rest on the stylus tubes and the front rests in the notch of the axis-orbital support. The stylus is pushed in until it contacts the nose. The support is now raised until the point of the stylus touches the point on the nose. It is rotated so that the thumbscrew is below, but not touching, the axis-orbital indicator frame. This will be used later in mounting. The axis-orbital support is locked securely, and the indicator is removed.

Since the face bow cannot be changed to fit the articulator, a mounting frame must be provided to project the axis of the articulator to meet the face-bow stylus point, and the two are locked in position, while the cast is attached to the articulator. Likewise, the articulator settings must be oriented to the plane of reference by means of an orbital rest on the upper bow. Herein lies the need for an articulator in which the condyle path and the Bennett movement are a part of the upper bow just as in the skull, and the axis in the lower bow just as in the mandible. Otherwise the settings cannot be oriented to the plane of reference.

The transfer is completed by taking a centric bite (Fig. 95), as explained in Chapter 7.

*Chapter* 7

# Centric Bite Procedures

The problems of obtaining a correct centric bite stem from a group of factors which operate simultaneously and are of equal importance. Centric relation is the relation of the two compartments of the temporomandibular joint to each other. Centric occlusion is the relation of the teeth to each other. A correct centric bite requires orientation of the teeth to each other in the terminal hinge position of the temporomandibular joint.

There is no one method of obtaining a centric bite which is best under all circumstances. Depending upon the kind of models to be oriented, different materials and methods are used. But, as far as the joint aspect is concerned, all these methods are designed to accomplish the same objectives. Two things are necessary: the teeth must be related to the hinge axis and they must be related to each other in the most posterior superior position of the hinge axis.

The clinical problems associated with obtaining a centric bite on the patient arise from the fact that in normal muscular action the two compartments of each joint work simultaneously and, therefore, both joints must be involved. In reality, four joints are all moving at once and, unless the operator clearly understands the actions that are occurring and how to control them, it becomes impossible to locate centric precisely.

## JOINT RELATIONS

To add to the problem, the reflexes developed over many years as the result of premature contact make the patient attempt to avoid terminal hinge closure, which would cause injury and discomfort. This is dealt with in more detail in Chapter 1 (p. 2). These reflexes are initiated by proprioception from pressure on the teeth and usually occur just prior to tooth contact. For that reason, it is desirable to take the bite at a slightly greater opening than the occlusal level, but not so great that it exceeds the patient's rest position and creates muscle stress, which would make it increasingly difficult to secure an unstrained rhythmic rotation of the condyle on the meniscus. The operator cannot force the patient to make this rotary closure: the patient must execute it with his own muscle action. This, in turn, requires that the patient have good co-ordination, which is a human variable and frequently can tax all the ingenuity and patience of the operator. Fortunately, a little practice by a skilled operator can overcome this in a minute or two in the vast majority of patients.

The patient is told what the operator is trying to accomplish. He is to open his mouth without making any effort to push it open. He is told not to attempt to open it wide. The operator's thumb is placed against the patient's chin, and gentle pressure is exerted down and backward. No attempt is made to shove him back. At the start, it is not necessary to be concerned about how wide he opens. After a few tries he will open wider and wider without effort. He should practice a few times before any attempt is made to insert the bite. As the patient is executing this rhythmic opening, the operator's thumb against the chin should exert just enough pressure to overcome protrusion. The amount of pressure is judged by how hard the patient pushes against the thumb. Since the patient cannot use pure rotation by voluntary muscle action, it is necessary to aid the muscles by manual manipulation. This can be a critical procedure, since the purpose is to aid, not to force, the patient. It is necessary to develop skill to acquire the necessary "feel."

The temporomandibular joint is unique in that it is not held together by ligaments but by muscle action. The ligaments limit the range of movement. So, at rest, the joint hangs loosely suspended by the ligaments. As the muscles contract to overcome resistance between the teeth, the condyle is lifted to brace itself on the meniscus so that the mandible can rotate to closure. The nonfunctioning patient seated in the dental chair must be assumed to be in rest position, with the condyles dropped down and forward.

The most difficult part of the procedure is to get the condyle up, not merely retruded. Most people will go readily to their most retruded position, but many will not elevate the condyle to its functioning position during the manipulation involved in most centric-bite procedures. In many cases, it is very difficult to avoid a physiologic rest bite. Physiologic rest is not a functioning position. The methods used to relate the teeth are not normal functional movements. In function, the condyle is lifted out of physiologic rest and braced on the meniscus to overcome resistance between the teeth. So we are attempting by nonfunctional actions to bring the teeth and the joints into a functional relation. Therein lies the chief problem of the centric bite. This situation is further complicated by the neuromuscular reflexes, which already have been discussed in detail.

To avoid these proprioceptive reflexes, it is desirable to take the bite at an increased vertical dimension. But, after mounting, the models must be closed or opened, as the case may be, to the vertical dimension required for the restoration. So the bite must be taken with pure rotary motion, in the most posterior superior position of the condyle on the slope of the eminentia. These are the same position and action that are required to locate the hinge axis, but, since the teeth are not now covered by clutches, they present much more of a problem with neuromuscular reflexes. To aid further in overcoming these reflexes, the material used to form the bite and relate the models should be as soft as possible, to offer the least possible resistance and pressure on the teeth responsible for these reflexes. At the same time, resistance down and backward anteriorly on the chin forces the muscles to elevate the condyles to overcome this resistance.

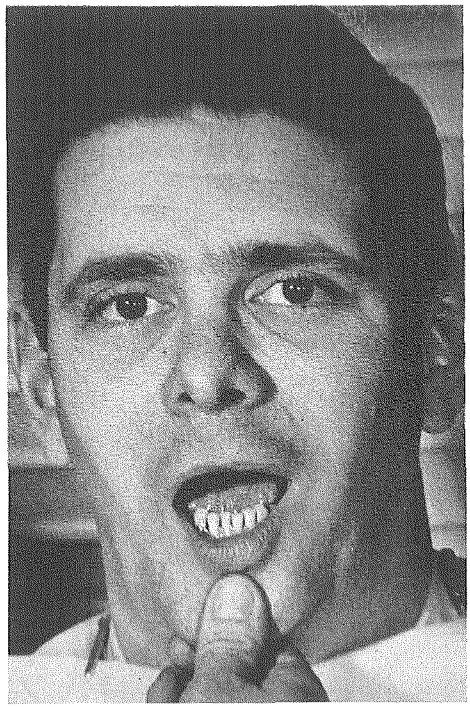


FIG. 96. Guiding the patient.

To recapitulate, there are three problems to solve: (1) combating the protective action of the proprioceptive reflexes, which tend to activate the muscles to move the mandible away from a centric closure; (2) forcing the patient to use his own muscles to lift the condyles out of rest up to the functional position; and (3) overcoming the natural instinct to use the actions of both rotating and gliding.

## PATIENT PROBLEMS

In a theoretically ideal situation, Problem 1 would be solved by taking the bite at an increased vertical dimension, with zero resistance between the teeth. The reflex takes place just prior to tooth contact and depends upon the pressure on the teeth. Therefore, it is related to the materials used to take the

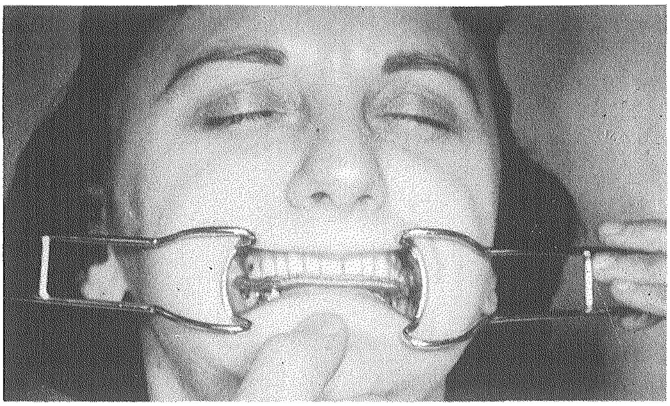


FIG. 97. Using cheek retractors.

bite. Opposing this is the practical fact that the bite must be formed with a material which will enable two models to be positioned accurately for mounting.

Problem 2 is solved by creating a downward pressure on the chin as the patient attempts to close (Fig. 96) and, most important, by repeated closures. This is paramount. *A centric bite of any kind is never taken with a single closure to a static position.* No matter what the method and the material of choice under a particular set of circumstances, the patient must make repeated rhythmic rotary closures to assure lifting the condyles out of rest into bracing position.

Problem 3 requires backward pressure against the chin to overcome the natural tendency to protrude the mandible. Many patients will execute the rotary motion without any trouble until something upon which to bite is introduced into the mouth. The rotary closure is not a natural act, but neither is it abnormal, since every movement of the mandible is a resultant of this rotation combined with some gliding path. However, it is necessary to take the bite with the rotary closure, not only to satisfy the reflex problem but also to be able to change the vertical dimension on the articulator and to use the rotary component of joint movement correctly in articulating teeth.

These are all problems of patient behavior. The patient is not a manikin: he is a human being with human problems. The operator is also a human being. As in any human relationship, some patients are better co-ordinated and better able to co-operate than others. Likewise, some operators are better able to handle some patients. There are definite psychological as well as physical problems involved in the taking of a centric bite.

In most discussions and definitions of centric relation, retrusion is stressed as the chief problem. Retrusion is necessary, but failure to elevate the condyles is of even greater clinical significance. The patient seated in the chair is in rest position. Powerful forced retrusion can push the condyles back so that the patient is unable to elevate them. Likewise, there is no assurance that the force is being applied in precisely the right direction. It is quite possible to push the patient into a Bennett movement and to hold him there by force while he closes into a bite.

There are some patients who resist retrusion so powerfully that forced retrusion may be the lesser of two evils. But the operator should be aware of the dangers involved in such procedures. The use of mechanical elastic retruders presents the same risks. Applying such retruders to tire the muscles before taking the bite defeats the whole purpose.

Tiring the muscles by the use of a retruder, either as a trainer or actually to take the bite, is the one thing not desirable in taking a centric bite. The routine use of such a device, which may be useful on rare occasions, is no guarantee of a good centric bite. Restorations constructed from such a bite may appear to be good on casual examination, but that is because the patient is not functioning. He is in rest position, and the teeth can guide him into an apparent centric closure. Like many other appliances in dentistry, the retruder has an occasional but limited field of usefulness when it is applied with an intelligent understanding of what it can do.

It is almost impossible to take a centric bite without adequate cheek retraction (Fig. 97). The operator must be able to see what he is doing, and the cheeks and the lips must not interfere with the proper seating of the soft material. Suitable retractors must hold the cheeks all the way back to the second molars. Lip retractors are not adequate.

## WAX BITES

For simple purposes, such as mounting study models, a sheet-wax bite is adequate. The thickness of the bite should be such that the cusps of the teeth can produce a shallow imprint in the wax without penetrating enough to make contact with an opposing tooth. To determine the thickness, the patient should be closed repeatedly in the same position as the centric bite, with the cheeks well retracted to determine the opening between the teeth when the first cusp makes contact. The bite should be thicker than this space by one thickness of base-plate wax. For this purpose Aluwax cloth denture forms (Fig. 98) are quite satisfactory.

The posterior half of the wax is dipped in hot water so that the portion which will contact the posterior teeth will be as soft as possible and still able to be carried into the mouth, but the anterior portion will be stiff enough that it will offer resistance to penetration by the anterior teeth. Good retraction is essential, so that the cheeks will not interfere with the placement of the wax.

When the wax has softened, the patient is instructed to make repeated closures before the bite is inserted, while the thumb on the chin gently guides the mandible back to pure rotary closure. When the pressure that produces no protrusion has been determined, the wax is placed over the teeth and the patient is instructed to close gently. Many people will protrude instinctively as soon as the wax is inserted in the mouth.

The first closure should barely imprint the wax. The patient continues to make repeated closures while the thumb guides the chin down and back so that the pressure offers resistance to closure. Each closure should deepen the imprint in the wax. This is continued for from six to eight times until the operator is satisfied that he has obtained pure rotary closure and a sufficient imprint in the wax (Fig. 99) to provide a definite seat for the models. The wax should not run into the interproximal embrasures, nor too deeply into the sulci, as it may prevent the seating of the model.

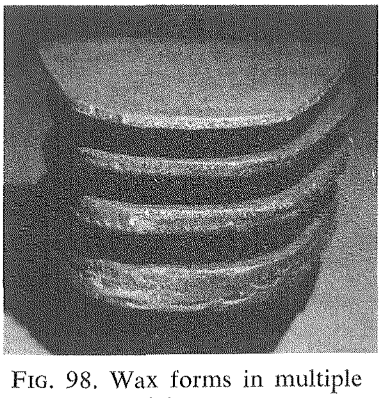


Fig. 98. Wax forms in multiple thicknesses.

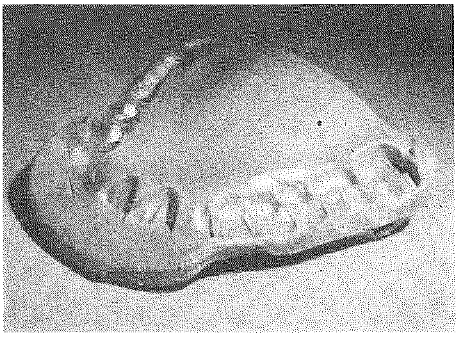


Fig. 99. A wax centric bite. Note the depth of the indentations.

Removal of the wax is sure to cause some distortion, and it is usually not practical to chill it sufficiently in the mouth. After removal, the bite is floated in room-temperature water to chill it enough that it can no longer flow but is still bendable. Now it is replaced in the mouth and the former procedures are repeated until there is no spring to the wax on closure. In checking the bite, the wax is placed on the upper teeth and the lowers close into it. Finally, the thumb is removed from the chin and it is determined that the patient can readily close into the bite without guidance.

If, when he attempts to close voluntarily into it, the patient has to move his mandible to find his way into the wax, the bite should be discarded, as it is almost certainly not a correct centric bite. On the other hand, if the patient can easily close repeatedly into precisely the same imprint in the wax without any guidance, it is an indication, but not a proof, of a correct centric bite.

In addition to the centric bite, a correct mounting also requires a face bow transfer taken on the hinge axis. To make subsequent remounts, the casts must also be oriented to a plane of reference. After the centric bite has been taken, the hinge bow is used as a transfer bow to orient the upper model to the hinge axis and the axis orbital plane. Compound is applied to the bite fork to make a sufficiently deep imprint of the upper teeth to seat the model, but not so deep as to prevent the seating of the model or break any frail margins of the model. Since, in this case, biting is merely to hold the fork in place, no concern need be given to the closure. It is interesting to observe that almost invariably the patient will close in lateral protrusive. The fork with the softened compound is placed in the mouth and seated with a gentle biting pressure. When the compound has stiffened, it is removed and chilled in room-temperature water. The compound is trimmed so only the imprint of the cusps remains, returned to the mouth and checked for accurate seating. The face bow is attached and the operator proceeds as usual.

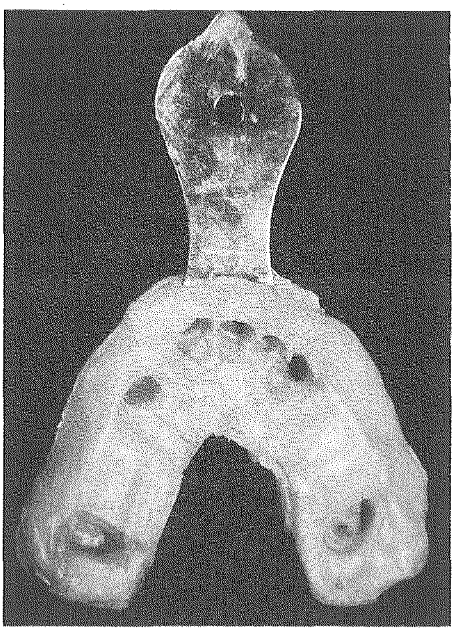


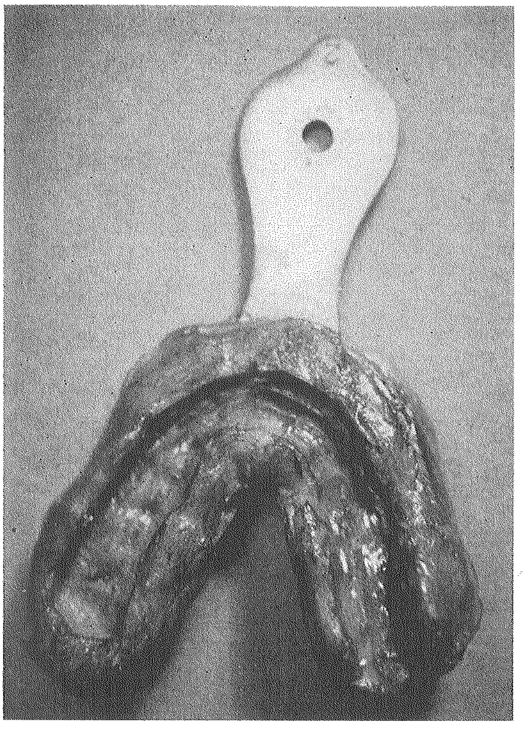
FIG. 100. A preliminary wax bite in Ash's bite frame.

The basic procedures of manipulation are the same, regardless of the kind of models that are to be seated in the bite, but the materials vary for different purposes. The plain wax bite is not sufficiently accurate for seating working models of prepared teeth for full-mouth restorations.

## RUBBER-BASE BITES

For prepared teeth, a rubber-base bite in a wax or acrylic tray is very satisfactory. It is suitable only when the rubber can flow all the way around the teeth through the interproximal preparations, such as M.O.D. or full-crown preparations. It is particularly advantageous for large fixed or removable restorations with edentulous spaces. The initial bite, which becomes a tray for the rubber, must be sufficiently thick that, when it is cut out of contact with the teeth, it can be undercut to form a tray and provide a mechanical lock for the rubber. It will not adhere to a bite such as the kind used for mounting study models, even with the use of an adhesive.

The initial wax bite (Fig. 100) is held in a frame such as an Ash's Bite Frame. It is



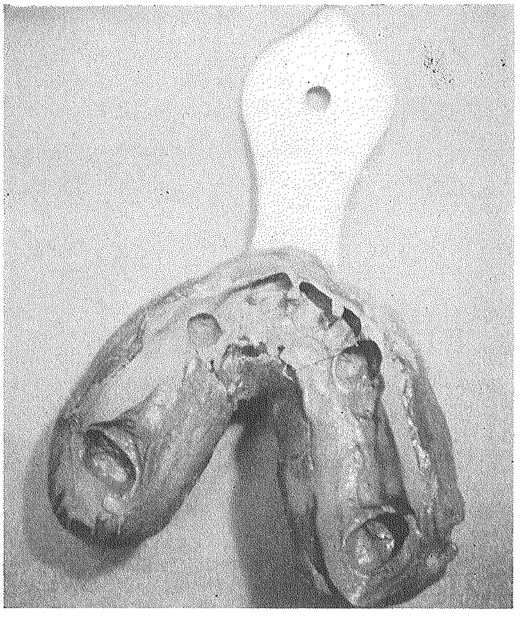


FIG. 101 (*Left*). The wax is undercut to form a bite tray.
FIG. 102 (*Right*). A rubber-base bite in a wax tray.

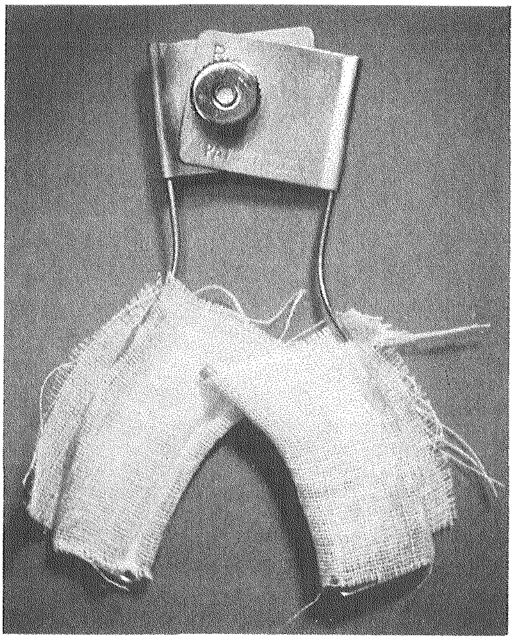
formed from a hard-base plate wax such as Kerr's Sure Set Wax, or an equivalent, which will not soften at mouth temperature. It should be about ½ inch thick in the posterior areas and about ¼ inch thick over the anteriors. A roll of the wax is formed in hot water and pressed into the frame, being locked securely to the frame around the edges.

It is softened in hot water, being made as soft as it can be and still remain in the frame. If it is too soft, it will become granular. The water temperature should be about 140° F. The bite is taken just as though it were to be the final bite. The wax must cover both the buccal and the lingual surfaces of the teeth. It is removed and chilled in room-temperature water. Then it is returned to the mouth and checked. The patient is instructed to close hard to straighten the wax.

All the wax touching the posterior teeth is scraped out (Fig. 101), and the wax is undercut, leaving a tray of hard wax which will extend all the way up to but will not impinge on the gingival tissues. The wax which seats the anterior teeth is not scraped away. This will serve as a stop and hold while the rubber is setting. The mouth should be checked to make sure that the wax does not contact the posteriors. A thin coat of tray adhesive is applied all over the wax, except on the imprint of the anterior teeth. This will soften the wax to some extent, and it must be thoroughly dried with a gentle stream of air.

A fast-setting mix of heavy-bodied rubber-base material is made by using more accelerator. Since the rubber will not be used to record precise marginal detail, it is not necessary to have it as soft as an impression, and the teeth need not be as thoroughly dried as for an impression.

The cut-out part of the wax bite is filled with the rubber, which is pressed well into the undercuts. Excess material will flow over the wax. That is why the whole wax surface must be coated with adhesive so that the rubber will not peel. The rubber is allowed to set until it begins to thicken but will still flow. As before, the patient makes repeated guided rotary closures before the bite is returned to the mouth. The bite is seated on the



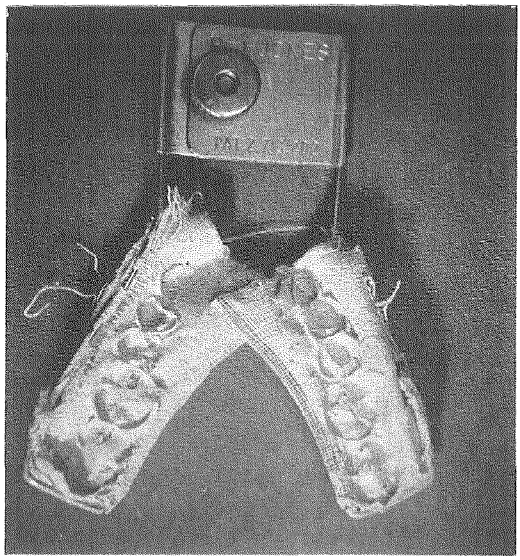


FIG. 103 (*Left*). The Jones bite frame.
FIG. 104 (*Right*). A zinc oxide paste bite.

upper anterior teeth and repeated closures are made again until the lower anteriors are seated in the bite. The patient is instructed to hold this with firm pressure until the rubber has set.

The bite is removed from the mouth and rinsed in room-temperature water. With a pair of Quimby curved tissue shears, the rubber which flowed through the anterior interproximals (Fig. 102) and the rubber which contacted the soft tissues are trimmed away. The seating of the working models is checked. The rubber should fit with no bounce or rebound and literally grip the model to hold it. If it shows any yield or rocking of the model, no attempt should be made to use it. The rubber should be peeled out and the procedure repeated.

## ZINC OXIDE BITES

For remounting restorations, the greatest accuracy is required. Remounting is a crucial step, since it is the accuracy of the remount which finally determines how accurate the relationship will be. For this purpose, the best bite is made of zinc oxide impression paste impregnated into fine, soft, pliable gauze. This bite is so precise that not many models could be seated in it. It is used only when the model is to have the same restorations seated in it that were used in the mouth to form the bite. That is why it is used only for remounting.

It is necessary to use a wire frame to serve as a vehicle to carry it to place in the mouth. For this purpose the Jones Bite Frame (Fig. 103) is ideal. It comes with a gauze strip already formed and cemented to plastic tubing for holding it on the frame. The zinc oxide paste should be one that is sensitive to humidity, sets hard and fast in the mouth, and is still not too brittle. Kerr's Bite Paste meets these requirements admirably. The gauze is cut in such a way that when it is folded over the paste there will be two thicknesses interposed between the teeth to enable the paste to penetrate and harden, so that it will have enough bulk not to break when the model is being seated. The procedures are the same as before, except that the tip of the thumb is placed against the labial surface of the lower anterior teeth so that the upper teeth will contact the nail. This provides a stop so that the teeth will not penetrate too deeply (Fig. 104). The operator tests for this position before the bite is

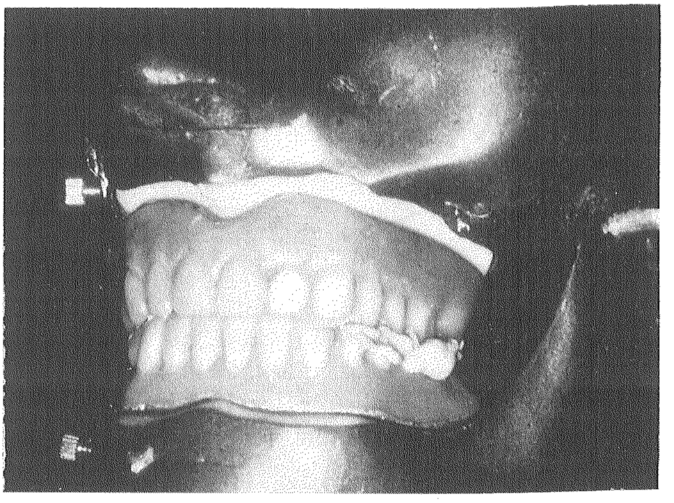


FIG. 105. A stone bite to check centric on a full denture.

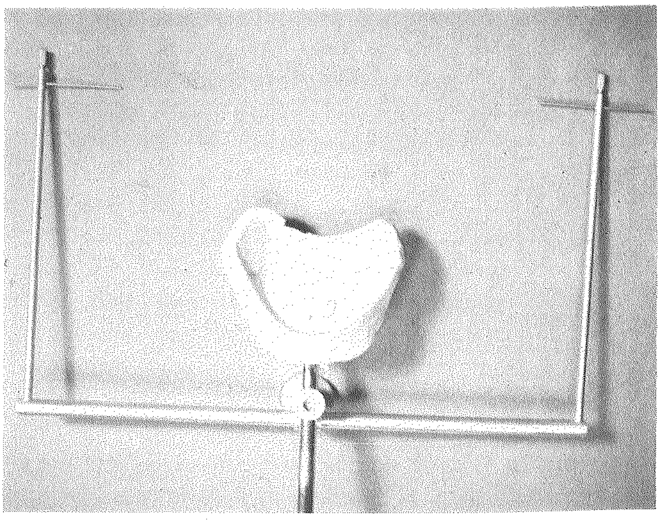


FIG. 106. A centric bite taken with a hinge bow.

seated. The handle of the frame rests on the knuckle while the paste is setting, and the teeth rest on the thumbnail to prevent shifting of the mandible.

## FULL-DENTURE BITES

For the final centric bite on full dentures, a fast-setting, self-curing acrylic is used. This is suitable only when the restorations can be kept intact with the bite. If it is necessary to separate the bite and then attempt to reseat it, it will not return to place accurately. It is used only for a thin bite, as a final check on centric.

For this purpose, a very fast-setting repair material is used. It is not a good general-purpose material as it contains so much peroxide that it oxidizes readily. But for this purpose it is good, as it sets fast and hard. It is mixed in a dappen dish to a thick, creamy consistency. With a cement spatula, a small amount is applied in the sulci and the fossa of the lower teeth—not enough to run out over the denture. As before, the patient makes repeated closures until the material starts to become stringy and filaments form as the mouth opens. Now the patient's mouth is closed and kept closed until the material has set hard. The dentures and the bite are removed as a unit, without separation. As the upper model is already mounted, only the lower has to be attached.

A similar procedure can be carried out with acrylic teeth, using fast stone and wax stops (Fig. 105), as described in Chapter 11.

### CENTER BEARING PINS

In taking a centric bite with a center bearing pin, there is danger of rocking the mandible if the patient attempts to bite too hard on the pin. This can be observed by attaching to the lower a very light hinge bow (Fig. 106) such as the Bruce Clark Hinge Locator. This is adjusted to the hinge axis marks on the face before the bite is taken. As the bite is hardening, the points of the bow can be watched to detect any change in position. If the center bearing point is not located at the precise dynamic center—which would be very difficult to achieve—hard biting may cause the mandible to rock on the pin. This procedure is not usually required, but can be most useful in bad joint-problem cases. The patient with such a problem is very difficult to control. Even when all possible precautions have been taken, there is great uncertainty about such a centric bite until the joint symptoms have subsided. Any centric bite taken with a center bearing pin should be rechecked by subsequent remounting of the restoration before completion.

In all the foregoing procedures, the basic objective is to have as near zero resistance as possible between the posterior teeth, to avoid initiating the neuromuscular reflexes while creating anterior resistance to closure, and to force the condyles up into functional position. This is the major problem and objective of all centric bite procedures.

*Chapter* 8

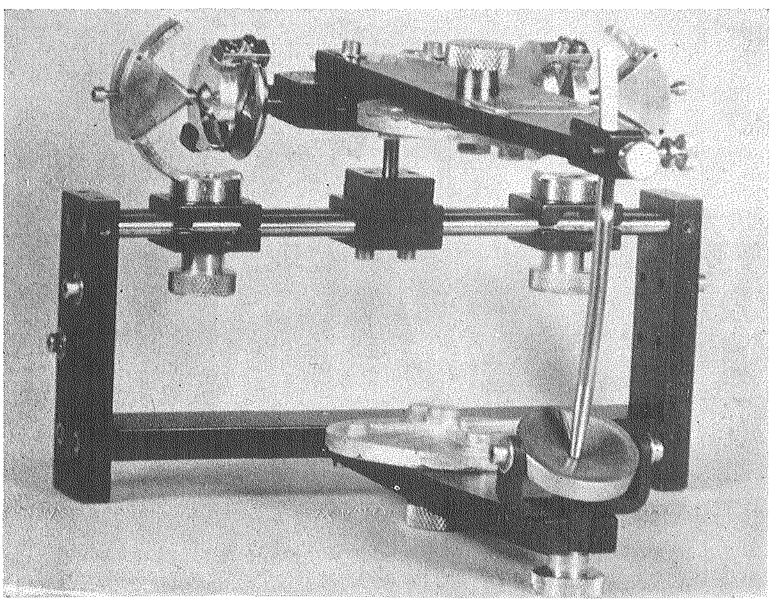
# The Articulator

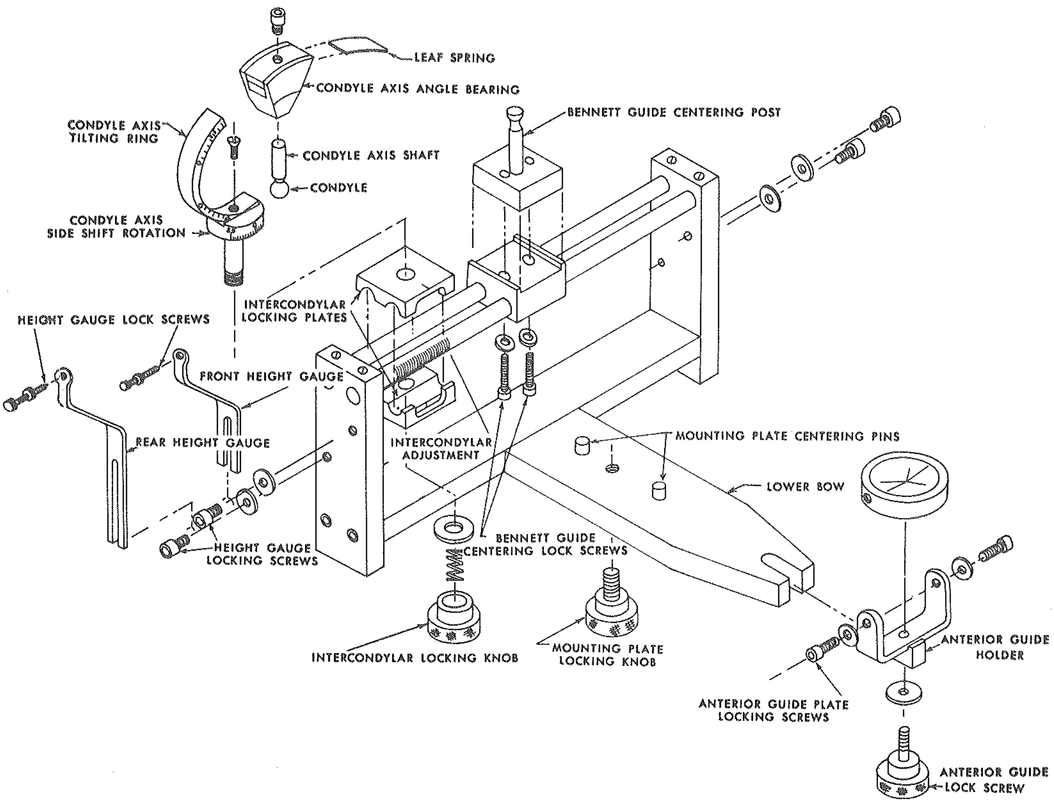
An articulator is a prosthetic tool. It neither prescribes remedies nor treats the patient. It is to the dentist what the square and the saw are to the carpenter and the violin is to the maestro. It aids the dentist in the application of his skill and knowledge. Figuratively speaking, it transfers the patient to the laboratory bench, where restorations may be constructed, as simple or as intricate as the operator feels are indicated, for treatment of the problem at hand.

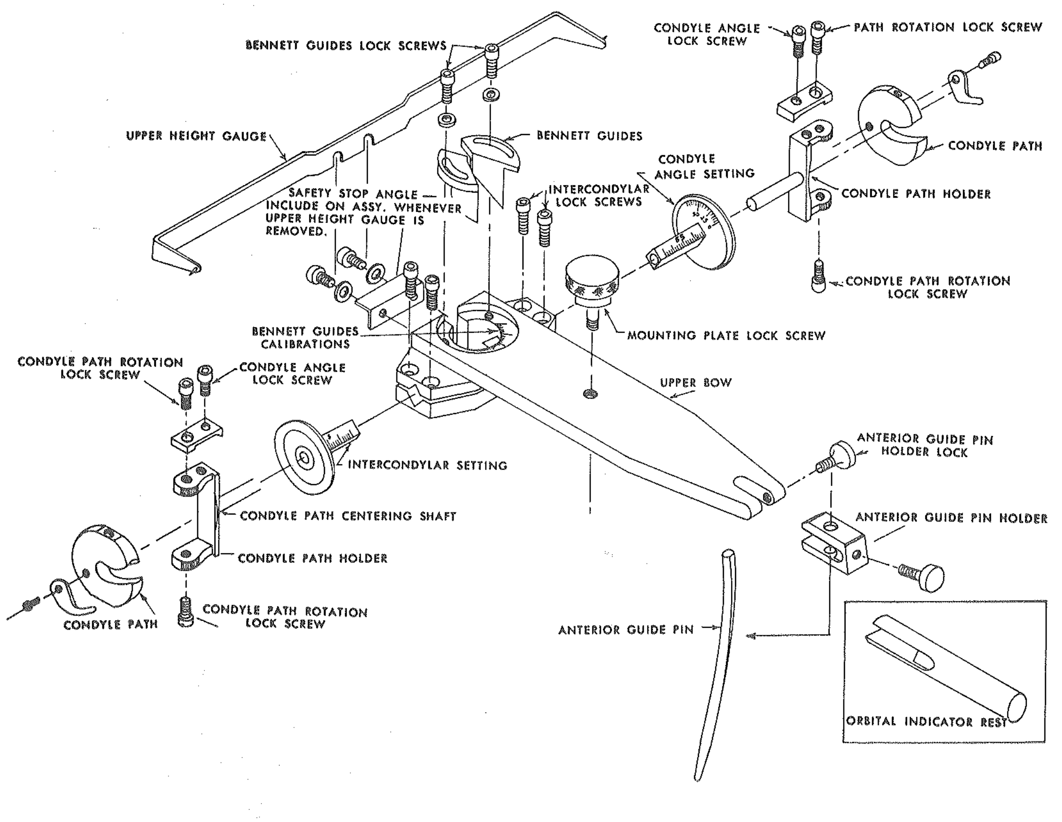
The articulator (Fig. 107 A) does not reproduce the anatomy of the patient. It does reproduce the functional relations of the teeth which result from that anatomy. Though all people possess the same anatomic structures, the actual form and the functional relations differ widely. In order to be able to reproduce the precise details of these variables, the articulator is provided with various adjustments. The method used for arriving at the proper adjustment for a particular patient depends upon the choice of the operator. Basically there are two methods: check-bites and the use of a pantograph. Their applications are described elsewhere in this book (pp. 92 and 138). Here we are concerned with a description of these adjustments and how they should be made. The two exploded views (Figs. 107 B and 107 C) show all the parts concerned with these adjustments.

Although each adjustment is described here as a separate operation, it should be understood that a change in any one will bring about a change in the result of the others. For example, if the condyle path has been set to a given angle, altering the tilt of the axis will have the effect of changing that angle when the condyle moves into a lateral excursion. So a change in one setting will call for a corresponding change in another setting.

FIG. 107. The gnatholator: A (*above*); on the next page are B (*top*) and C (*bottom*). (H. D. Justi & Son, Phila., Pa.)




LEAF SPRING
CONDYLE AXIS ANGLE BEARING
BENNETT GUIDE CENTERING POST
CONDYLE AXIS TILTING RING
CONDYLE AXIS SHAFT
CONDYLE
CONDYLE AXIS SIDE SHIFT ROTATION
INTERCONDYLAR LOCKING PLATES
HEIGHT GAUGE LOCK SCREWS
FRONT HEIGHT GAUGE
REAR HEIGHT GAUGE
INTERCONDYLAR ADJUSTMENT
MOUNTING PLATE CENTERING PINS
LOWER BOW
HEIGHT GAUGE LOCKING SCREWS
BENNETT GUIDE CENTERING LOCK SCREWS
INTERCONDYLAR LOCKING KNOB
MOUNTING PLATE LOCKING KNOB
ANTERIOR GUIDE HOLDER
ANTERIOR GUIDE PLATE LOCKING SCREWS
ANTERIOR GUIDE LOCK SCREW


BENNETT GUIDES LOCK SCREWS
CONDYLE ANGLE LOCK SCREW
PATH ROTATION LOCK SCREW
UPPER HEIGHT GAUGE
BENNETT GUIDES
CONDYLE PATH
CONDYLE ANGLE SETTING
SAFETY STOP ANGLE — INCLUDE ON ASSY. WHENEVER UPPER HEIGHT GAUGE IS REMOVED.
INTERCONDYLAR LOCK SCREWS
CONDYLE PATH HOLDER
CONDYLE PATH ROTATION LOCK SCREW
BENNETT GUIDES CALIBRATIONS
MOUNTING PLATE LOCK SCREW
CONDYLE PATH ROTATION LOCK SCREW
CONDYLE ANGLE LOCK SCREW
UPPER BOW
INTERCONDYLAR SETTING
ANTERIOR GUIDE PIN HOLDER LOCK
CONDYLE PATH CENTERING SHAFT
ANTERIOR GUIDE PIN HOLDER
CONDYLE PATH HOLDER
CONDYLE PATH
CONDYLE PATH ROTATION LOCK SCREW
ANTERIOR GUIDE PIN
ORBITAL INDICATOR REST

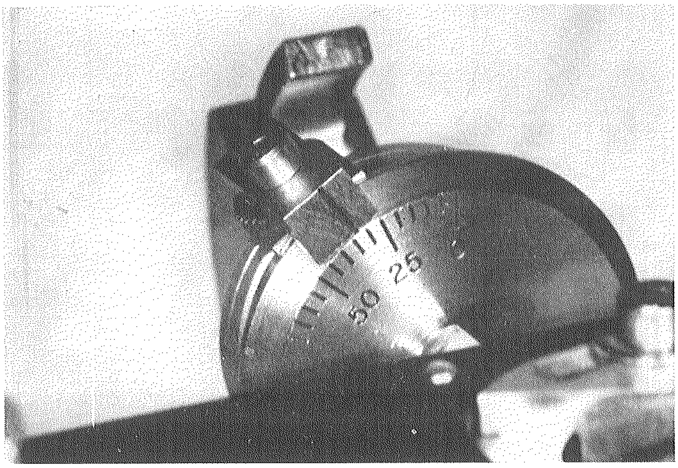


FIG. 108. Setting the angle of the condyle path.

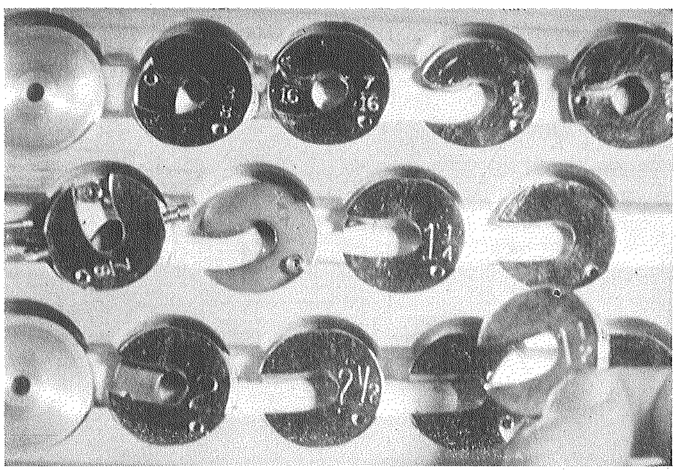


FIG. 109. Condyle paths of varying radii.

## ADJUSTMENTS

**Condyle Path.** The angle of the condyle path is adjusted and locked by means of the condyle angle locking screw. The angle is recorded on the angle setting disk (Fig. 108) by the line scribed on the angle setting lock. On the student check-bite instrument, the curvature of the path and the anteroposterior rotation of the path are fixed, since there are no means of determining these settings by check-bites.

For pantograph adjustment, the condyle path may be rotated on its axis by loosening the condyle path locking screws. The amount of rotation is recorded by the markings on the top of the condyle path holder.

Also for pantograph adjustment, there is provided a set of condyle paths of varying curvatures (Fig. 109), which, with proper Bennett movement adjustment, will make it possible to adjust the instrument to reproduce the irregularities of most patients. By removing the condyle path locking screws, the condyle path may be removed and replaced by another one of suitable curvature.

The condyle path, the condyle path holder, and the condyle path angle setting disk are collectively referred to as the condyle path assembly.

**Condyle Axis Assembly.** This consists of the condyle bearing and shaft (referred to on the drawing simply as the condyle), the angle bearing, the tilting ring, and the rotation index. The condyle bearing follows the path determined by the adjustment of these parts. The articulating surface of the condyle is

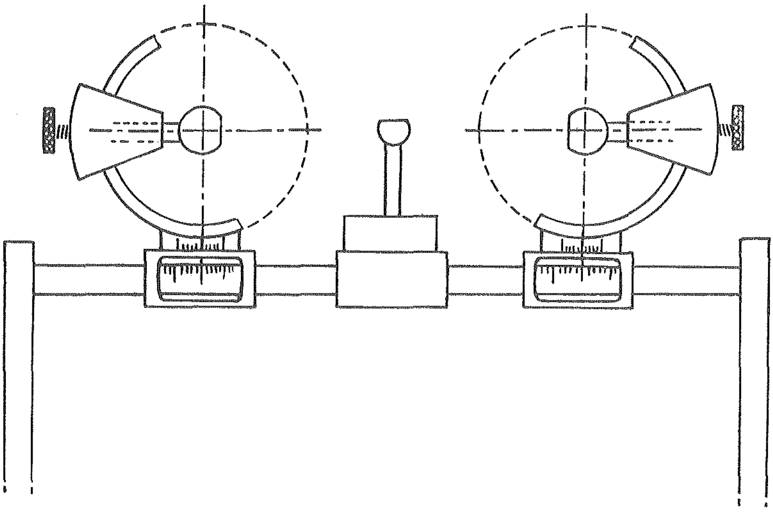
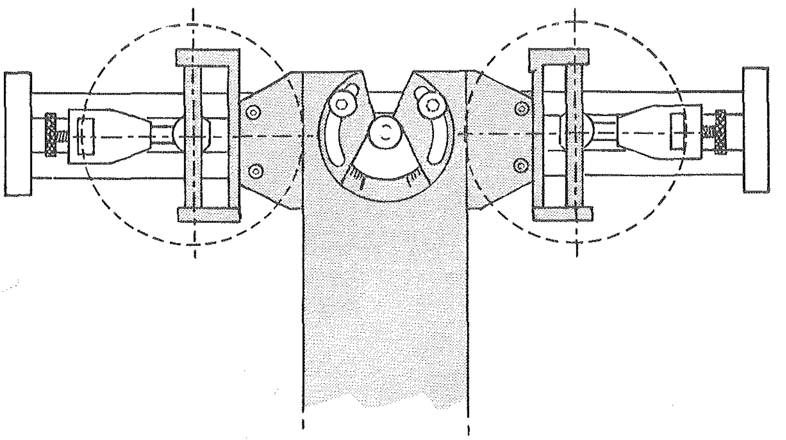


FIG. 110. The condyle axis is the center of the sphere.

FIG. 111. In centric, the condyle bearing is in the center of the sphere.



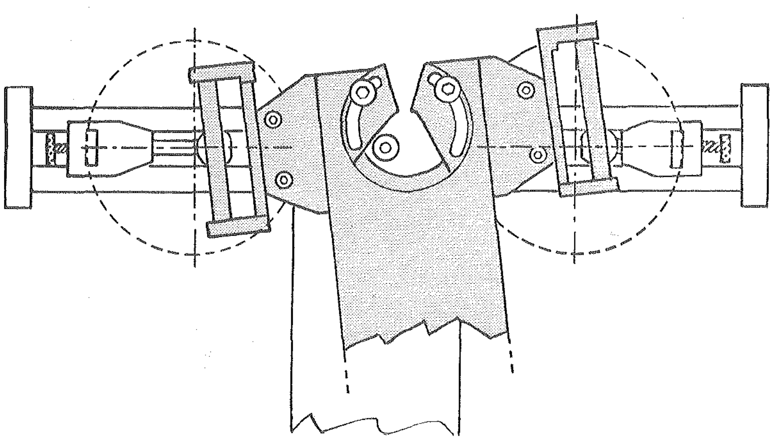


FIG. 112. On the working side the center moves out, and on the balancing side it moves in.

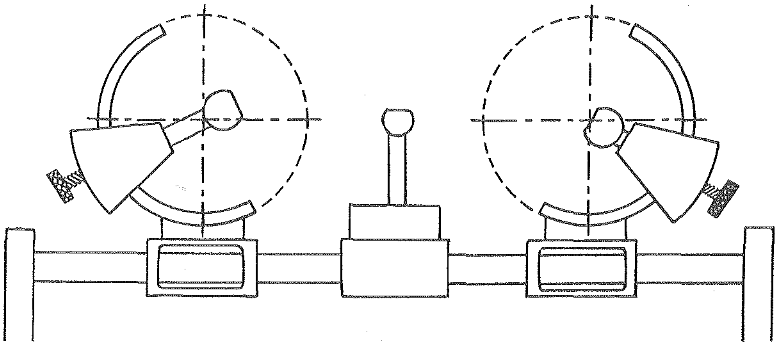


FIG. 113. Tilting the axis for the Bennett movement.

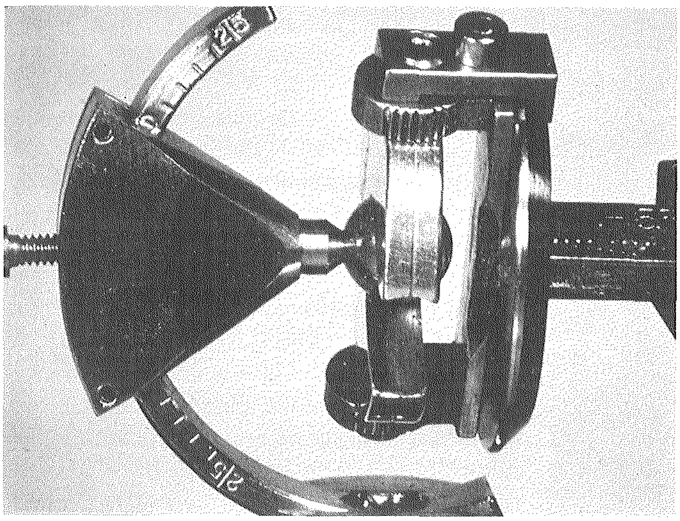


FIG. 114. Raising the axis angle bearing to "split" the axis.

never a perfect sphere. Yet the actions of the whole lower compartment with relation to the teeth, in tooth-contacting movements, are as though it were a ball and socket. In order to have three simultaneous axes of motion, it revolves around a point center. This is further evidenced by the fact that the mandible can describe pure vertical arcs around stationary projections of a horizontal axis. In order for this to be reproduced on an instrument as a mechanical equivalent, its bearing must be a ball.

The curve of the tilting ring and the rotation of the ring on the sliding block form an imaginary sphere (Fig. 110), with the condyle located at its center. In centric, the condyle remains in the center (Fig. 111) so that any adjustments that are made will not alter the centric mounting. Likewise, in a protrusive movement, the condyle still remains in the center of the sphere and, therefore, adjustments will not alter the angle of the protrusive path. However, in lateral excursion (Fig. 112) the center of the sphere moves so that the bearing is no longer centered. On the working side the center moves outward, and on the balancing side down, forward and inward. The center of the sphere is the axial center of the condyle. Tilting the axis bearing (Fig. 113) moves the center up or down as it slides laterally in the Bennett movement. Connecting these two centers with an imaginary line, as in the skull, forms the hinge axis of the mandible. These centers are fixed to the lower member (mandible) of the articulator. Thus, the adjustment of the

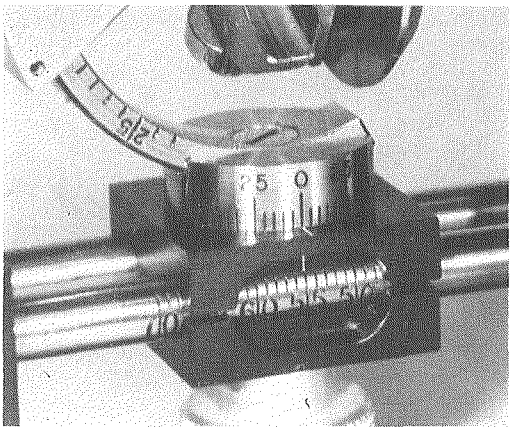


FIG. 115. The axis rotation index.

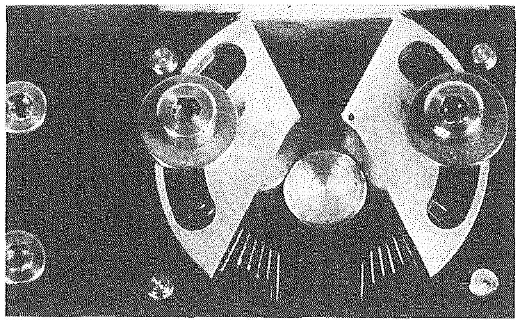


FIG. 116. Adjusting the degree of the Bennett movement.

axis angle bearing and the axis rotation determines the path of motion of the hinge axis in lateral excursion.

Raising the angle bearing on the working side (Fig. 114) will cause the center of the sphere (axis) to move outward and upward. When this becomes the balancing side, the center (axis) will move inward as the condyle travels down and forward. As in the skull, this will produce a steeper condyle path in lateral excursion than in protrusive.

If the axis rotation index (Fig. 115) is rotated on the working side, as the axis moves out it will also travel forward or backward, depending upon which way it is rotated. Rotating the axis rotation index will also induce a slight change if this becomes the balancing side. To make the adjustment for axis rotation, the intercondylar locking knob is loosened slightly. It should be just loose enough to permit rotation of the index, without allowing the sliding block to move and change the intercondylar adjustment. After axis rotation, a check should always be made to be sure that the intercondylar mark is still lined up with the correct calibration. If this is not done, the centric mounting may be affected.

**Bennett Movement.** The paths of the axis that were just described constitute the Bennett movement in lateral excursion. Their effect upon the teeth will depend not only upon the angles at which they are set but also upon how much the axis shifts to the side in lateral excursion. The amount of side-shift is determined by the setting of the Bennett guides.

The axis of the center post lies on the axis of the condyle bearings. Rotation of the Bennett guides (Fig. 116) and changes in vertical dimension will not affect the centric contact of the Bennett guides. The angle of the Bennett guides determines the amount of side-shift in lateral excursion. Each line on the Bennett guide ring represents five degrees of rotation of the guide around the center post. By loosening the locking screws, the Bennett guide may be rotated to determine the degree of side-shift and, therefore, the amount of the change in the axis position in lateral excursion.

For pantograph use, the Bennett guides are ground to reproduce the Bennett path of the individual patient. These are scribed with the name of the patient, and the settings are recorded on the chart, so that they may be replaced each time the instrument is used for that patient.

**Intercondylar Distance.** The intercondylar setting is the position of the center of rotation on each side. The Bennett movement is the path of the center of rotation where it intersects the hinge axis. It is the relation of the cusps to the center of rotation which enables the cusps to pass around and be-

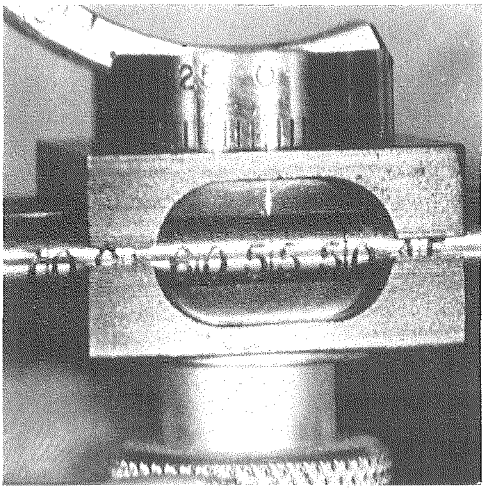


FIG. 117. Intercondylar setting of the condyle assembly.

tween each other without colliding and bumping. Therefore, the correct setting of the intercondylar location is one of the most important of all the adjustments.

The condyle bearing must be in the center of the sphere and the center post must be in the center of the Bennett guide ring in order to maintain centric when the instrument is in centric. Therefore, when the intercondylar setting of the condyle assembly is changed, the condyle path assembly must be changed in a similar way to maintain the same *precise* intercondylar distance of both upper and lower assemblies.

The crossbar of the lower frame is calibrated in millimeters of intercondylar distance. To change the setting (Fig. 117), the intercondylar locking knob is loosened and the block is slid in or out, as the case may be. The center line of the axis is marked in the recess of the top block, which is not necessarily in the center of the block.

The intercondylar setting of the condyle path assembly is also marked in millimeters, on the square shaft of the condyle angle locking disk. To make this adjustment, the intercondylar locking screws on the upper bow are loosened and the square shaft (Fig. 118) is slid in or out. The correct line

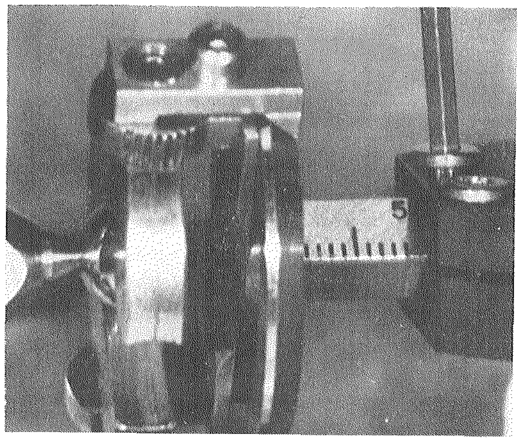


FIG. 118. Intercondylar adjustment of the condyle path.

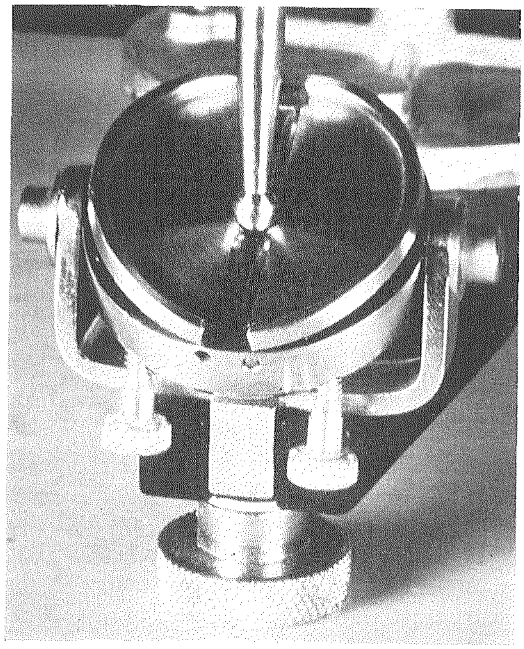


FIG. 119. Split anterior guide.

should be just visible at the edge of the top block.

**Anterior Guide Pin.** The anterior guide pin is curved along the portion represented by the calibrations so that the ball of the pin will remain centered on the guide plate. Each mark on the pin represents one-half degree of the arc of opening around the axis. The mark is read at the level of the top of the guide-pin holder. Since this is the only portion which is curved, adjustments for opening or closing should be made only within the calibrated range.

**Anterior Guide.** The anterior guide plate can be adjusted for angle and, in addition, the split guide (Fig. 119) can be adjusted to a different lateral path than the protrusive. This split guide is intended primarily for use in treating natural dentitions with excessive overbite. In the center of the guide is a depression in which the ball of the pin rests. The sudden rise of the pin from the depression will create cusps somewhat in excess of the normal cusp form. This is to aid the technician in subsequent adjustment of the restoration after remounting. During remount adjustment, the guide pin is removed. As adjustment proceeds, the cusps are reduced, and it is easier to reduce cusps than to deepen sulci. Furthermore, there is less chance of going through a restoration.

## GENERAL HANDLING

The gnatholator is a precision instrument, built to very exacting standards and tolerances. *It must be kept clean and oiled.* Bits of wax, stone, porcelain and similar grit that collect in the moving parts can cause them to stick and wear excessively. Before a case is started the following rules should be observed. The upper bow should be removed, the condyle path should be cleaned with carbon tetrachloride on a cotton applicator, and a small amount of the oil supplied with the instrument should be applied.

The condyle shaft is removed from the bearing. The shaft, the condyle and the inside of the bearing are cleaned with carbon tetrachloride on a cotton applicator. Oil is applied to the shaft and it is replaced.

The crossbar and the sliding block are wiped with carbon tetrachloride, but not lubricated.

Petroleum jelly is applied to the center post where it contacts the Bennett guides.

All plaster and stone are cleaned from the frame by wetting it and rubbing with a towel. Knives and sharp instruments are not used. The frame is constructed of an aluminum alloy that was designed for surgical and dental instruments. It is anodized and lacquered to resist corrosion and prevent the sticking of wax and plaster. Scraping will cut through the anodized surface.

The surface and the pins which seat the mounting plates should be cleaned very carefully. A drop of oil is always placed in the threads of the mounting plate before it is attached.

To avoid accidental slipping of the upper bow, the condyle locks are always kept in place. In addition, when the instrument is not in use, a #84 rubber band is kept around the upper and the lower bows behind the guide pin and the guide plate.

When the instrument is moved during the construction of the restoration, the upper bow is grasped in one hand and the lower bow in the other, with the fingers against the corresponding models. The instrument guides the models; the operator supplies the muscular force. In straight protrusive, the upper bow is moved backward so that the center post is kept centered between the Bennett guides, and both condyles move forward equally.

In pure lateral excursion, the upper bow is moved so that the center post is held in contact with the Bennett guide on the working side. The working condyle is held tightly seated while the upper bow rotates around it and the balancing condyle moves forward in its path.

In lateral protrusive, the Bennett guide on the working side is maintained in contact, while both condyles move forward equally, in a diagonal path. The anterior guide pin will move diagonally halfway between straight protrusive and pure lateral excursion. Each time the instrument is closed, the pin is tapped lightly on the plate to make sure that neither the new wax nor the porcelain addition has raised the pin, and the upper bow is held firmly against the condyles as it returns to centric.

The center post, in centric, should rest lightly in contact with the Bennett guides. A piece of cellophane, placed between the post and the guide, should drag but not hold as it is pulled out. If, by some mishap, the center post loses its adjustment, it can be readjusted as follows: The upper bow is removed. The two Allen screws under the center block, which hold the sliding block and the post, are loosened just enough to allow the block to slide but not to rock. Usually about a half turn is enough. One piece of .001 tin foil is wrapped around the ball. The upper bow is replaced. The post is slid back until it just contacts the Bennett guides and the upper bow does not rock on it. The two Allen screws are tightened securely. The foil is removed from the post and the cellophane is checked to see that it can be pulled out from between the ball and the guide.

Acetone or a similar solvent should not be used to clean the articulator. It might damage the finish. Only carbon tetrachloride should be used. A small amount of care devoted to keeping the instrument clean and oiled not only will make it much easier to use but also will result in many years of accurate service.

## USING THE ARTICULATOR

An articulator is used to reproduce on a mechanical instrument the functional relation of the teeth as they will come together in the mouth. The patient never makes a pure hinge closure. The closing rotation can be combined with a great variety of gliding paths. It may be combined with a protrusive path, it may take place in lateral excursion with a full Bennett movement, or it may be in any lateral protrusive between these two extremes. The articulator mounting orients the casts on the instrument to its axis in the same way in which teeth in the mouth are related to the axis of the condyles. The articulator adjustments reproduce the paths of the mandible on the instruments.

Since the rotations of the mandible which bring the teeth into contact are rotations around the hinge axis, paths of motion which create the different contacting positions are paths of motion of the hinge axis. The center of rotation is the axis that is vertical to the hinge axis, about which the hinge axis is rotating on the working side as it is closing upward and inward to create tooth contact. The path of the center of rotation is the Bennett movement.

Thus, it is necessary to locate and transfer the hinge axis, the center of rotation, the Bennett movement and the condyle path. The casts on the articulator must be oriented correctly to these paths of motion. For this purpose it is necessary to establish a reference for mounting that is termed the plane of reference. The plane of reference used here is the plane that is formed by two lines from the hinge axis on each side to the right infraorbital notch. This is called the axis-orbital plane. The angles of the condyle path and the Bennett movement are formed by their paths and the axis-orbital plane. If, subsequently, the casts are mounted on the hinge axis and properly related to the axis-orbital plane, the paths of motion of the teeth will be correctly related to the paths of motion of the joint. This will be true no matter what changes in tooth relation may have occurred in the mouth. For example, recordings may be made prior to extraction or tooth preparation. The recordings are made and mounted according to the axis-orbital plane. After extraction or tooth preparation, the casts likewise are mounted with reference to the axis-orbital plane. Then restorations constructed on those casts will bear a correct relationship to the paths of motion of the joint.

The technical procedures of making these recordings are described in other chapters in this book (Chaps. 10 through 15). Here we are outlining the steps of procedure in using the articulator.

The first step is to locate the hinge axis and transfer it to the articulator. This is accomplished by means of a hinge bow attached to the mandible. With natural teeth this is attached by means of a clutch cemented to the teeth. In the edentulous mouth the hinge bow is retained by means of a chin clamp. A head cap is employed to avoid errors due to skin movement.

When the axis has been located and marked on the skin, the hinge bow is used as a transfer bow. It is attached to the upper clutch or to an upper edentulous bite block. Then the axis-orbital indicator is attached to the transfer bow to orient the clutch to the plane of reference. Upon removal from the mouth, the bow is attached to the mounting frame. The mounting frame is used to transfer the axis and the plane of reference from the patient to the articulator.

Before the clutch is removed from the mouth, it must be used to record the paths of motion. So the transfer bow is attached to the clutch by means of a separable stud. This enables the bow to be removed for recording and to be reattached in the same position onto the clutch for subsequent mounting.

There are two methods of recording the paths of motion of the hinge axis: by means of check-bites or by means of a pantograph recording. The inherent weakness of check-bites lies in the fact that they do not record the actual curvature of the paths of the joint but merely the positions of the axis. They do not show how it arrived at them. A pantograph records all the actual paths simultaneously in three dimensions.

Pantographing most edentulous mouths involves problems of stabilizing the apparatus which frequently offset the advantages of an accurate recording. An inaccurate recording may be worse than none at all. Check-bites in the edentulous mouth, and large partial dentures, carefully and properly executed, can prove more accurate than a poor pantograph recording. The check-bites may be taken with clutches cemented to natural teeth or with check-bite plates attached to edentulous base plates. Details of the procedure may be found in Chapters 11 and 14.

The adjustment of the articulator with check-bites is accomplished by means of height gauges. These devices, shown in the articulator drawings, are attached to the instrument and are used only for setting. After the articulator has been set, they are removed.

The adjustment of the articulator with the pantograph follows an entirely different procedure, which is described in Chapter 15. Although the pantograph itself is a more complex piece of equipment, the recording on the patient with natural teeth, and the subsequent setting of the articulator, are far easier and quicker than check-bites.

Therefore, in general, check-bites are usually limited to complete dentures and large partial dentures. The pantograph is used largely for natural teeth or for unusual denture cases.

# Chapter 9

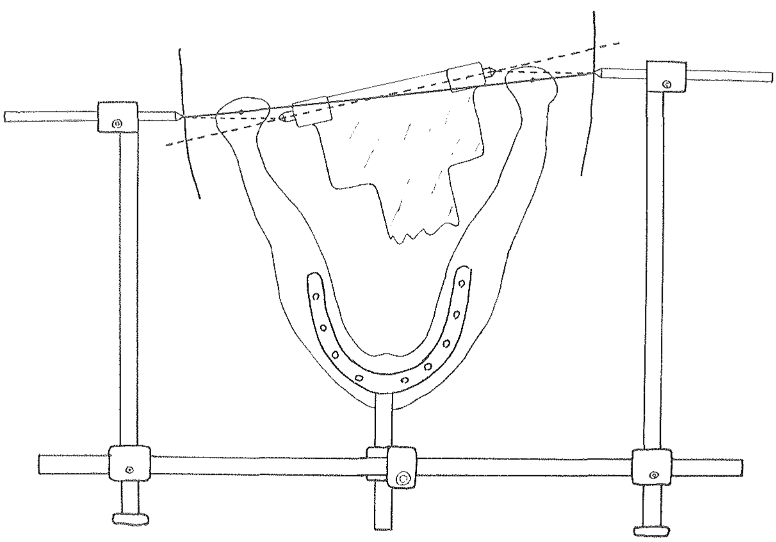
# Mounting Models

Since the mandible is never symmetrical, the axis points located on the face with the hinge bow are projections of an imaginary diagonal line through the condyles. Due to this asymmetry, the hinge axis is seldom at right angles to the sagittal plane. If the styli of the hinge bow are moved in or out (Fig. 120) to adjust them for mounting on the articulator, then the points no longer will lie on the hinge axis. Instead, the axis of the articulator must be projected out to meet the axis points of the hinge bow, just as the tattoo marks on the skin are projections of the axis in the patient. The solid line in Fig. 120, passing through the condyles and connecting the points of the styli, represents the true axis. If the styli were moved in to meet the points of the articulator, as shown by the dotted lines, the axis on the articulator would be the dotted line passing through the articulator instead of the true axis.

For this purpose, a mounting device, usually referred to as a mounting frame (Fig. 121), is employed. It serves a 3-fold purpose. First, it orients the hinge axis of the patient to the axis of the articulator; second, it provides a mean of holding the articulator and the hinge bow in position while the cast is being attached; and third, it orients the plane of reference to the articulator to transfer recordings of paths of motion from the patient to the articulator.

The mounting frame consists of a support for the upper bow of the articulator (Fig. 122), holding calibrated adjustable axis pins which can be moved out to meet the styli of the hinge bow. The support can be adjusted by means of elevating screws (Fig. 123) to bring the points to exact vertical opposition. It can be adjusted forward and back for horizontal alignment. A locking bar clamps and holds the axis support (Fig. 124) so that it cannot shift while the model is being mounted. The axis support of the upright keeps the articulator centered. The upper bow can be

FIG. 120. The styli points lie on a diagonal projection of the hinge axis.



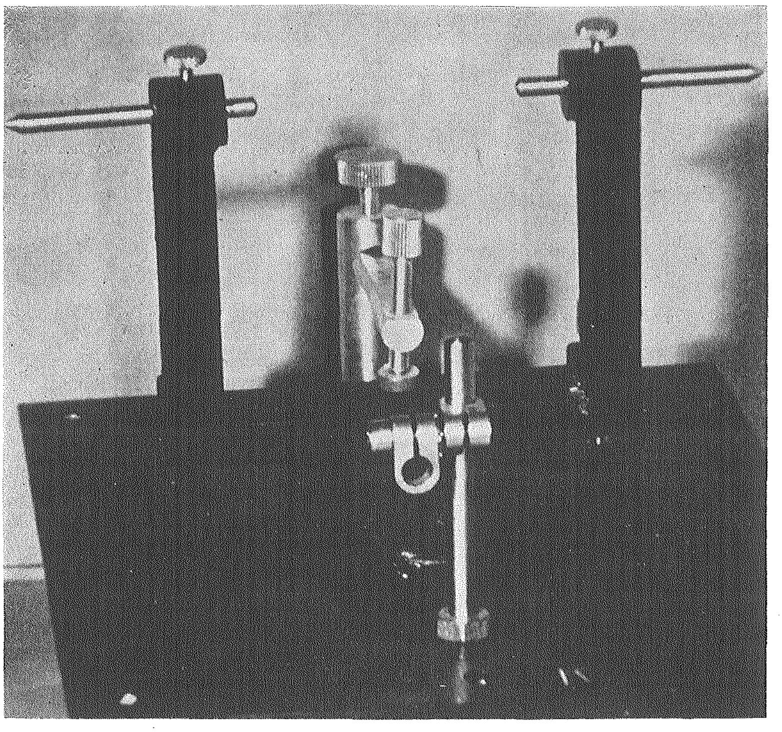


FIG. 121. The mounting frame.

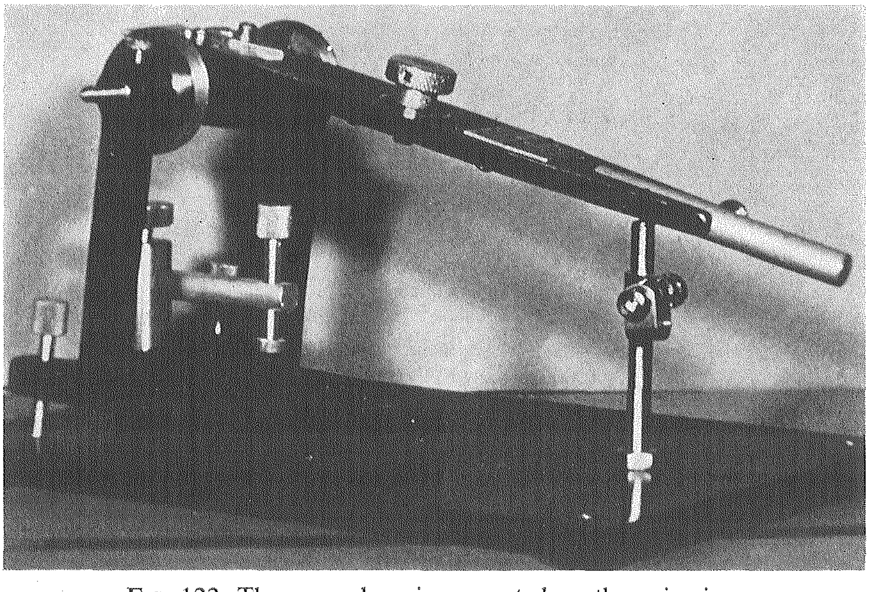


FIG. 122. The upper bow is supported on the axis pins.

opened and closed on the axis pins to apply the artificial stone for mounting.

The hinge bow is held by a universal clamp, attached to the bite fork and to an upright stud on the front of the mounting frame. The end of the bite fork is inserted in half the clamp (Fig. 125), and the other half fits the stud. Being a universal clamp, the hinge bow

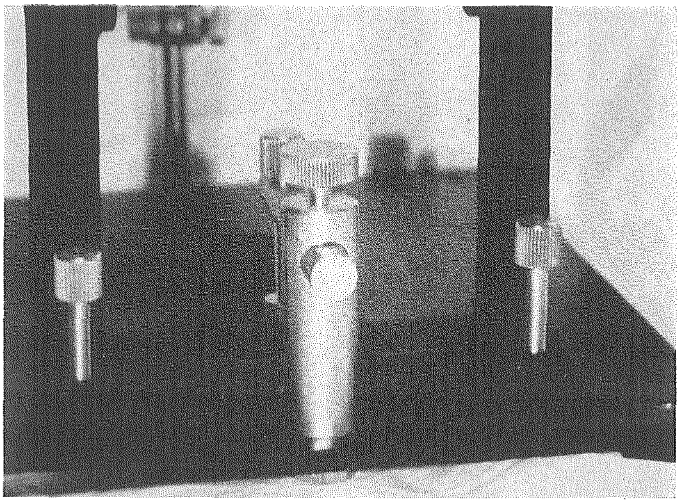


FIG. 123. Elevating screws to adjust the axis of the mounting frame.

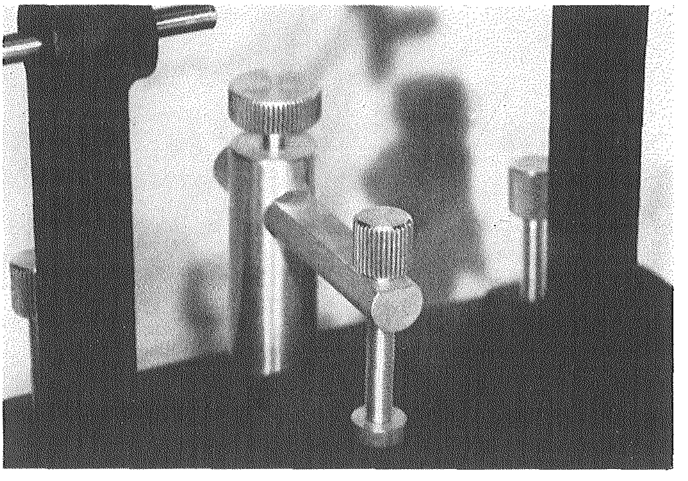


FIG. 124. The locking bar holds the bow support in place.

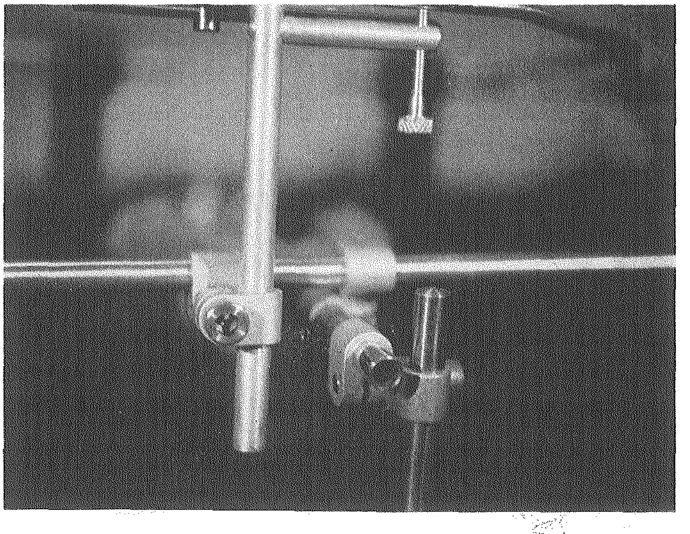


FIG. 125. The bite fork is locked in the universal clamp.

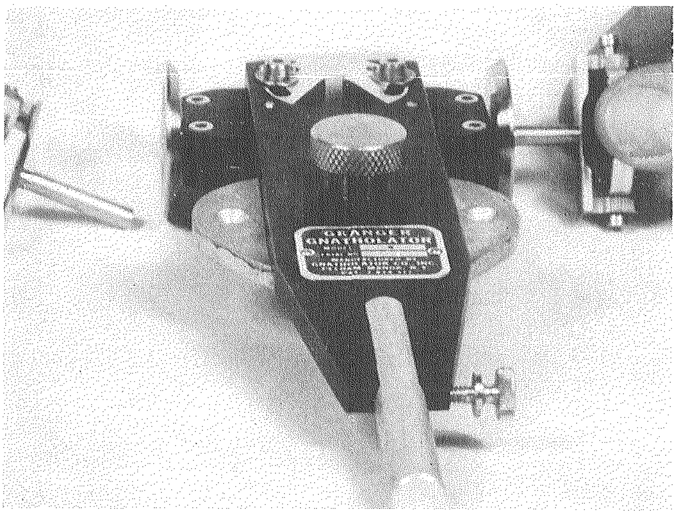


FIG. 126. The condyle holder is removed from the angle index.

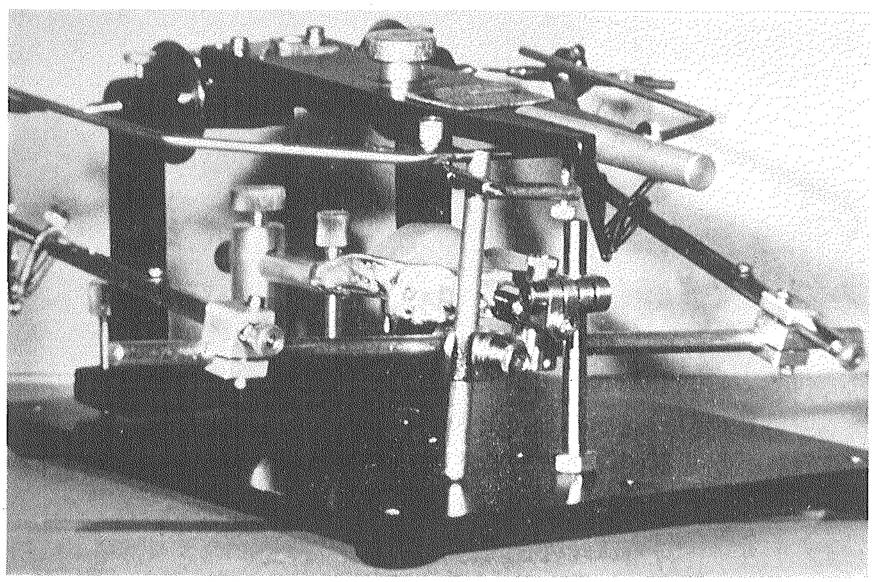


FIG. 127. The orbital rest is supported on the orbital indicator.

can be adjusted in any direction and then locked in position. It is clamped so that the points of the styli are slightly above and in front of the axis pins of the mounting frame.

The upper bow is removed from the articulator by loosening the condyle path centric locks. The condyle path angle setting clamp is loosened enough to draw the condyle path holders (Fig. 126) all the way out of the angle setting disks. The intercondylar locking screws are loosened and the angle setting disks are pushed on both sides all the way in to the minimum intercondylar width. The axis pins are removed from the mounting frame upright, and the upper bow is set between the uprights with the holes of the angle setting disks over the axis pin holes of the upright. The pins in the upright are a loose fit in the holes of the upright, since it is the bow which holds the pins on the axis, not the mounting frame. The upright merely clamps the upper bow in position. The pins are inserted through the upright into the holes in the locking disks (Fig. 122). In unusually small cases, as in children, it may be necessary to remove the Bennett guides to insert the pins all the way. In most cases this is not necessary.

The guide pin holder is removed from the front of the bow (Fig. 122) and it is replaced by the orbital rest. This rest is made to parallel the upper bow of the articulator with the axis orbital plane, so that variations in placement of the axis-orbital indicator on the patient are projections of the same plane. The stylus of the axis-orbital indicator is swung parallel with the front section of the indicator frame so that it will not interfere with the mounting. The indicator frame is placed in the orbital support on the hinge bow, with the ends resting on the axis styli of the hinge bow. The upper bow of the articulator (Fig. 127) is rested on the axis-orbital indicator frame. If the orbital support was properly positioned on the patient to bridge the nose, the orbital rest will fall over the cross support of the orbital support. The thumbscrew is now elevated (Fig. 128) to support the orbital indicator so that the weight of the upper bow will not cause it to tip.

The locking bar and the thumbscrew holding the upright are loosened. The elevating screws are turned to raise the axis pins to the height of the hinge-bow styli. The axis pins are calibrated in millimeter grooves (Fig. 129), every fifth groove being deeper for easy counting. The axis pins are slid out an equal amount until they just meet the points of the hinge bow. The pins are locked with the thumbscrews. The axis pins must be equally extended in order that the cast may be placed in the same asymmetry on the articulator as in the skull.

## ATTACHING THE MODELS

When the points of the axis pins have been adjusted to meet the hinge bow (Fig. 130), the locking bar is tightened. Then the upright is locked with the thumbscrew. Now the upper bow is locked in proper relation and may be opened to attach the model. A

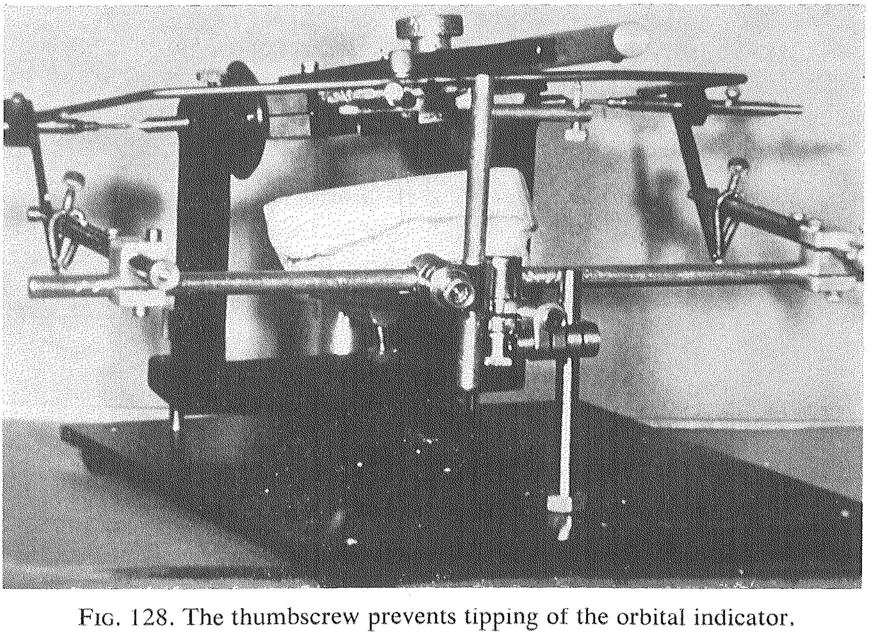


FIG. 128. The thumbscrew prevents tipping of the orbital indicator.

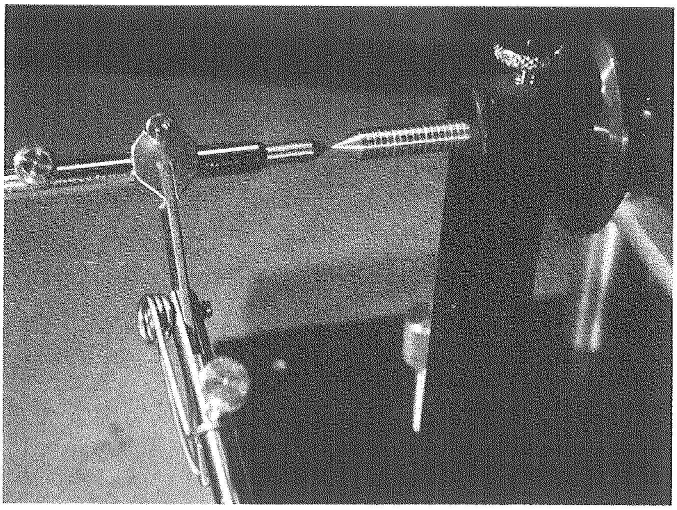


FIG. 129. The axis pins are grooved for equal spacing.

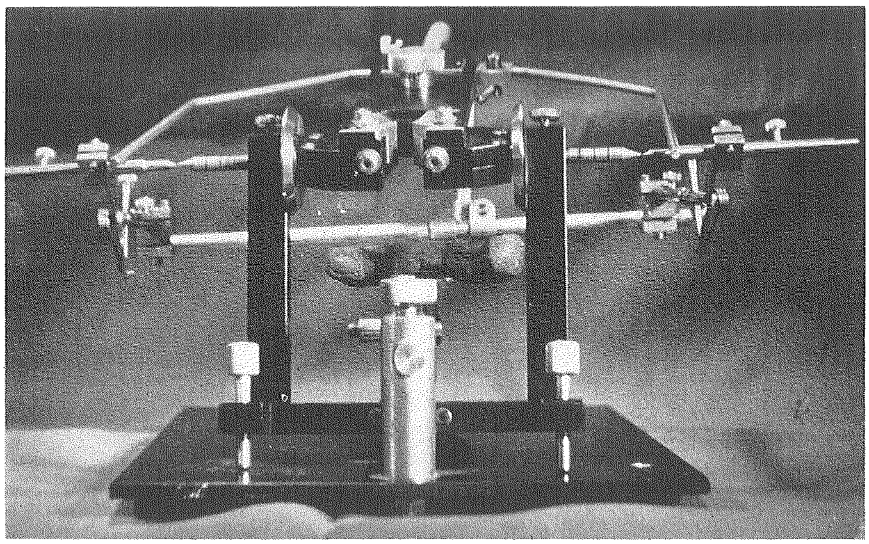


FIG. 130. The axis pins are adjusted to meet the hinge-bow styli.

mounting plate is attached to the upper bow and completely seated in position. The upper cast is attached to the bite fork, Greyrock is placed on the mounting plate and the cast, and the upper bow is closed (Fig. 131) to rest on the orbital indicator.

When the stone has set, the locking bar is loosened and the upper bow is removed from the mounting frame. The condyle path holders are replaced, and the angle is set to about 45° so that the weight of the bow will hold them well seated on the condyles. The lower intercondylar distance is set at 45 mm. and the Bennett guides are set at 0. The incisal guide plate is set at 45°. The model and the mounting plate are removed from the upper bow and joined to the lower with the centric bite. The casts are checked for accurate seating in the bite and are waxed securely together with sticky wax. The casts are soaked in room-temperature water to prevent the sticky wax from becoming too brittle and breaking when the lower cast is mounted.

The orbital rest is removed from the upper bow and replaced by the anterior

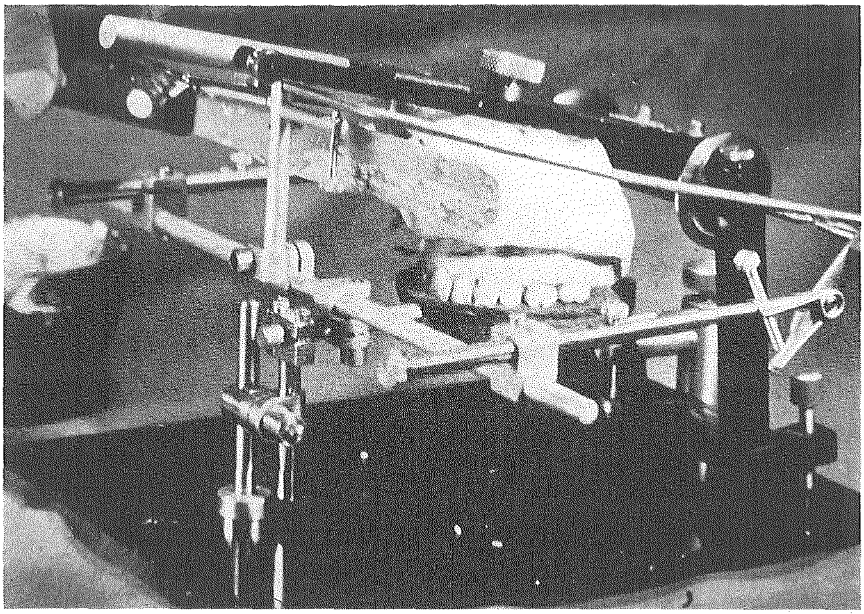


FIG. 131. Attaching the upper model to the upper bow.

guide pin. With a centric bite of average thickness, the pin should be opened about two index lines. Each line represents one half a degree of the arc of opening. The pin should be opened enough that, after the bite is removed, the range of adjustment for the desired vertical dimension will fall on the curved part of the pin in the calibrated range. Otherwise, the pin will no longer fall in the center of the guide plate. If, because of an error, the bow has to be lowered more than the curved range, the pin will contact the plate in front of the center depression. If the bite is unusually thick and was taken at a vertical opening known to be greater than the restoration, the pin should be opened more. However, in some cases it may be necessary to open rather than close from the bite relation. Therefore, it is advisable to mount with a range in either direction.

The thoroughly soaked models are now reattached to the upper bow. The condyle paths are seated on the lower, and the centric locks are securely tightened. The articulator is inverted on the mounting block (Fig. 132) so that the weight of the lower bow is carried by the condyles seated in their paths. The lower bow is raised, and the lower model is attached with nonexpanding stone. The lower bow is closed on the soft stone until the ball point of the incisal guide pin rests in the center of the bearing plate.

When the stone has set, the articulator is turned upright and the centric bite is removed. The articulator is set according to the charted registrations and is ready for construction of the restorations.

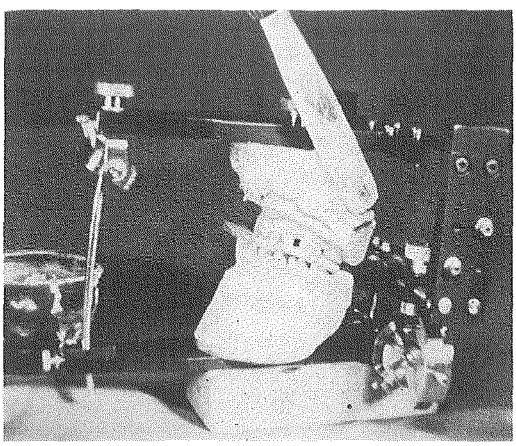


FIG. 132. Attaching the lower model.

*Chapter* 10

# Check-bites

In recent years the term "check-bites" has come into common usage as being synonymous with centric bites. As originally used by Stansbury and others, it meant bites taken in various excursions to check positions of the mandible at these relations. Perhaps the term "positional bites" would have been better. But, as used here, the term designates bites taken at any position to orient bite plates.

The common practice of taking a single protrusive check-bite and using it to set an articulator is capable of doing more harm than good. If it is taken without a hinge axis mounting, the vertical rise of the teeth will be different from that of the hinge opening of the mandible, causing a clash of the cusps. Even worse, it is the relation of the cusps to the center of rotation in the Bennett movement which enables cusps to pass each other without colliding. Cusps created by a protrusive bite, without the incorporation of the Bennett movement in lateral excursion, can cause more lateral stress than no cusps at all.

This is responsible for much of the misunderstanding about the part cusps play in dental health. Because cusps formed without proper relation to their functional action are likely to interfere with each other in mastication, many have been led to believe that the use of cusps per se is wrong. They have not learned to differentiate between physiologic and pathologic cusps.

## WAX CHECK-BITES

The use of wax for accurate check-bites presents problems which can tax the most painstaking operator. The material itself does not make for accuracy in maintaining precise relations to set an articulator. By their very nature, check-bites present enough problems in accuracy without the introduction of this added hazard. The patient must close into the wax in exactly the correct relation; with many patients this is very difficult to control. Reseating models and holding them in position during the adjustments that are necessary to set the Bennett paths accurately can produce very deceptive results. Wax does not possess the rigidity that is required to set height gauges. Judging the proper seating of the check-bites by eye when setting the articulator requires a high degree of skill and ingenuity.

The greatest drawback to the use of wax check-bites is the difficulty in positioning the condyle in its proper position on the condyle path. Check-bites are positional bites. Originally they merely were used to record static positions of the mandible. They were not related in any way to the joint. The restoration had to be completed with the mandible in exactly the same static positions. This required the vertical dimension, the cusp height and the vertical rise from centric to each excursion to be established in the mouth at the time of taking the check-bite—a technical impossibility except by pure chance. It might happen to be acceptable to an occasional patient. Usually it involved gross grinding and adjustment in the mouth. Much of the work so painstakingly performed in the laboratory was destroyed during tedious, frustrating hours at the chair. Eventually most of the occlusal form was destroyed so that the end-result was little better than a plain line articulator.

Check-bites described in this chapter are still positional bites, but they are positions of the hinge axis in paths of motion of the condyle. They are not concerned with positions of the mandible at the time of making the bites, except as a means of fixing positions of the axis at functioning relations. It is not necessary to determine the vertical dimension, nor the cusp rise. Indeed, for reasons described in Chapter 7 on Centric Bite Procedures, it is desirable to take these bites at an increased vertical opening in order to avoid interference from neuromuscular reflexes. This is one of the factors that mitigate against the use of any bite by merely closing the patient into it in a lateral excursion.

However, there is a much more important reason why a check-bite should not be taken by allowing the patient to close into it. The condyle path is a curve. The angle of the condyle path is the chord of the arc, at that position on the curve where the condyle stopped. To secure one setting of the articulator which will be acceptable for all check-bites, the angle must be the same in all excursions. So the condyle must stop in the same place on its path for each check-bite. The difference between the protrusive and the lateral bites will disclose the Bennett movement. The Bennett movement is certainly as important as the condyle path, if not more so. To put it differently, the Bennett movement is the working stroke of tooth contact. While the balancing condyle path does bring about the Bennett movement on the working side, its effect is of much less magnitude in working contact. That is, minor errors in the condyle path curvature are of less functional significance than errors in the Bennett movement angle and amount. Check-bites are limited to restorations in which the teeth are embedded in plastic, such as in full or large partial dentures, or have good bone support. The use of average curves for the condyle paths, provided the angles are correct, presents, with check-bite settings, a lesser problem than it would in settings made from pantograph recordings.

## STONE CHECK-BITES

Roughly, the method consists in locating the horizontal axis of the condyle by means of a hinge bow, reproducing its path of movement by check-bites taken in various excursions, and transferring these records to an articulator for the purposes of treatment. The method is unique in that it uses check-bites to obtain these records prior to actual treatment and relates them to a fixed plane of reference. No matter what changes take place in the mouth, subsequent models can be mounted readily with complete fidelity in correct functional relation without the necessity for new records. The compromise lies in the important fact that the meniscus does not move in straight paths. The mandible moves in paths resulting from the various combinations of curved paths of the condyle. With one exception, all present-day adjustable articulators except the gnatholator move on straight paths. A check-bite does not yield information about the curve of these paths between the terminal position and the extremes of excursion. It merely records the position of the axis at the terminal position of the mandible, and the various excursions which estimate the path the condyle followed to bring about the movement. It fails to reproduce all the intermediate irregularities between these two. The precise cusp relationship in the most important phases of mandibular movement, from the periodontal standpoint, cannot be developed to maintain equal simultaneous contact. Therefore, the limitations lie in the treatment of complicated periodontal problems. From the standpoint of vertical rotational relation or so-called "bite-raising," it is technically correct, particularly as applied to the prosthetic field and the treatment of various joint dysfunctions.

The basic check-bite procedure consists in recording the changing relations of the hinge axis from centric to excursion by means of stone wafers formed between metal check-bite plates. The check-bite plates are attached either to edentulous bite blocks, or to trays, called clutches, that are cemented to natural teeth. A center bearing pin separates the plates and allows room to inject soft stone between them. The hinge axis is located and marked on the face. Stone is injected between the check-bite plates in centric, protrusive, and right and left lateral excursions. It is arranged that the protruding condyle makes the same length of excursion each time, so that the differences between protrusive and lateral bites record the Bennett movement.

By means of the hinge bow, used now as a transfer bow, and the orbital indicator, the relation of the upper check-bite plate to the hinge axis and to a plane of reference is established. By the use of a mounting frame, this relation is transferred to the articulator and is mounted on its axis and plane of reference. Now, as each stone bite is placed successively between the bite plates, the changed relation of the lower check-bite plate to the plane of reference requires the establishment of paths of motion of the articulator. Since the changed relation in excursions in the mouth formed the stone bite originally, the paths of motion on the articulator which bring about the same relations will reproduce the same position of the axis. Of course the difference lies in the fact that in the mouth these are curved paths, whereas the stone bite gives no information about the curves. This problem is minimized by the use of average curves on the articulator, and the check-bites are used to establish the angle of the chord of the arc of these curves.

When the articulator has been set to reproduce the paths of the patient, the check-bite plates and the clutches are discarded. Now, by means of the transfer bow and the axis-orbital indicator, the upper model of the mouth is related to the axis and the plane of reference just as the upper check-bite plate was. The lower model is oriented to the upper by means of a centric bite. Using the mounting frame again, the upper model is now related to the instrument in correct functional relation to the paths of motion. Regardless of changes in the mouth, such as tooth preparation or extraction, if the model is related to the plane of reference and the hinge axis, it will be in correct functional relation to the joint. Restorations constructed on these models also will be in correct functional relation. The controls are on the upper member in fixed relation to the upper cast, just as, in the skull, paths of motion are in the upper compartment in fixed relation to the upper teeth. Therefore, since the mounting is on the axis, changing the vertical opening will not affect either the centric or the paths of motion. It is not necessary to predetermine the vertical opening or the anterior guidance at the time of taking the check-bites. Therefore, it is apparent that the validity of the check-bite is dependent upon locating the axis and the plane of reference. Since both of these must be used later to mount and remount models, the hinge axis and the axis-orbital plane must be established as permanent reference points by being tattooed into the skin. Once they have been established, all that is necessary for future mountings is to take a transfer bow mounting from these tattoo marks. It is not necessary to repeat the records at some future date for continuing treatment and maintenance. Once established, the functional relations can be maintained throughout life by a simple mounting that can be made in 5 minutes.

Since the models likewise are mounted on the hinge axis, it is not necessary to establish the vertical dimension when taking the centric bite. As explained in Chapter 7, it is desirable to take this bite at an increased vertical dimension and determine the vertical on the articulator, that is, the vertical at which the models are mounted does not have to be the same vertical at which the original check-bites were taken.

*Chapter* 11

# Complete Dentures

The following denture technic is suggested as a means of using stone bites to record positions of the joint. Although the procedures in general resemble previous plaster check-bite technics, the purpose for which they are used is quite different. Most check-bite technics are used to record positions of the mandible which must then be used for orienting teeth in those positions and at that particular vertical dimension. Since with this technic the stone check-bites are used to record positions of the axis at any opening, it is not necessary to establish either the positions or the bite opening at which the teeth will articulate at the time of taking the check-bites. In a general way the procedures follow pantographing, except that check-bites instead of tracings are used to trace the paths of the axis. If metal bases are employed, the steps of making and stabilizing the base plates will be eliminated, or the impression trays may be readapted.

Impressions are taken and stone casts made by the operator's method of choice (Fig. 133).

If a special tray or a metal base has not been constructed for the case, it will be necessary to make an acrylic base plate. A shellac base plate will not do for this purpose. The cast is shimmed (relieved) by adapting a sheet of base plate wax over the base area and pressing it into place with a towel. Severe undercuts are filled with wax. Over this is placed a sheet of household aluminum foil

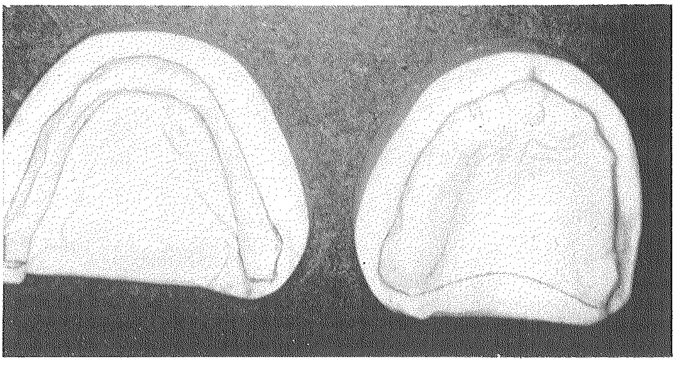


FIG. 133. The working models.

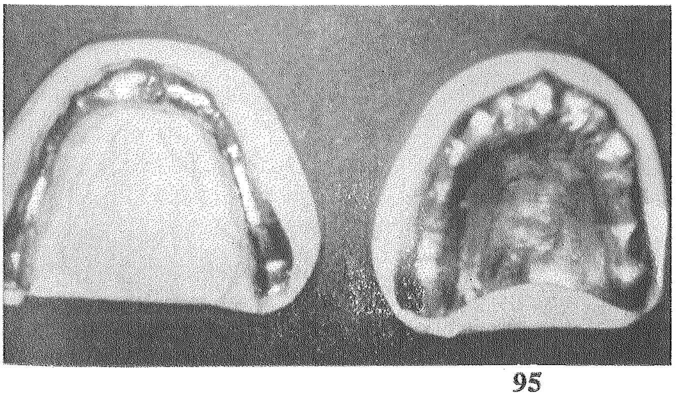


FIG. 134. The shimmed models are foiled.

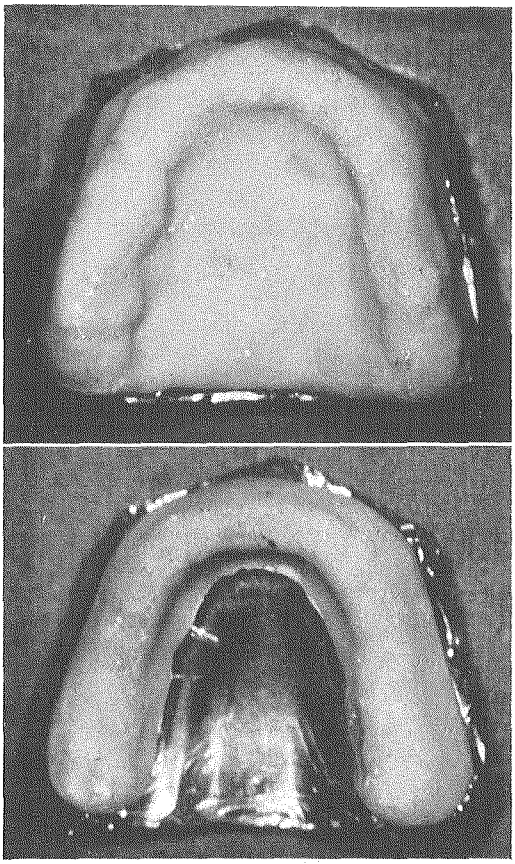


FIG. 135. Acrylic base plates.

as a separating medium (Fig. 134). Sheets of wet cellophane are placed on both halves of an acrylic base plate press. A suitable mix of self-curing base plate acrylic is poured into the press, which is closed with hand pressure. When the acrylic has set enough to be handled without flowing, but is still plastic, it is removed with the cellophane covering and adapted to the cast over the foil. When the acrylic is thoroughly set, it is removed from the cast and the cellophane is peeled off (Fig. 135). The acrylic is trimmed to the outline of the denture.

This base plate can be used for the subsequent steps in just the same way as a cast tray. Since it is necessary either to have a metal base or to construct such a base plate, it is usually better to make an impression tray of either acrylic or aluminum and refit that for use as the base plate. If a metal base has been constructed, a model is poured into it for mounting purposes, instead of refitting the tray to the master cast. In either case, the procedure steps are the same. They are shown here on the aluminum tray used for the original impression. In complete dentures the use of retractors is limited. Therefore, for the sake of clarity, some steps are shown on a manikin as well as on the patient.

A twisted wire fork is attached to the lower denture (Fig. 136), with the shaft ¼ inch to the left of the mid-line. The ends of the fork should rest on the ridge just in front of the retromolar pads. The front of the twisted wire should likewise be over the ridge and raised about ¼ inch above the base plate to allow lip room. The fork is attached at the heels and the mid-line, with enough self-curing acrylic to hold it securely.

Another wire fork is attached to the upper denture, with the shaft projecting about ¼ inch to the right of the mid-line. The twisted wire should be parallel with and raised about ⅛ inch from the upper ridge. This also is attached at the heels and the mid-line with self-curing acrylic. The space between the base and the fork is filled with base plate wax.

Finally, the base plates must be adapted to the master casts. Deep undercuts are filled carefully with wax. Over the cast, .001 tin foil is burnished by using a gum eraser and then an orangewood burnisher. A thin mix of self-curing acrylic is placed inside the base plate and pressed into place over the foil on the master cast. After it is set and trimmed, the foil is left in place.

## LOCATING THE HINGE AXIS

The chin clamp is positioned on the lower fork (Fig. 137) by sliding the angle clamp on the fork until the two stabilizers of the chin clamp fall under the second molar region of the base plate. The angle clamp is tightened on the bite fork and the chin clamp is loosened from it, so that the angle clamp remains attached to the base plate fork, and the chin clamp is removed. The chin clamp is placed in hot water and the stabilizers are

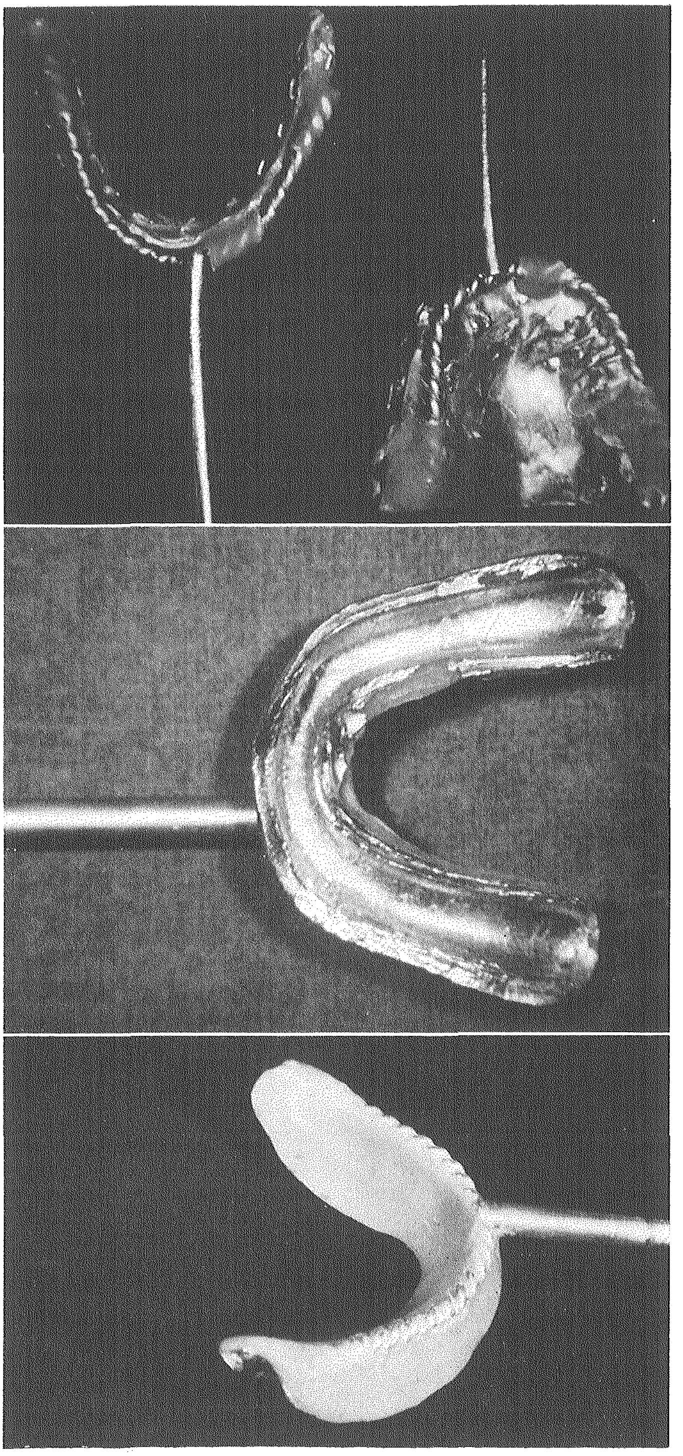


FIG. 136. Wire forks are attached to the base plates

covered with ⅛ inch of the impression compound.

The base plates are filled with heavy-bodied rubber base impression material. This is allowed to thicken until it is quite stiff. Adhesive should not be applied to the base plates. The base plates are inserted and seated in the mouth and held until the rub-

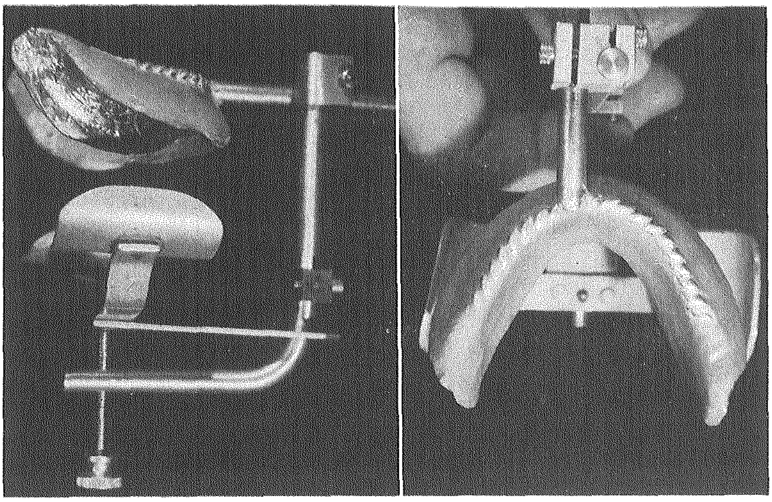
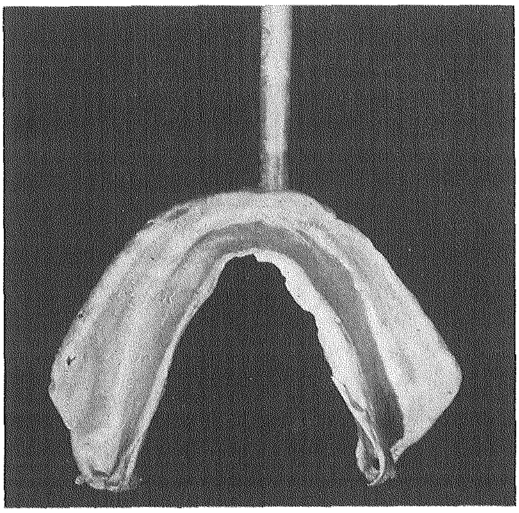


FIG. 137. The chin clamp is positioned under the base plate.



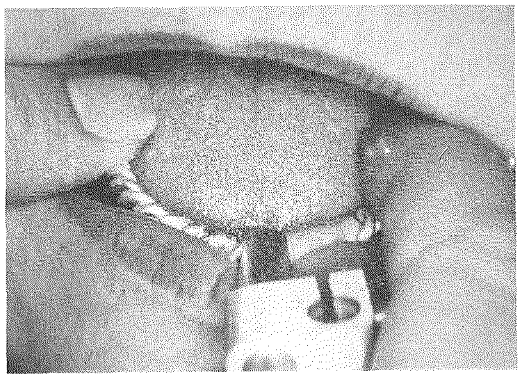


FIG. 138. The rubber base cushion in the lower is held while it is setting.

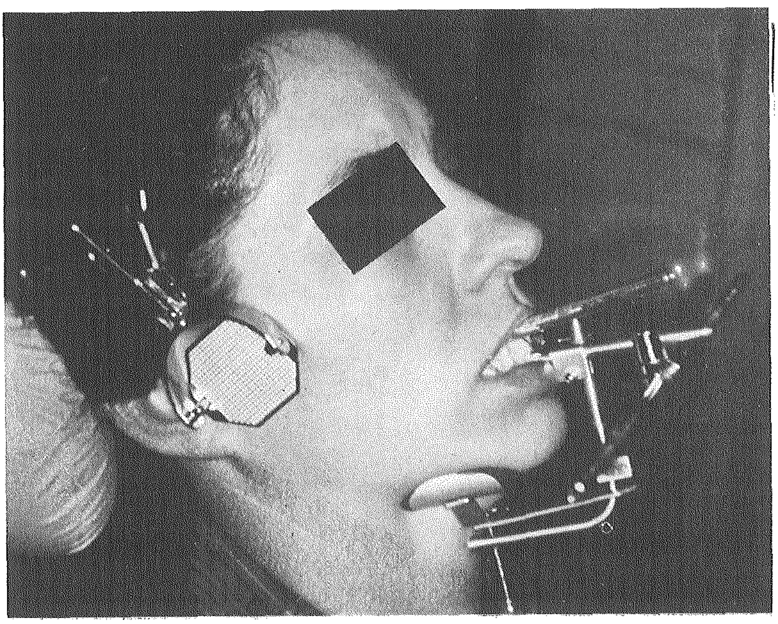


FIG. 139. The chin clamp and the axis head cap are on the patient.

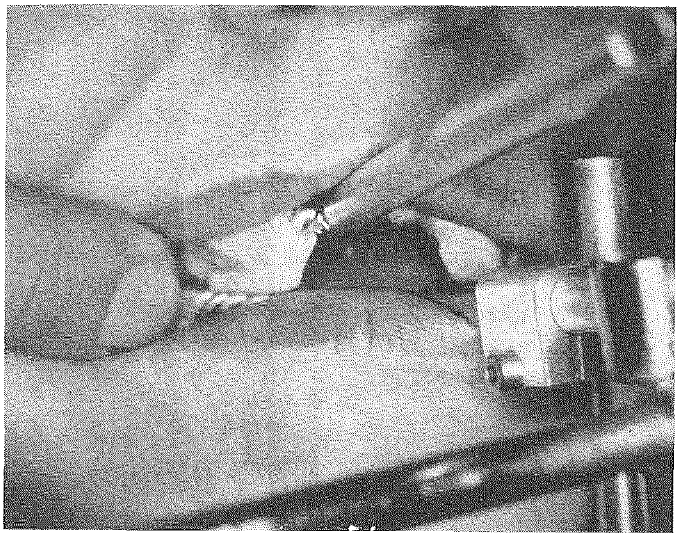


FIG. 140. Acrylic stops are placed on the wire fork.

ber has set (Fig. 138). They are removed and washed in warm—not hot—water to stiffen the rubber. A small amount of adhesive powder is sprinkled over the surface and the base plate is inserted in the mouth. Since we are not concerned here with the fit, this is merely to hold them in place while the chin clamp is attached.

The chin clamp is removed from the hot water and slid up in the clamp attached to the bite fork until the compound shapes itself to the lower border of the mandible (Fig. 139). The angle clamp is locked in order to hold the chin clamp. To secure additional stability, the thumbscrew is turned to tighten the chin clamp on the mandible as the compound is setting.

Stops must be provided which the patient can close against. These are formed by placing a small mound of self-curing acrylic of a doughy consistency on the upper wire fork (Fig. 140) in the region of the first bicuspid on each side. The patient is guided into repeated closures with gentle contact of the acrylic against the lower fork until it hardens.

The head cap with the flags and the lined paper is placed just in front of the tragus of the ear (Fig. 141). The hinge bow is attached to the lower fork (Fig. 142) and, by adjustment of the side arms, with repeated hinge closures, the hinge axis is located. The

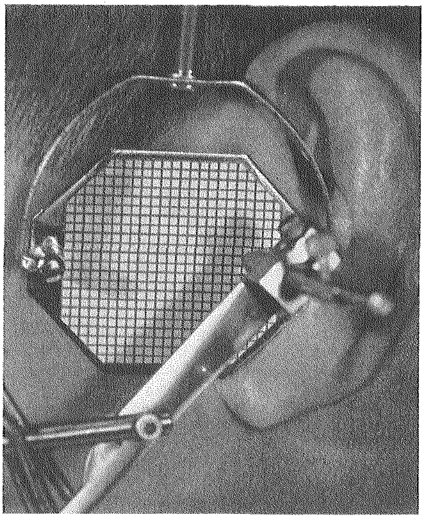


FIG. 141. The flags are positioned in front of the tragi of the ears.

head cap is removed and the skin is permitted to return to normal before the axis is marked. The patient is instructed to hold the stops in firm contact but not to clench. He is seated upright in the chair. The styli are removed from the hinge bow, and the points are touched with a wet indelible pencil. The styli are replaced in their tubes and slid in to make gentle contact with the skin, leaving an indelible mark on the skin at the axis point.

The next step is to make a permanent mounting of the upper cast, and a temporary mounting of the lower, in order to position

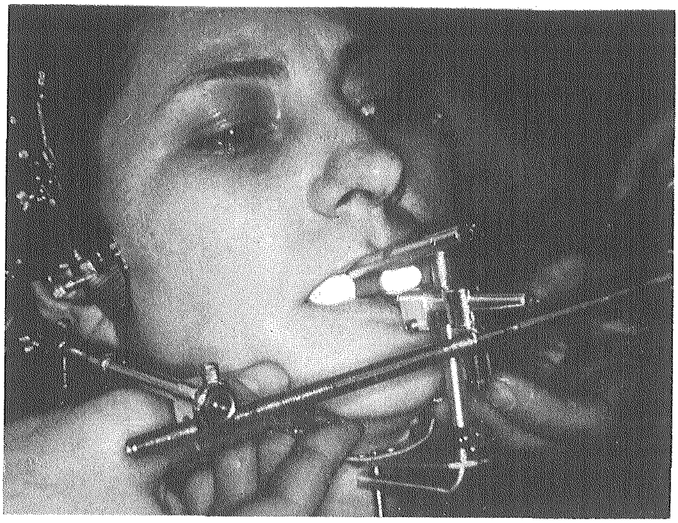


FIG. 142. The hinge bow is attached to the lower fork.

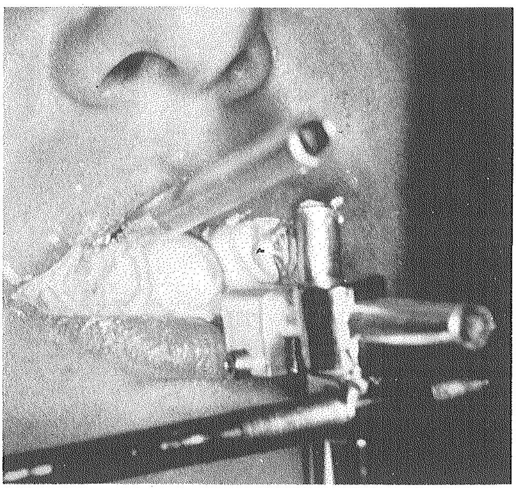


FIG. 143. A temporary centric stone bite.

check-bite plates. The base plates and the hinge bow are removed from the mouth. The rubber base material is peeled out. The base plates are returned to the mouth and are luted together by a small amount of check-bite Greyrock placed on each of the acrylic stops. The patient closes in centric on the stops and holds until the stone has set (Fig. 143). Now the hinge bow is attached to the upper fork. The axis-orbital indicator is attached and positioned (Fig. 144). The nose mark is established with an indelible pencil, and the base plates, with the hinge bow attached, are removed from the mouth.

Using the mounting frame, the upper master cast is attached to the articulator. The hinge bow is detached, and the lower cast is luted to the lower bow of the articulator. The wire forks are removed by cutting the acrylic which holds them to the base plates. The acrylic is smoothed to allow for attaching the check-bite plates (Fig. 145).

## ATTACHING THE CHECK-BITE PLATES

The upper check-bite plate is placed on the base plate with wax so that the plate parallels the ridge (Fig. 146) and the front edge is even with the labial flange of the ridge. This is attached by painting self-curing acrylic around the edge of the plate. To allow for tongue room, the bite plates should be set high in the mouth.

The spacer ring is placed in the center of the upper check-bite plate and attached with sticky wax around the rim (Fig. 147). This is set on the lower plate in such a way that the posterior border of the lower plate (Fig. 148) lies ⅛ inch in front of the posterior border of the upper. The ring is waxed to the lower to hold the plates parallel and separated. Now the articulator is closed (Fig.

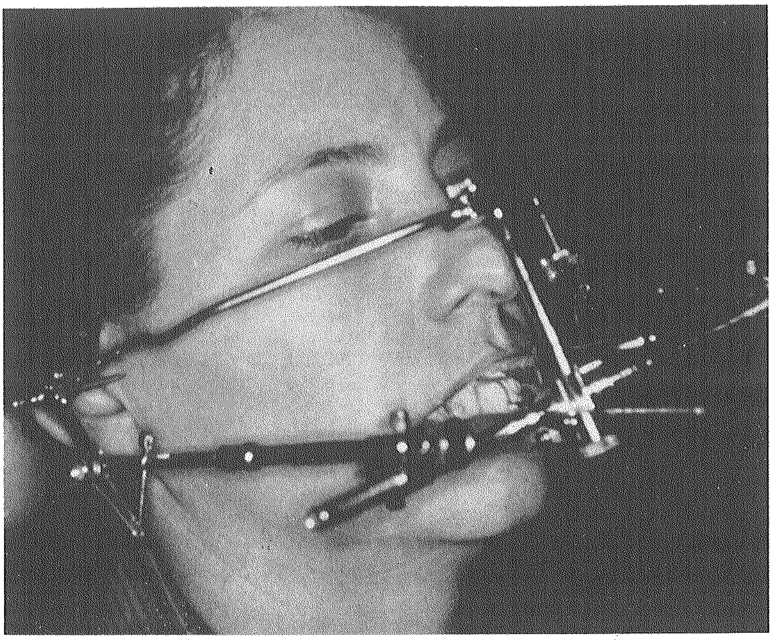


FIG. 144. The transfer bow is attached to the upper fork.

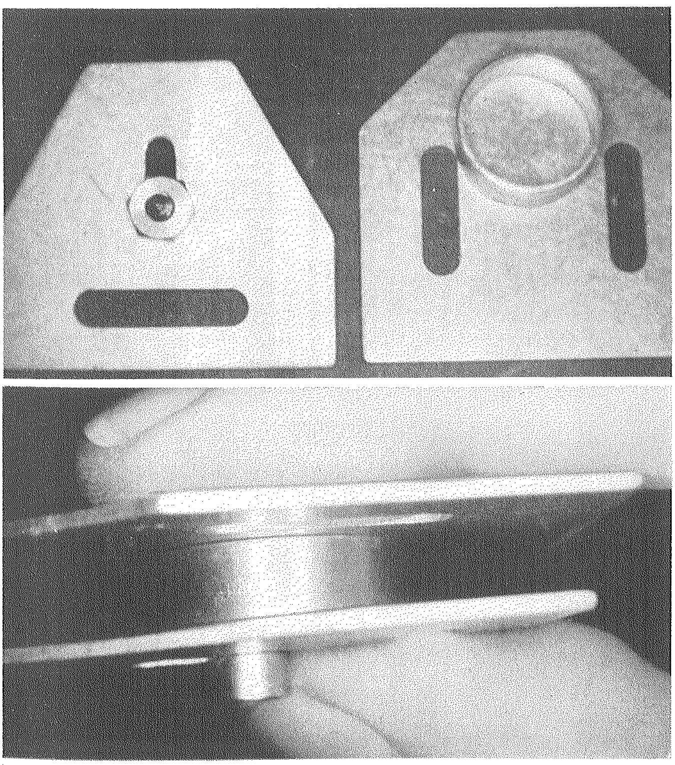


FIG. 145. The check-bite plates.

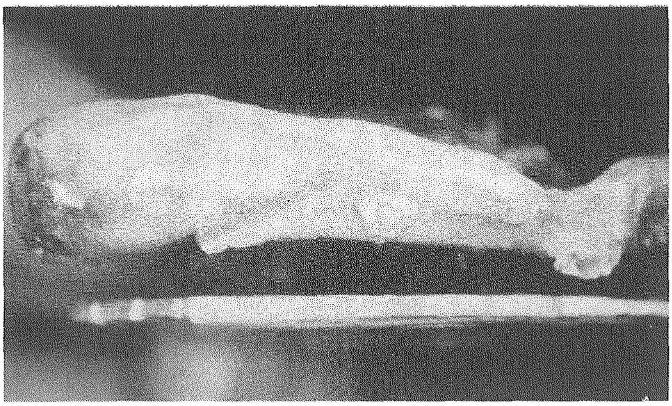


FIG. 146. The upper check-bite plate is parallel with the ridge.

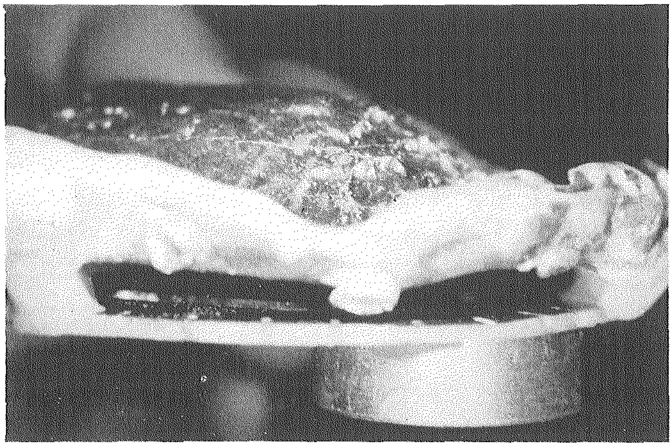


FIG. 147. The spacer ring is waxed to the upper bite plate.

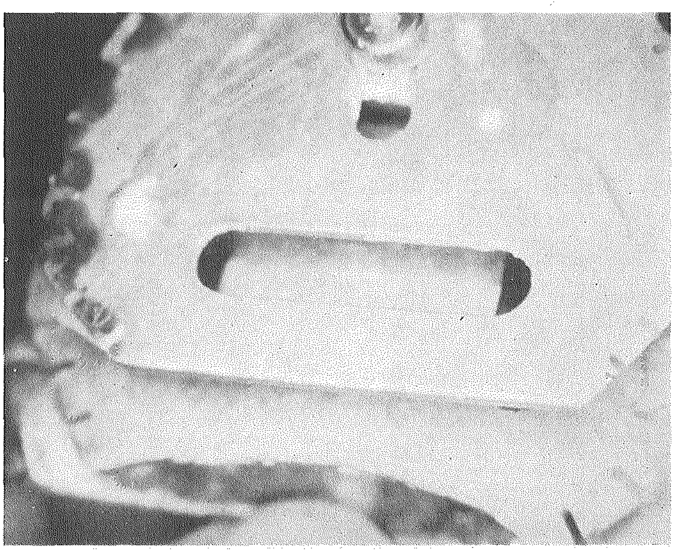


FIG. 148. The upper plate must extend beyond the posterior border of the lower plate.

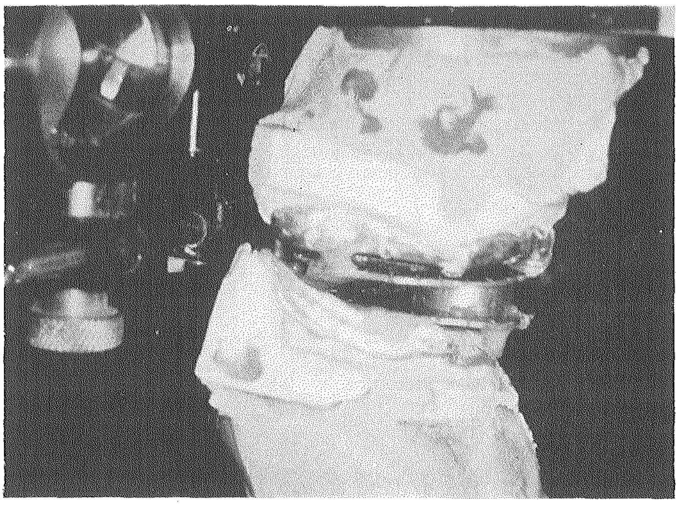


FIG. 149. Positioning the lower plate on the articulator.

149) until the lower check-bite plate contacts the lower base plate. If the opening appears to be excessive, the base plate, or, if necessary, the check-bite plate is trimmed to allow it to close to a comfortable vertical dimension. Then the lower-check bite plate is attached to the base plate with self-curing acrylic. The spacer ring and the sticky wax are separated and removed. The center bearing screw is placed in the slot.

The anteroposterior slot in the lower check-bite plate is provided so that the center bearing pin can be placed as far forward as possible, without causing tipping of the upper base. The farther forward the pin, the less danger there is of rocking the mandible. Conversely, the farther forward the pin, the more danger there is of tipping the upper base. So it is necessary to adjust the pin in the mouth to the best position to satisfy both requirements.

The cross slot in the lower plate and the two diagonal slots in the upper plate are designed so that the stone will run through and lock the plates together while the lower model is being mounted and, later, when the height gauges are being set. The center bearing pin has a 120° point so that it will mark the upper plate without making deep scratches. If the plates are properly posi-

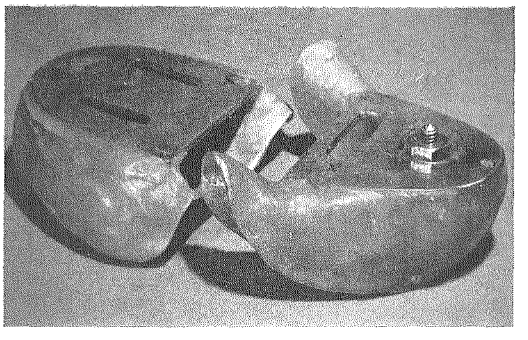


FIG. 150. The labial flange is covered with wax.

tioned, the lower plate should be shorter than the upper when they are in the mouth. The tongue will bulge over the back of the lower plate, sealing the opening and preventing stone from running back into the throat. If the lower plate is longer than the upper, the tongue cannot seal the space, and stone will escape into the mouth. The plates should be approximately parallel to avoid slipping to the side, and separated ¼ inch in centric.

The labial flange is covered with base plate wax (Fig. 150) down to the bite plate. It is shaped so that it tapers from the periphery to the base plate, for easy removal of the stone bite. The wax is polished with a wet towel and a film of petroleum jelly is applied.

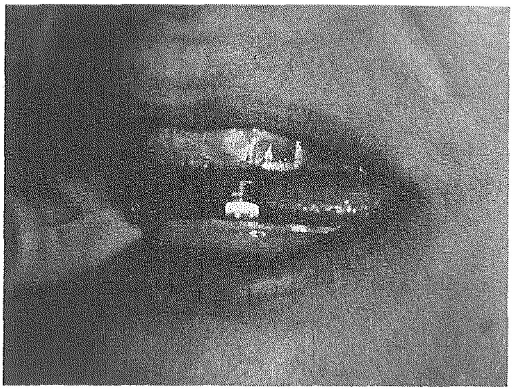


FIG. 151. Stone is forced between the plates.

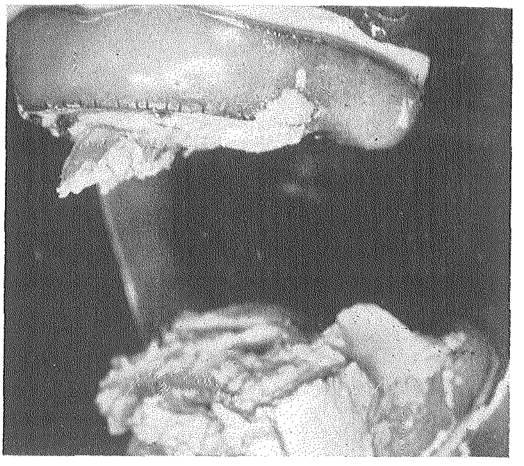


FIG. 152. The patient makes repeated closures into the stone and holds it until it is set.

The lower is treated in the same way. The first step is a new centric check-bite.

## MAKING THE CHECK-BITES

With the bases in position in the mouth, the patient is instructed to slide the mandible back and forward several times. Each time the mandible retrudes, the chin is gently pushed back until it stops. After several tries produce a definite stop, the patient is instructed to hold this position with firm pressure, but not to clench. Check-bite Greyrock is mixed to a stiff cream and poured into a plastic cone. The cone is inserted between the plates (Fig. 151), well back toward the bulging tongue, and is squeezed to expel the stone. As the stone is ejected, the cone is withdrawn slowly to fill all the space between the plates.

When the space between the plates is filled, the thumb is placed on the chin, and the patient is instructed to open and close, as in taking any centric bite. The centric bite is never taken with a single closure in a static position. The patient is guided in repeated hinge closures (Fig. 152) until the stone begins to thicken. Then he is closed in centric and instructed to hold it firmly until the stone sets.

When the stone has hardened, the upper and the lower bases, joined by the stone, are removed as a unit. Without separating, the lower model is now remounted in centric. To separate the stone bites, a knife is used to cut the stone which ran through the slots flush with the underside of the lower and the upper sides of the upper plates. Then the plates can be pried apart gently to preserve the bite for future checking. The plates and the bases are washed to remove all the stone.

The excursion check-bites must be taken in a definite order and in definite positions. The protrusive check-bite is used to determine the angle of the condyle path. The lateral check-bites are used to determine the Bennett movement which, in lateral excursion, was combined with that condyle path. The object is to secure a setting of the articulator which will be acceptable for all the check-bites. To determine the accuracy of that setting, height gauges are used as described in Chapter 12. The condyle path is a curve. The angle of the condyle path is the chord of the arc of that curve. So, in each excursion, the protruding condyle or condyles must stop at the same point on that curved path. Otherwise the chord and, therefore, the angle setting would be different for each excursion. Since the full range of the condyle path is not used in tooth contact, only that portion of the path which will incorporate the Bennett movement in lateral excursion should be used in taking the check-bites of all excursions.

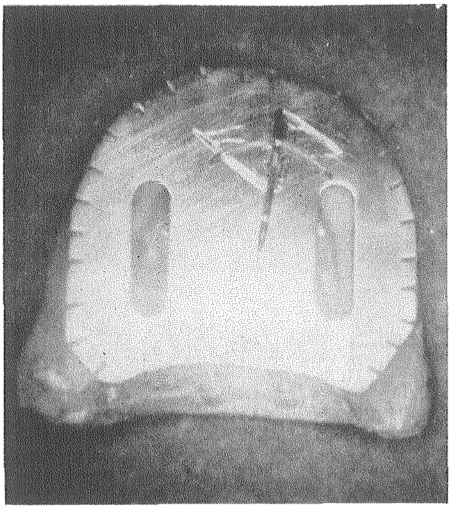


FIG. 153. A hole is drilled 3 mm. behind centric.

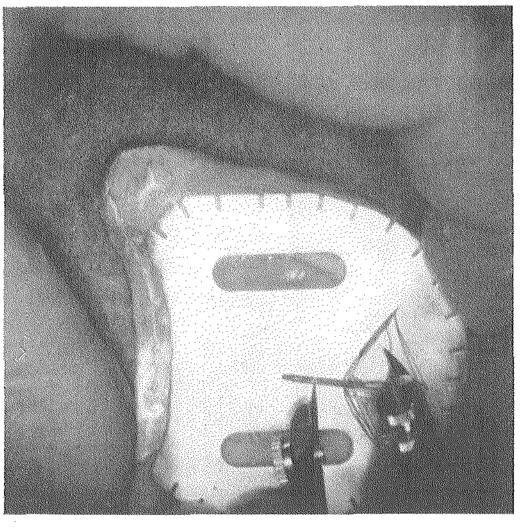


FIG. 154. An arc is scribed to intersect the Gothic arch.

To accomplish this, the base plates are returned to the mouth, and the patient is instructed to make repeated lateral and protrusive excursions. If this is accurately executed, the so-called apex of the Gothic arch does not exist, since it would be eliminated by the Bennett movement. A ruler is placed at the terminal end of the protrusive line, and a mark is scribed 3 mm. behind the most retruded position. With a #1 round bur, a hole is made in the plate directly behind centric (Fig. 153), in a place which the mandible cannot reach. A small metal scribing compass is set at an opening of 8 mm. The point of the compass is placed in the hole and an arc is scribed (Fig. 154) which crosses the Gothic arch tracing on both sides.

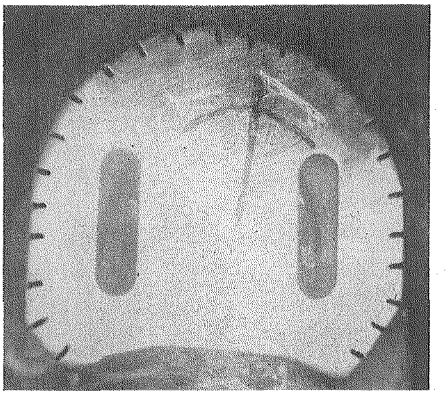


FIG. 155. Holes are drilled on the arc.

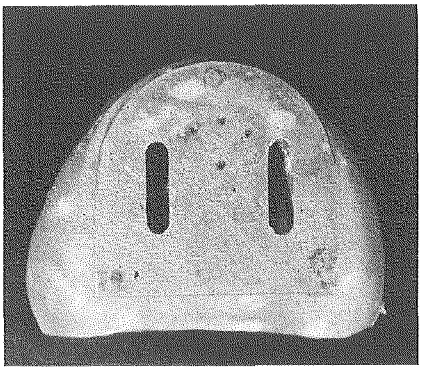


FIG. 156. The scratches are polished off, leaving the holes.

Where the scribed arc intersects the Gothic arch tracing on each side, a hole is made with a #½ round bur. A third hole is made on the arc directly in front of the first hole and exactly midway between the holes in the lateral lines (Fig. 155). To reach this last, protrusive hole, both condyles will have to come forward equally in a pure protrusive path. The scratches made by the center bearing pin (Fig. 156) are removed with a rubber wheel so that they will not confuse the patient as he executes each excursion.

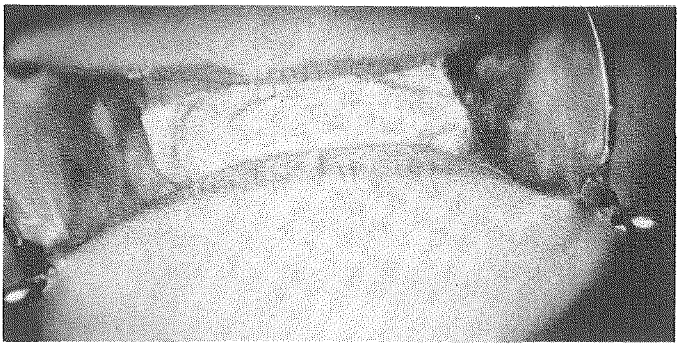


FIG. 157. The protrusive bite is taken first.

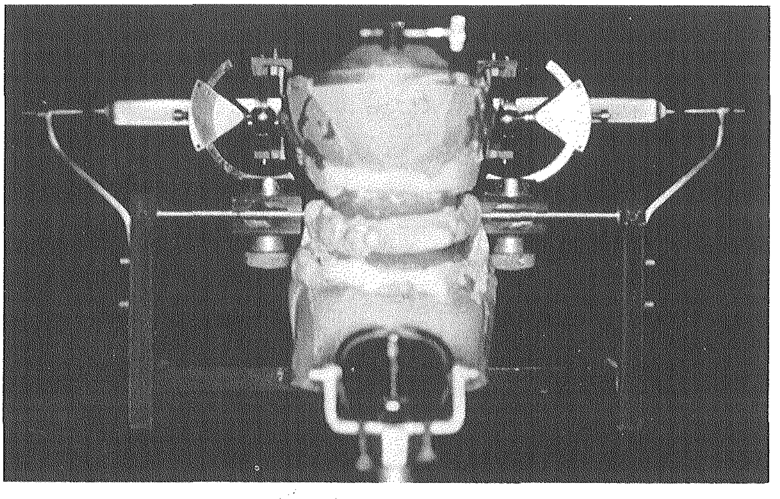


FIG. 158. Setting the protrusive height gauge.

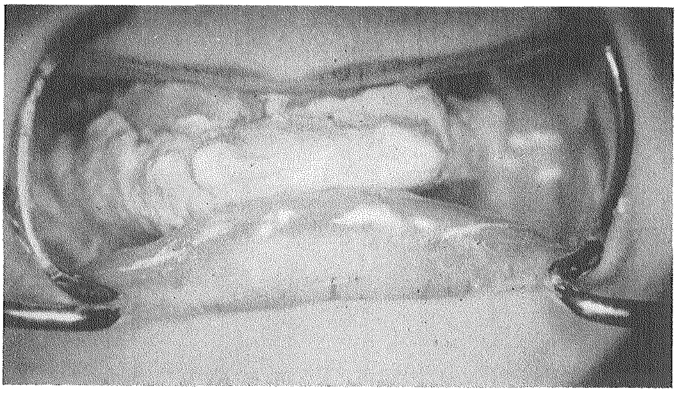
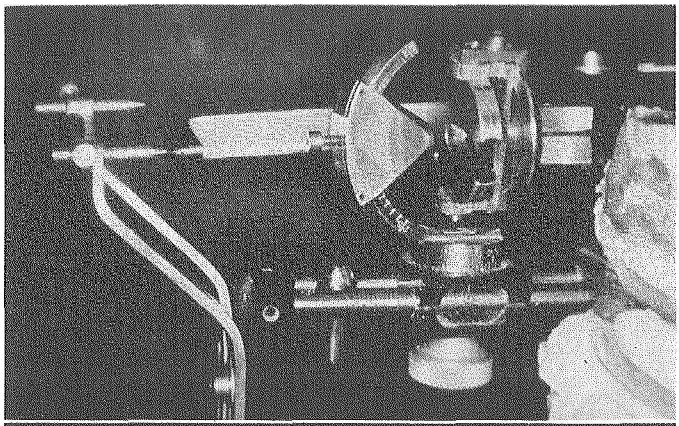
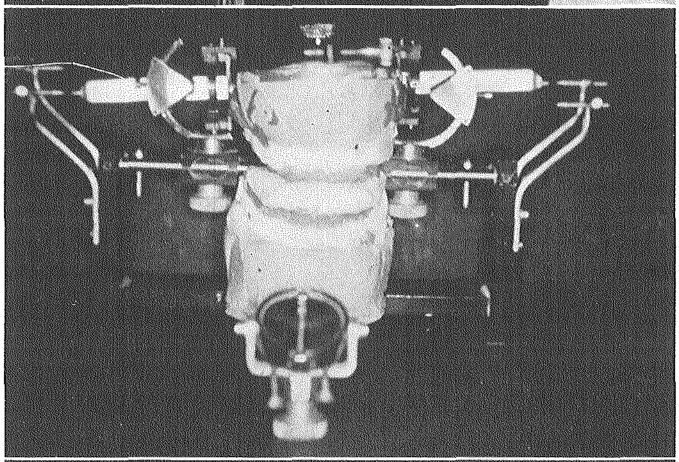


FIG. 159. A lateral check-bite.

The bases are replaced in the mouth, and the patient is instructed to move the mandible alternately in each excursion until he feels the pin drop into the hole. The pin has been provided with a 120° point so that it will not lock in the hole and hold the patient. *This is of the utmost importance. He must be instructed to hold the given position with his own muscular force.*

The protrusive bite must be taken first. A thin film of petroleum jelly is applied to the plates. The patient is instructed to slide the mandible forward until he feels the pin in the hole. He holds this position while the stone is injected, as before, and until the stone sets (Fig. 157). Without separating the bite, the assembly is removed and returned to the articulator. By means of the





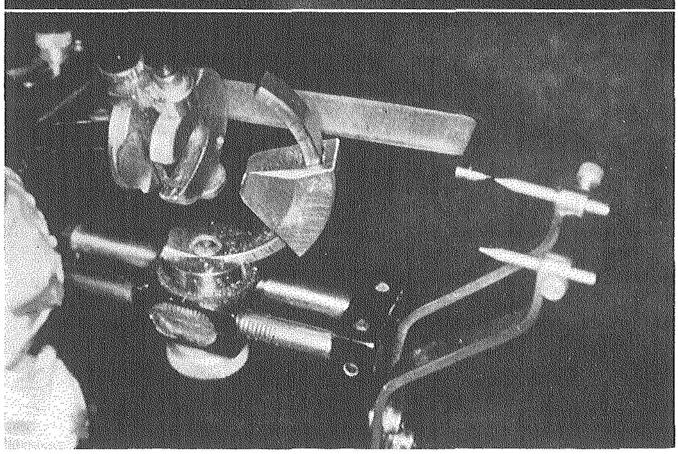


FIG. 160 (*Top*). Setting the working gauge; (*bottom*) setting the balancing height gauge.

height gauges (Fig. 158), the angle of the condyle path is set and locked. The bite is separated by cutting off the excess stone under the slots. It is marked with a "P" and set aside for future checking.

The plates are washed, dried, covered with petroleum jelly and returned to the mouth for a lateral check-bite. The patient is instructed to move into lateral until the pin drops into the hole (Fig. 159). This is held and stone is injected again. It is removed without separating, returned to the articulator, and the appropriate height gauges and the Bennett guide are set (Fig. 160). No

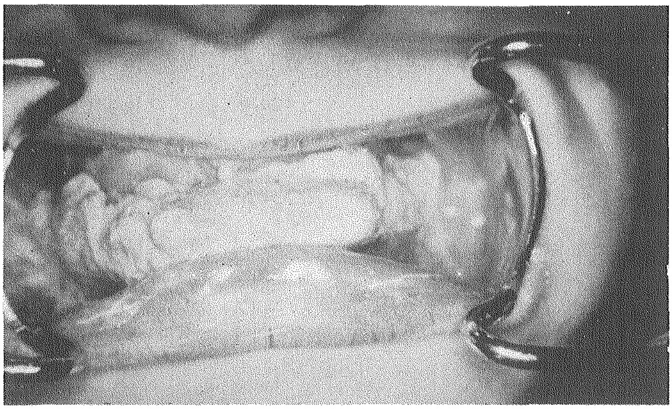


FIG. 161. Taking the other lateral check-bite.

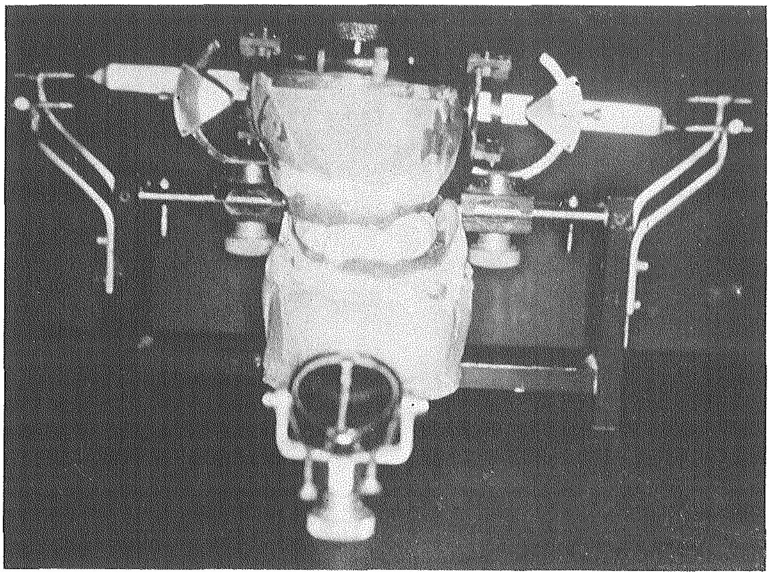


FIG. 162. Setting the other lateral height gauges.

attempt is made at this time to set the articulator. The check-bites are separated and set aside for future use.

The procedure is repeated for the other lateral excursion (Fig. 161), and the other height gauges (Fig. 162) and the Bennett guide are set. This check-bite is separated and marked for future reference. The patient may now be dismissed and the articulator set from the height gauges at the operator's convenience. The methods of setting are described in Chapter 12.

The working models now have been mounted in a properly set articulator, and the construction of the restorations is completed as usual.

## CHECKING THE MOUNTING

It is usually necessary to make bite blocks for the purpose of establishing the vertical and the lip line, and for setting teeth, as described in Chapter 16. As an aid to articulation, these should be made with curved occlusal surfaces formed by a BOG plate. The bite blocks are made on the bases used for the check-bites. They are made on the articulator at an estimated vertical and checked in the mouth. The check-bite plates are removed from the base plates by cutting around the rim with a large fissure bur. Bite blocks of hard-base plate wax are formed on these bases, using a metal BOG template of an 8-in. sphere. These templates are ob-

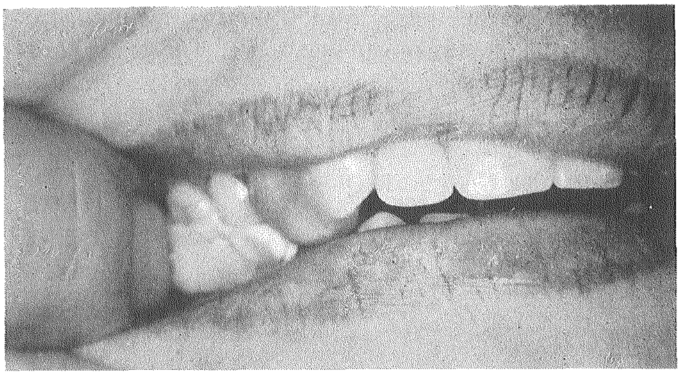


FIG. 163. Checking centric with a stone bite.

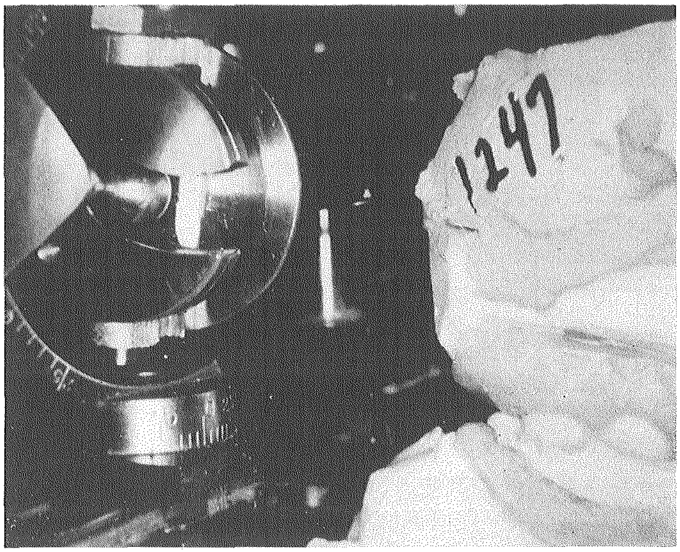



FIG. 164. Checking the stone bite on the articulator.

tainable from a number of manufacturers. If the base plate was used and has warped during this manipulation, it should be refitted to the model by lining it with tin foil and a thin mix of zinc oxide paste such as Ackerman's powder and liquid. It is immersed in cold water to harden the paste thoroughly. To adjust the height of these bite plates in the mouth, they can be softened safely in warm water so that the patient can close into them. They should be done separately so that the curve of the BOG will not be lost. However, it is wise to make a further check of centric and the axis mounting. If they are not correct, there is no use in proceeding further until they are correct. A quick and easy determination of their accuracy can be made with a trial setup in wax.

This is done by taking a new centric bite in an open position and seeing if the articulator will accept it. A small wedge of wax is placed between the bicuspids on each side. It is softened and the patient is instructed to make repeated hinge closures until the wedges contact equally and the teeth are separated about 3 mm. A thick mix of checkbite stone is used to cover the posterior teeth (Fig. 163), and the patient is instructed to make repeated closures into the stone until the wax touches the opposing teeth. He holds this position until the stone sets. It is removed without separating. It is returned to the articulator, and the operator tests to see if it will close in it (Fig. 164) without displacing the condyles in centric. If it does, the hinge axis mounting and the centric bite must have been correct. If it does not, the lower model is remounted with this new bite. The articulator is closed and the teeth are reset to centric occlusion. The same test is repeated. If it does not work this time, the hinge axis mounting was not correct. No attempt should be made to complete the case until it has been determined that these two steps are correct.

Finally, after the dentures have been in the mouth for several weeks, the cases are remounted by the same method, with a new face bow mounting, and any necessary adjustments to the occlusion are made.

*Chapter* 12

# Height Gauges

Height gauges are devices attached to the articulator for the purpose of setting it from check-bites. They are used only during the adjustment and are removed when the setting is completed. They are illustrated in the blown-up drawings of the articulator in Chapter 8 (Fig. 107). They provide a visual means of determining that the adjustment is correct, so that the check-bites are seated and the plates on the instrument are in the same relation as they were in the mouth when the bite was taken. To accomplish this, the settings of the articulator must be the equivalent of the functional movements of the patient which produced the check-bites.

The rationale consists of disengaging the upper and the lower bows of the articulator by removing the condyles and the shafts. The check-bite for each excursion is seated on the plates so that the plates are in the same relation as they were in the mouth, as registered by the check-bite, and the bows are now related only by the check-bite. Points attached to the upper and the lower bows on the hinge axis are adjusted until they approximate each other, so that they will be related by the check-bites and not by the articulator. After the gauges have been locked in this relation, the condyles are replaced and the instrument is adjusted until it will bring the points together in the same relation as in the check-bite. This is repeated with each bite, and then the instrument is checked to see that it is adjusted correctly so that it will accept all three check-bites: protrusive, and right and left lateral excursions.

The upper height gauge (Fig. 165) is attached by removing the back stop on the upper bow. It is fastened with the same screws, with the open end of the slots up. The Bennett guides are loosened to permit them to turn. The lower height gauges are attached to each side of the articulator, with the shorter one in front. Four holes are provided for various positions of the gauges. The rear one is used first in the upper hole, and the front one in the lower hole.

The points of the upper gauge are located on the hinge axis in centric, and the lower gauges represent the positions of the axis in excursions of the mandible as recorded by the check-bites. These changes of position are combined to reproduce the infinite variety of combinations of motion of which the mandible is capable. The check-bites must bear the same relation to the axis of the instrument that they do to the hinge axis of the patient, which is the purpose of the transfer bow mounting of the clutches. It is essential that the check-bites are seated accurately on the plates when the height gauges are set, if the setting of the articulator is to be correct. Any rocking of the check-bites on the plates will make it impossible to secure accurate relationships. Although we show here the setting using check-bites on clutches, the procedures are the same using bite plates on denture bases. The only difference lies in setting the height gauges before separating the bites from the plates.

## SETTING THE HEIGHT GAUGES

Setting the articulator follows a definite sequence. The protrusive bite is used to set the angle of the condyle path. The lateral bites are used to set the Bennett movement by tilting and turning the axis rotation, the angle of Bennett movement, and the intercondylar distances.

The lower clutch having been mounted (Fig. 166) by using the centric check-bite (p. 134), the protrusive check-bite is used

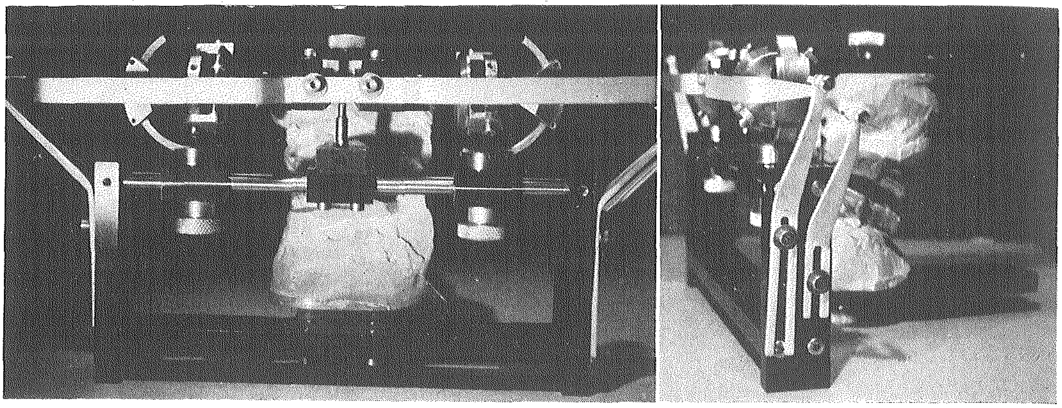


FIG. 165. Attaching the height gauges.

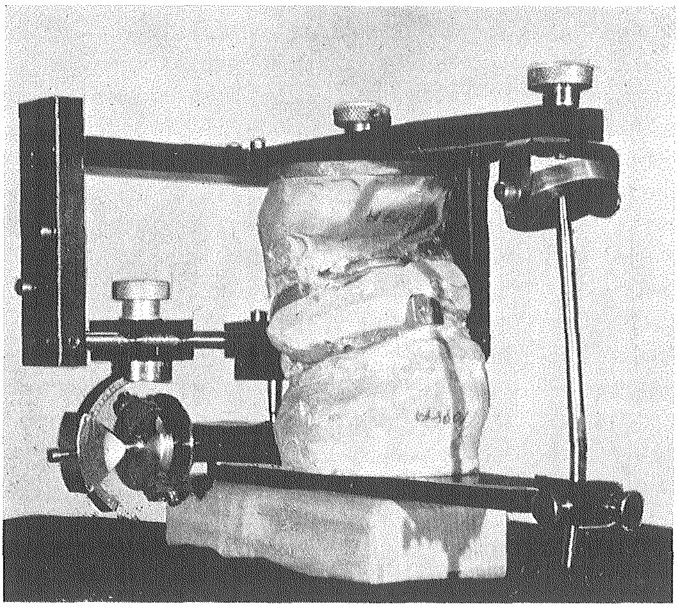


FIG. 166. The lower clutch is mounted with a centric bite.

first to establish the angle of the condyle path. The upper bow is removed from the articulator, and the two condyle axis shafts are removed and set aside. The clutches are seated in the stone bite and securely waxed together with sticky wax. The articulator being completely disengaged, the relation of the two bows to each other is maintained by the check-bite alone.

The rear height gauge on each side is adjusted until its point will coincide with the point of the upper height gauge (Fig. 167). The points should not quite touch, so that there is no chance of their hitting each other and throwing the gauges out of position. The Bennett guides are left loose at this time so that they will not interfere with any free protrusive movement of the articulator. The bows are held rigidly so that there is no possibility of rocking on the check-bite. The gauges are now locked tightly in position and the upper bow is removed.

The condyle axis shafts are replaced, and the condyle paths are loosened so that they will turn freely to adjust themselves to the position of the check-bite. The clutches are reseated on the check-bite, but are not waxed. The angle of the condyle path is adjusted so that the points of the height gauges coincide (Fig. 168). In order to take up the tolerance of the condyle ball in the condyle path, the setting of the condyle path should be as steep as the height gauge will permit. The points of the height gauges will indicate the correctness of the setting. Once the angle of the condyle path has been established and locked by means of the protrusive bite, it is not necessary to keep the height gauges locked, since the angle of the condyle path is not changed in the subsequent settings for the lateral bites. The check-bite is now removed from the articulator and kept for eventual rechecking of the final articulator setting.

If the angle of the condyle path is less than 20°, it is cause for suspecting that the centric bite is not correct, and this should be checked carefully before proceeding. If the centric bite is not correct, it will be impossible to obtain a setting of the instrument which will accept all the check-bites. Conversely, if it is not possible to secure a proper

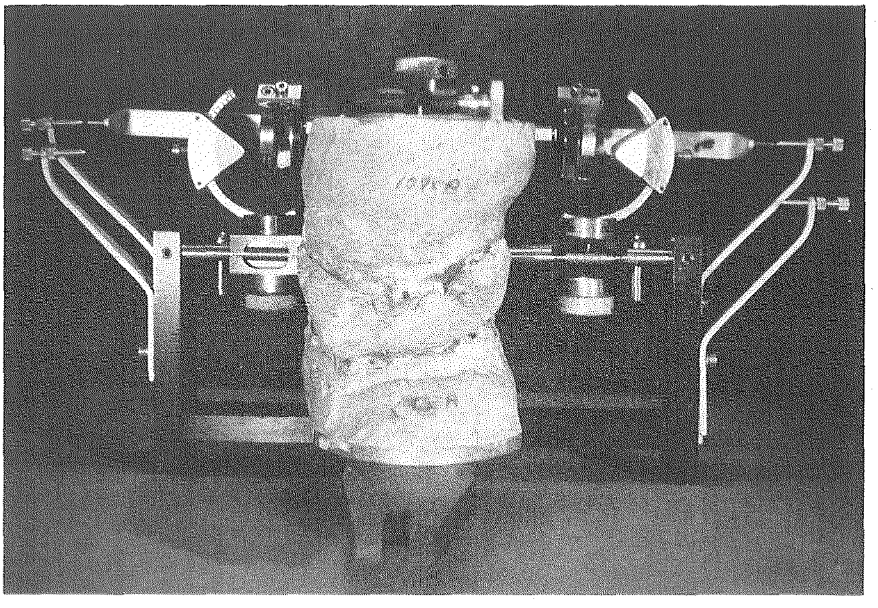


FIG. 167. The condyles are removed. The rear height gauges are adjusted.

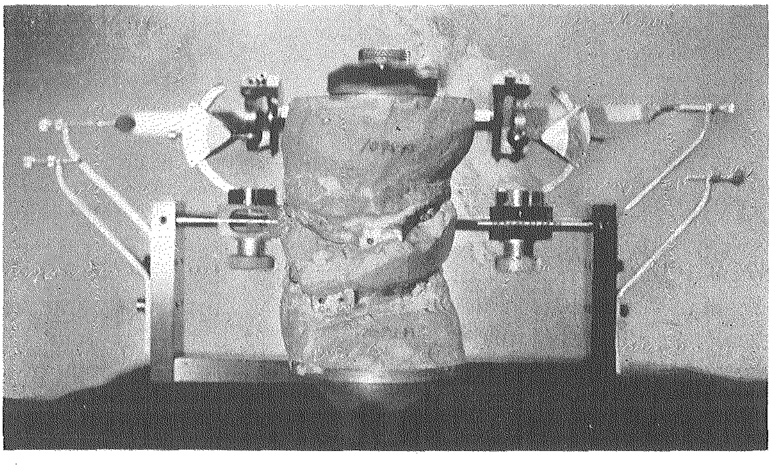


FIG. 168. The condyles are replaced. The angle of the condyle path is adjusted.

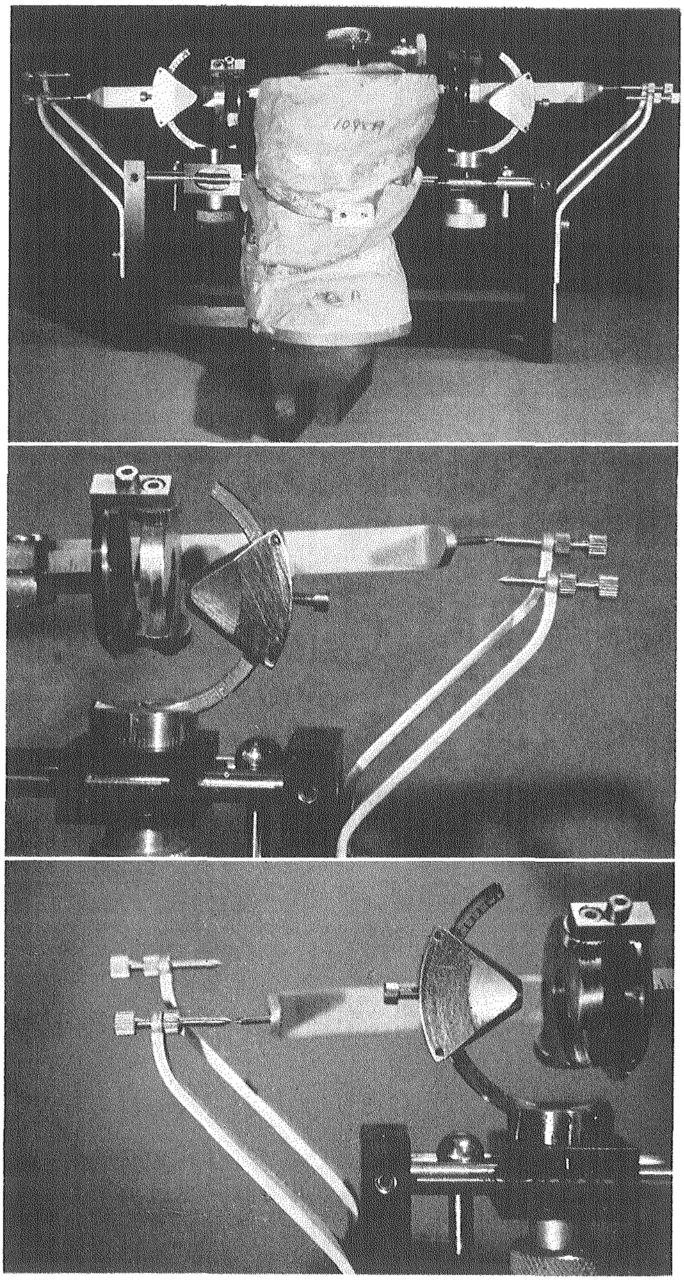


FIG. 169. One lateral bite is placed to adjust the gauges with the condyles removed.

setting for the lateral bites, the probable cause is an incorrect centric, or the holes in the plate are too deep. If the holes are so deep that they hold the patient in lateral, the condyles will sag and it will be impossible to set the instrument.

The condyle shafts are removed again, and the upper and the lower bows are related in a similar fashion by one of the lateral check-bites. The point of the rear height gauge is set to the point of the upper height gauge on the balancing side, and the point of the

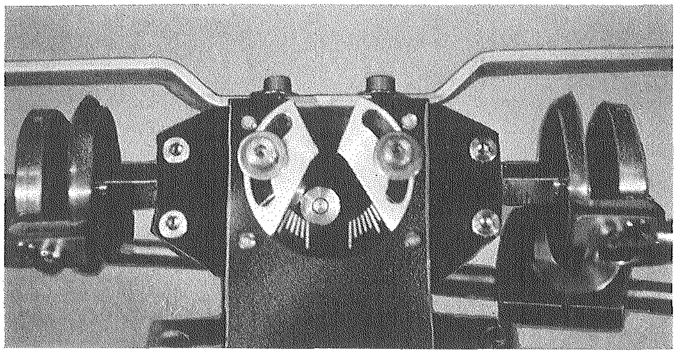


FIG. 170. The Bennett guide is locked against the post.

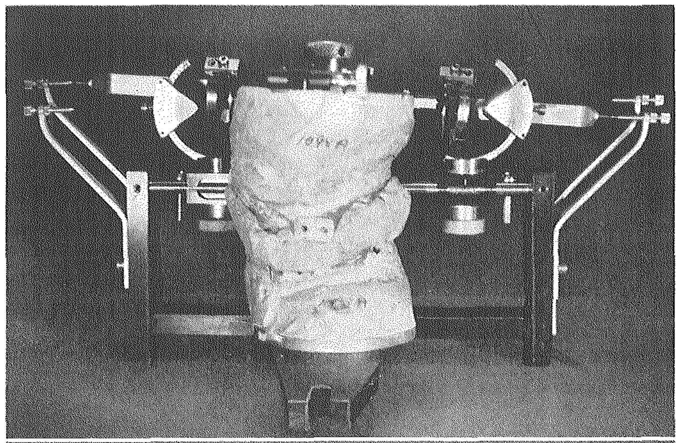
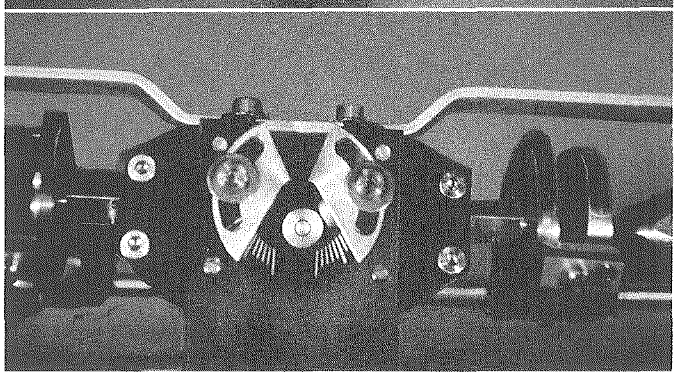


FIG. 171. The other lateral bite is placed to adjust the gauges and the Bennett guide. The condyles are removed.



shorter front gauge on the other side is set to the point of the upper height gauge on the working side (Fig. 169). When the height gauges have been locked in the position for lateral excursions, they must be kept there until all the articulator settings have been completed. The Bennett guide on the working side (Fig. 170) is now brought into contact with the center guidepost and locked, in order to set the degree of Bennett movement before separating the check-bite.

The check-bite is removed and, without replacing the condyle shaft, similar adjustments of the other height gauges are made (Fig. 171), using the other lateral check-bite. All the height gauges must be securely locked so that they cannot be displaced accidentally. The lateral check-bites will be

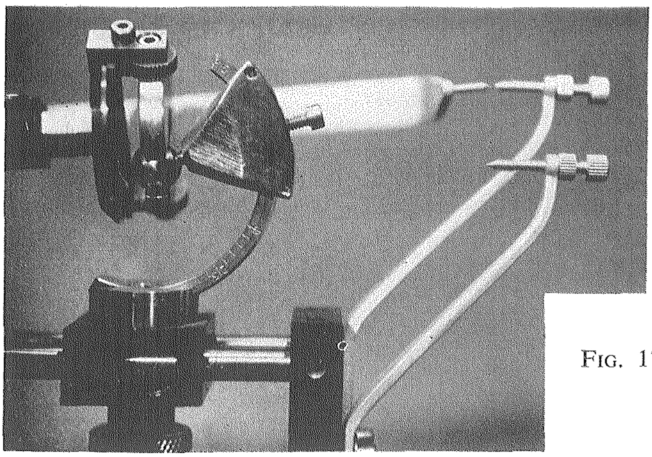


FIG. 172. Tilting the axis to adjust the balancing side.

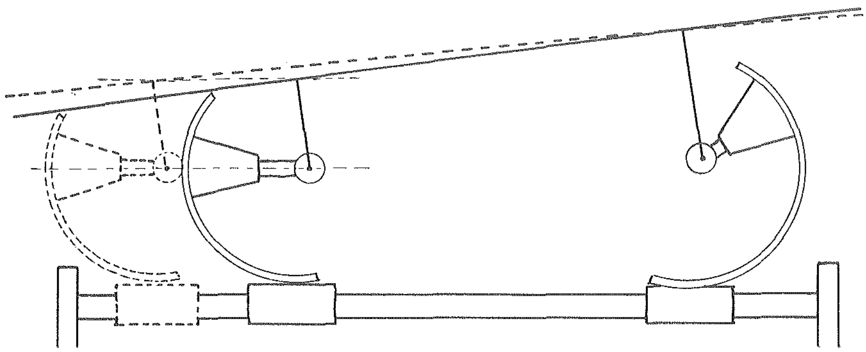
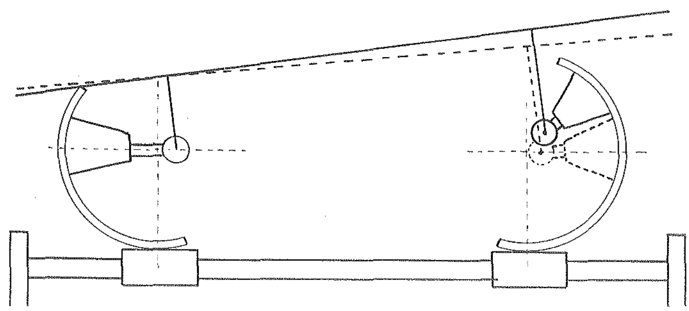
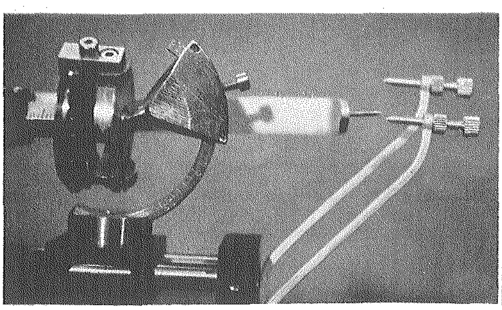
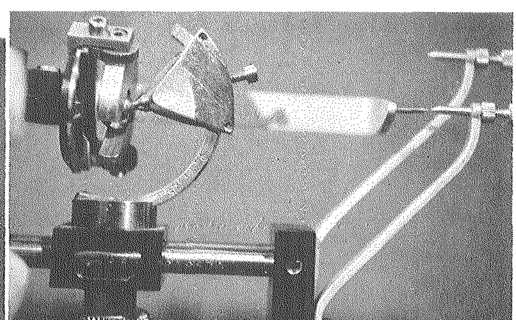


FIG. 173. (*Right*) The effects of tilting the axis and changing intercondylar distance are shown in the diagrams. (*Bottom, left*). The working side gauges do not coincide at the incorrect intercondylar distance. (*Bottom, right*) Intercondylar adjustment for the gauges on the working side.







used during subsequent setting of the articulator to bring the articulator back, with the same magnitude of movement, to the same position at which the height gauges were locked. By orienting the height gauges without having the condyle axis shafts in place, the relationship of the height gauges will be the same as that of the check-bites in the mouth, unaffected by the setting of the articulator.

## ADJUSTMENT OF THE ARTICULATOR

The instrument is adjusted for all the vertical relations of the points of the height gauges before they are adjusted for anteroposterior relations. Setting is accomplished by gradual refinement of the relationship rather than by a single definitive setting of each adjustment. This is because a change in relationship brought about by one adjustment will, to some extent, cause a change in the others, necessitating some correction of the previous settings.

The sticky wax is cleaned off the clutches and the check-bites so that they can be removed and reseated easily. The condyle shafts are oiled and replaced in their bearings.

One of the lateral check-bites is replaced. With the upper bow held tightly against the Bennett guide on the working side, the balancing side axis bearing is tilted (Fig. 172) until the points are brought together. If they do not coincide perfectly in vertical relation at this time, the operator should wait until subsequent adjustments have been made. He should not make any correction on the working side at this time.

The check-bite is removed and replaced by the other lateral bite. A similar adjustment of the axis tilt is made on the other—now balancing—side.

The axis tilt on the first side—made with the previous bite when that was the balancing side—may not be correct now that that has become the working side (Fig. 173, top). The tilt cannot be changed to make it accommodate the working relation, since that would spoil the balancing relation. On the working side, this vertical relation is corrected by changing the intercondylar width, as follows: When the instrument is in a lateral excursion, one side of the upper bow is raised by the slant of the condyle path and the axis tilt, so that the bows are no longer parallel. The Bennett movement has shifted the bow to the side, so that, on the working side, the condyle has moved out of the center of the sphere. The axis tilt, set in balance, has created a height between the upper and the lower bows when that is the working side at that intercondylar setting. This height will remain the same as long as the tilt has not changed. But, by moving the condyle assembly in or out (Fig. 173, bottom), this given height caused by the tilt will cause the upper bow to lift or drop to bring the points of the height gauges together. When this again becomes the balancing side, this alteration in intercondylar distances will cause a slight change, to be corrected by a slight change in the axis tilt. That is why the setting is a gradual process of refinement.

In order to have a range of adjustment of the intercondylar distance, the instrument should be set at 55 mm. at first. It must be remembered that at all times the upper and the lower condyle path assembly and condyle assembly must be kept precisely alike. If one is moved, both must be moved. Moving the assembly in to reduce the intercondylar distance will lower the height gauge on the working side. Moving the assembly out to increase the intercondylar distance will raise the height gauge on the working side. On the balancing side the action will be reversed. Thus, changing the intercondylar setting will affect both sides of the articulator.

Horizontal adjustment of the axis is made on the working side, after all other adjustments have been completed. The anteroposterior relation of the height gauge pin indicates that, as the condyle moved out in the

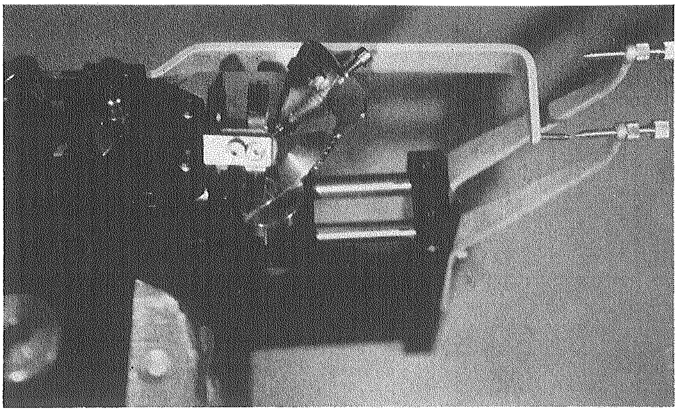


Fig. 174. Axis rotation for direction of the Bennett movement.

Bennett movement, on the working side it moved forward or back. Since changing the intercondylar setting also moves the height gauges forward or back, the anteroposterior adjustment is left until last. This is done by forward or backward rotation of the condyle axis shaft rotation (Fig. 174).

Repeated refinement of each setting in turn gradually will bring about an accurate end-result.

## ARTICULATOR SETTING WITH HEIGHT GAUGES

1. Angle of the condyle path: Set with protrusive check-bite. Remove the condyle bearing and set the rear height gauges. Replace the condyles and set the angle of the path to the height gauges.

2. Bennett guides: Set when the height gauges are set with the condyles out. Set each Bennett guide on the working side. Lock in light contact with the center post.

3. Axis inclination—angle bearing: Set on the balancing side, with the check-bite in place. Set to the rear height gauge. Do not change for the working bite. Set both sides before the intercondylar adjustment is made.

4. Axis inclination on other side: Use the lateral check-bite.

5. Intercondylar distance (condyle head position): Do on the other side at the same time as step 4. Set to the front height gauge.

6. Intercondylar distance: Repeat step 3 and set the condyle head position on the other side. Set to the front height gauge.

7. Refine by repeating steps 3, 4, 5 and 6 as many times as necessary to finish the horizontal adjustment.

8. Axis rotation—anteroposterior adjustment: Rotate on the working side with each lateral check-bite.

9. Axis rotation may sometimes require slight readjustment of the intercondylar distance to correct the balancing side.

When the setting is completed, the center bearing pin should drop into the holes in the plate if the instrument is moved without the bites in place.

# Making Clutches

Clutches are trays cemented to natural teeth, which are used to hold recording instruments for precise relationships of the temporomandibular joint. At no time are they used to mount models of any kind. No matter what the type of the clutch, it is always attached to the articulator by means of stone to relate the recording instrument to the articulator in the same joint relations that it had in the head.

Clutches may be constructed of aluminum (Fig. 175) or of self-curing plastics, depending upon their purpose. They are made in two pieces so that they may be separated for easy removal from the mouth. In use, the pieces are held together by small machine screws, which may be removed to split the clutch for separation. They are made in one piece and then sawed in half after threading. Plastic clutches do not possess the necessary rigidity for making pantograph recordings and should never be used for that purpose: pantograph clutches must be made of metal. For check-bite procedures, the clutches may be either metal or plastic, since this does not require the same degree of stiffness of the labial flange.

Since the clutch is merely a means of holding instruments, not mounting models, its fit is of no consequence. Clutches are made as loose-fitting trays, without undercuts. They are not precision castings. However, they should not be needlessly bulky, and when a center bearing pin is used its location is important. Likewise, the location of the studs is important. Therefore, individual clutches must be constructed on *mounted* models (Fig. 176) for every patient. The use of old clutches, or of universal clutches, is fraught with many problems and risks. Clutches which do not fit the patient, or are bulky and uncomfortable, will cause him to make abnormal movements to avoid discomfort.

For check-bites, the check-bite plates are cast into and become an integral part of the clutch. If a plastic clutch is used, the check-bite plates will stiffen that part of the clutch so that it will have the necessary rigidity.

Clutches for the pantograph may or may not have a center bearing pin and plate. When enough natural teeth are present, it is preferable to use the center bearing plate on the pantograph. But when many teeth are missing, the center bearing must be incor-

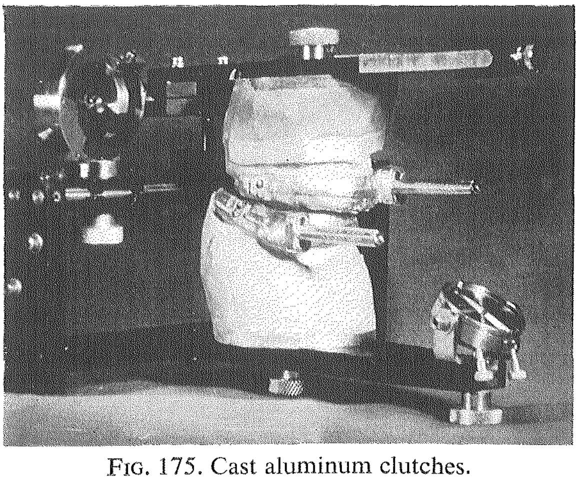


FIG. 175. Cast aluminum clutches.

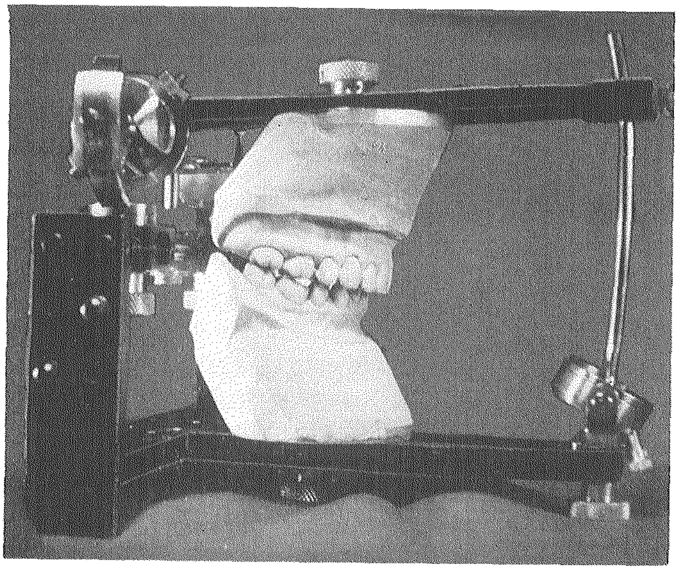


FIG. 176. Models must be mounted so that clutches may be constructed.

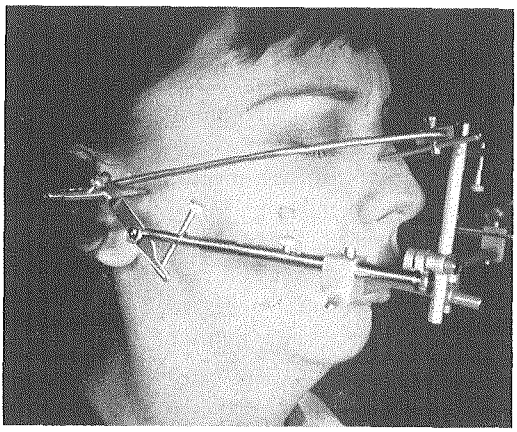


FIG. 177. An approximate face bow mounting is taken to mount the models.

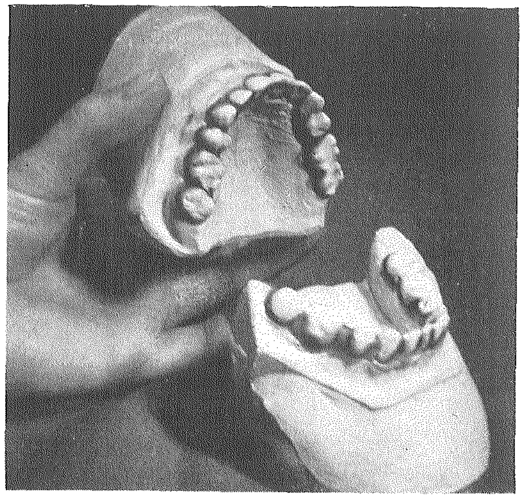


FIG. 178. Undercuts are blocked out with wax.

porated in the clutch. However, plastic clutches will not be stiffened enough by the bearing plate for use in the pantograph. Here, most of the strain is on the labial flange holding the separable studs. The technic for making plastic clutches differs in many details, and it is dealt with in a separate section (p. 127). For this purpose preformed metal insert pieces are used to hold the stud and to separate the clutches. Their use is described on page 127. If desired, they can be used on metal clutches by incorporating them in the casting. This will eliminate the steps of drilling and tapping.

## CONSTRUCTING METAL CLUTCHES

An accurate set of study models is made, using hydrocolloid or alginate impressions. The models are poured in stone. At the same time, a conventional face bow mounting (Fig. 177) is used to mount the models for convenience in shaping the clutches. It will avoid subsequent trouble in the positions of the studs and the check-bite plates. The pins of the face bow are set about 1 cm. in front of the center of the tragus of the ear. A centric bite is taken in Aluwax, using either the cloth

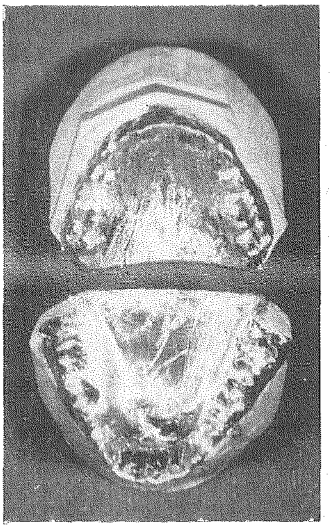


FIG. 179. Tin foil covers the teeth.

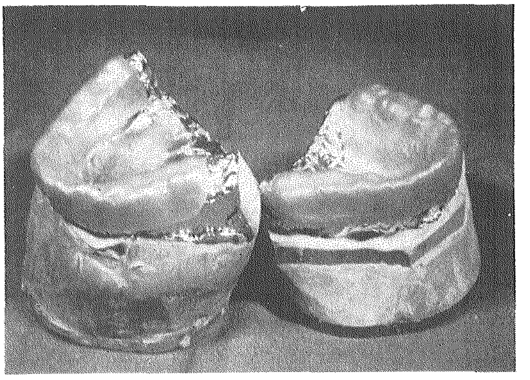
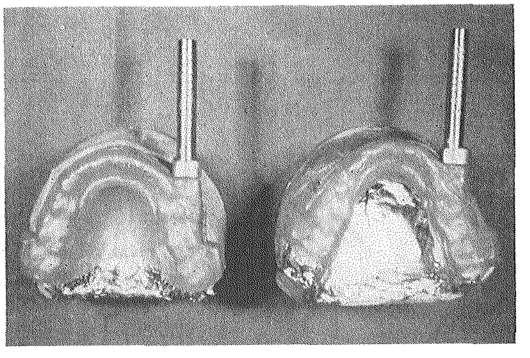


FIG. 180 (*Above*). The clutch patterns are base plate wax.
FIG. 181 (*Below*). Spacing the studs.



reinforced sheets or an Ash's Bite Frame, depending upon the teeth present.

The upper models are mounted with the mounting frame just as though it were a working model. The lower model is mounted against it with the centric bite. Artificial stone is used for these and all later articulator mountings. *Under no circumstances is plaster used at any time for any purpose.*

All the undercuts of the teeth and the model are blocked out by filling them with base plate wax (Fig. 178). A sheet of .003 tin foil is burnished over this, covering all the teeth (Fig. 179). All wrinkles are burnished flat. A thin coating of petroleum jelly is applied.

A device known as a separable stud is used to attach the hinge bow to a clutch. It consists of a hollow shaft, keyed to a base. The base is attached to the front of the clutch by means of two #2-56 machine screws with heads which fit the recesses in the base. An Allen screw extends through the hollow shaft and is screwed into the base. By this means, the hinge bow may be removed for convenience, while separating the clutches, and later replaced in the same precise relation. Two types of studs are available for this purpose: a V-grooved square base for check-bite clutches and a stainless steel socket type for use with the pantograph.

The pattern of the clutch is formed from a single thickness of S. S. White Tenax Wax (Fig. 180). This is thinner and more flexible than most base plate waxes. To stiffen the labial flange and provide a border for the check-bites, if they are used, a square rib is placed all the way around the labial and the buccal surfaces, about midway between the occlusal surfaces and the border of the clutch. The border of the clutch should extend beyond the gingiva, but not enough to impinge on the mucobuccal fold or the frenum. The upper stud is placed to the left of the frenum, and the lower stud to the right. A block is formed on the labial, to one side of the frenum, for the stud to be attached. The upper and the lower studs are placed on opposite sides of the frenum (Fig. 181) so that they will not conflict. A tapered block is formed on each side, opposite the first

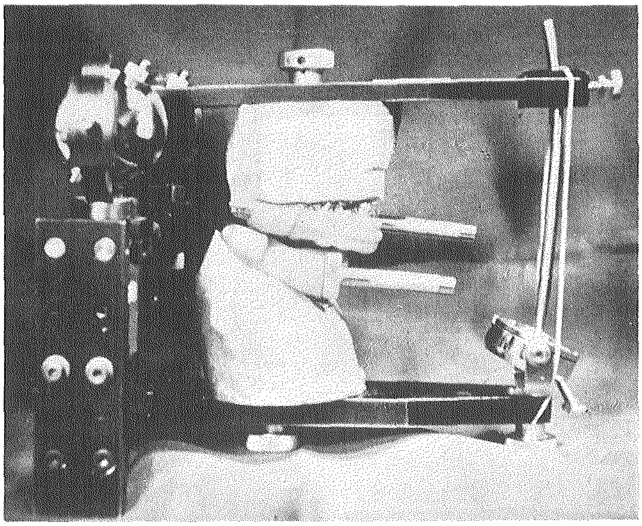


FIG. 182. Vertical spacing of the studs.

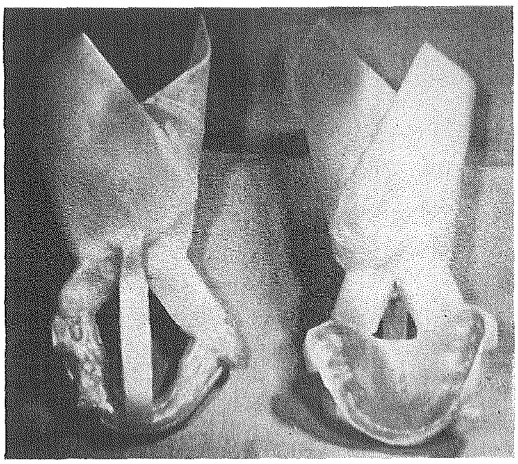


FIG. 183. Patterns sprued for centrifugal casting.

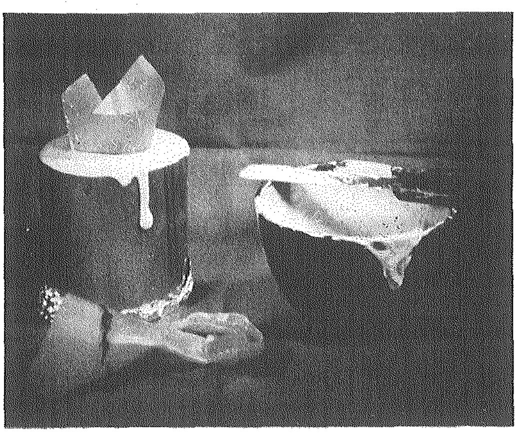


FIG. 184. Patterns invested.

molar, for the set screws which will hold the clutch together in the mouth.

The end of each stud is warmed and pressed into the wax block. The articulator is closed, and the studs are set (Fig. 182) so that they are approximately parallel and are separated vertically about ½ inch and horizontally about 1 inch. The wax pattern is chilled. The tip of the stud is warmed with a small flame until it drops off the wax pattern from its own weight. The end of the stud which will be attached to the clutch is separated. A thin coat of petroleum jelly is applied. The end of the stud is replaced on the pattern. Medium hard pencil leads of the kind used in older style mechanical pencils are used to form the holes for later threading. A heated, broken explorer is inserted into the wax through the screw hole of the stud to make a hole for the lead. A piece of pencil lead is held in the flame until it is red hot and then inserted in the pattern, being carried all the way through. The same is done with the other hole. In a similar fashion, leads are inserted in the tapered side blocks, parallel with the buccal surface and far enough apart to permit room for the screw heads. The pattern is sprued (Fig. 183) according to the type of casting machine used. The stud plate and the center bearing pin are removed from the pattern, which is chilled and removed from the model. It is invested

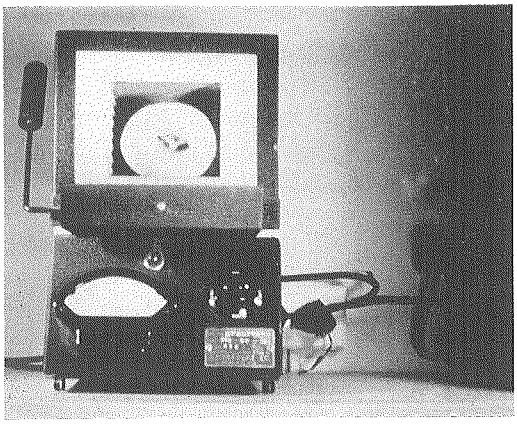


FIG. 185. The wax must be burned out completely.

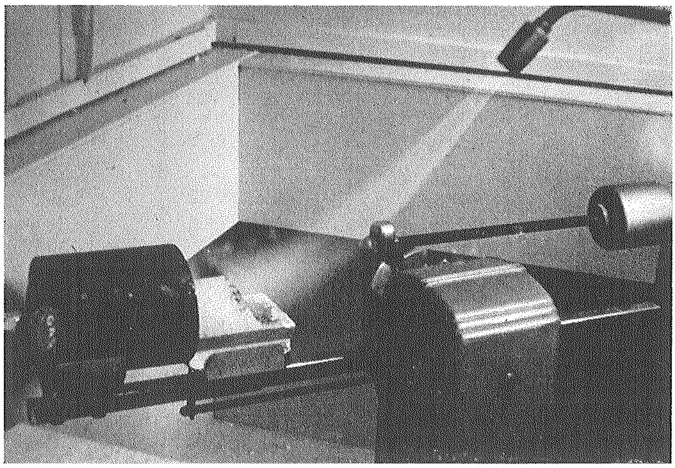
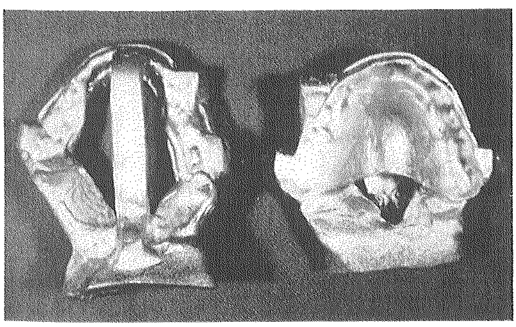


FIG. 186 (*Right*). A reducing flame is required to melt aluminum.

FIG. 187 (*Below*). The investment is brushed off the castings.



in a thin mix of any casting investment (Fig. 184). When the investment has set, it is placed in boiling water with the sprue hole up to eliminate the wax. It is removed and heated to 1,000° F. Then it is cooled to 500° and cast with a hard aluminum alloy, which is available in ingots of the correct size for one clutch. Alloys containing magnesium are dangerous to cast.

Melting and casting aluminum is not the same as it is for a noble metal like gold. The mold must be thoroughly burned out (Fig. 185) to eliminate all water of crystallization, but the casting must be made in a cool mold. Aluminum oxidizes very rapidly, and the oxide coating on the melt is highly refractory. Fluxes are of little use in preventing this oxide coating. The metal should be kept covered with a large brush flame (Fig. 186) in a reducing atmosphere by using more gas and less oxygen or air. Since the metal melts at about 1,200° F., it does not require as hot a flame as gold alloys do. The alloying elements in aluminum alloys are relatively small amounts of base metals, mostly copper. Since they are present in small amounts, the relative quantity is more critical. It is bound to burn out to some extent, so melting should not be prolonged and the used buttons should not be remelted for using a second time. It is quite inexpensive and should be discarded after each casting. Centrifugal casting machines are preferable for casting aluminum.

## THREADING AND SAWING

The casting should come out bright and clean (Fig. 187). The investment can be removed with a scrubbing brush, and no polishing should be required. Since alumi-

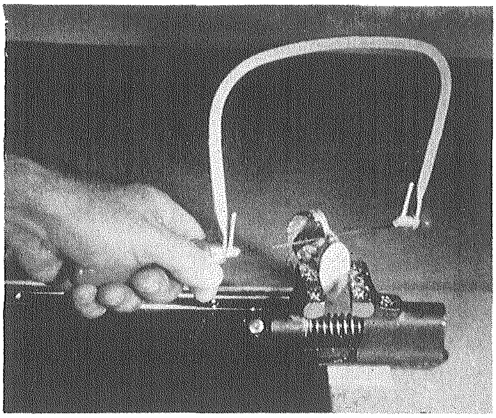


FIG. 188. The sprues are cut with a jig saw.

num is a metal which drags and clogs when cut with carborundum stone, the sprues are more easily sawed (Fig. 188) with small metal cutting saws that are made to be used in a jig saw. The holes to be threaded may be enlarged with a #704 fissure bur or, better if available, a #49 airplane type high speed drill in a hand drill (Fig. 189) or a drill press. The drilling and the threading must be done before the clutches are sawed in half. The holes are drilled all the way through.

Threading is done with a #2-56 machine tap (Fig. 190). Various types are obtainable in hardware stores. If the holes have been carried all the way through, so that they are not "blind" holes, it is best to use a starting tap all the way through. Since aluminum drags and binds more than most metals, there is less danger of breakage. If one does break, it can be removed with nitric acid without injury to the aluminum. The tap is kept well lubricated with a mixture of three parts kerosene to one part S.A.E. 30 oil. It is backed out frequently to clean the chips from the tap.

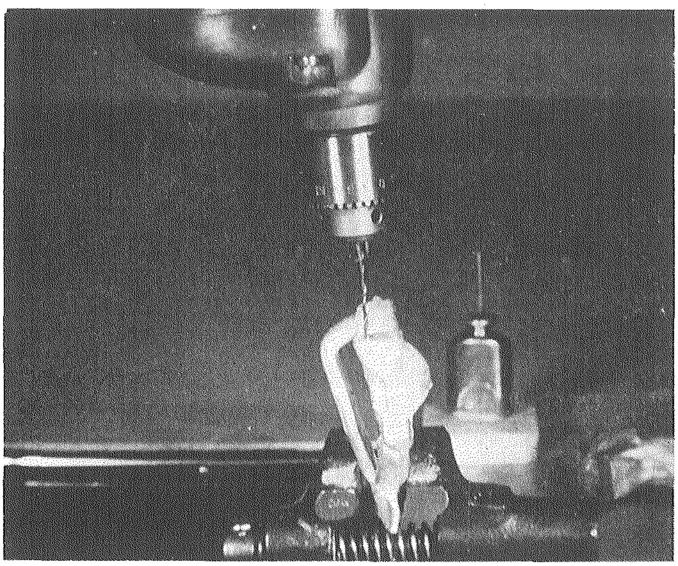


FIG. 189. The holes are enlarged with a hand drill.

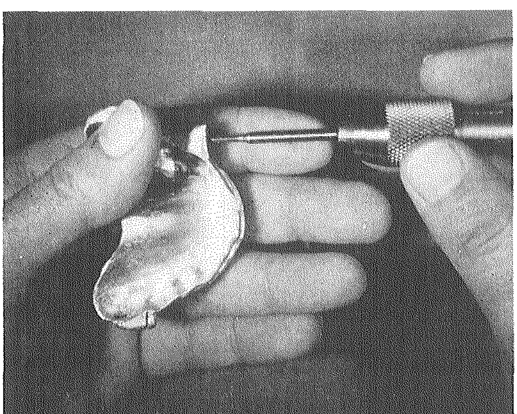
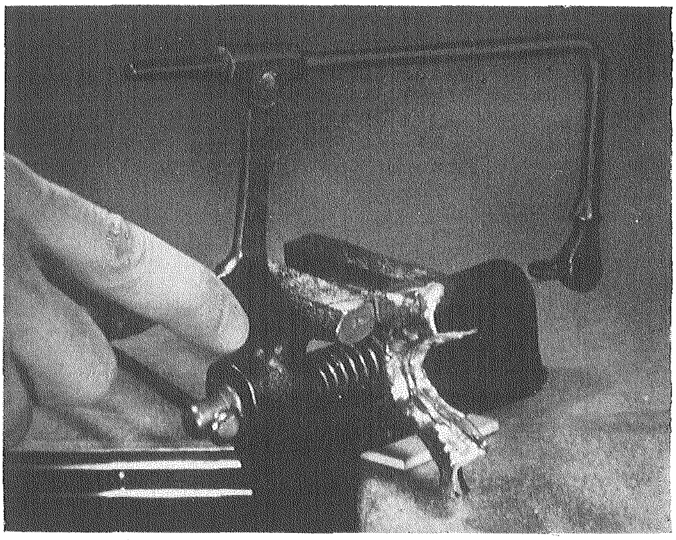
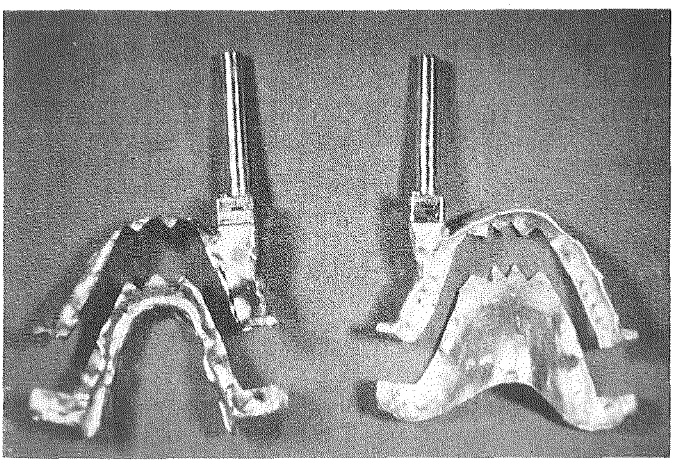


FIG. 190. Threading the holes.

The clutch is sawed in half, using a heavy gold saw (Fig. 191), and not the metal cutting saw used to remove the sprues. The stud holding block, but not the stud itself, may

FIG. 191. The clutches are split with a gold saw.





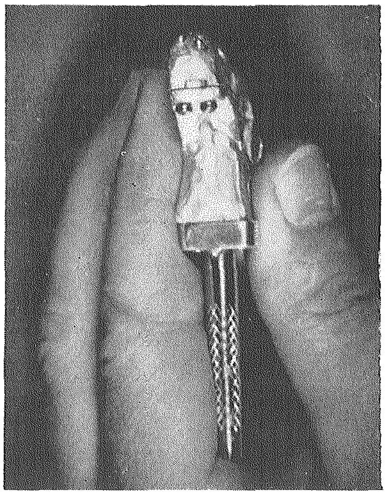


FIG. 192 (*Left*). The clutches after being sawed.
FIG. 193 (*Right*). Grooves for separation.

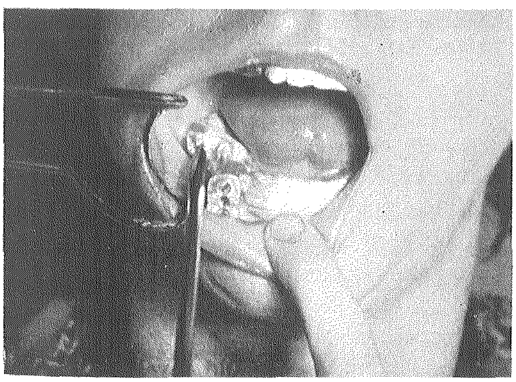


FIG. 194. Separating the clutches in the mouth.

be clamped in a vise to hold it tightly. The saw cut is started about $\frac{1}{16}$ inch behind the front of the separating block and carried through to the middle of the occlusal. It is continued around to emerge in the same position on the other side. After sawing, as shown in Figure 192, the clutch will be separated into two sections, to be joined with the #2-56 machine screws. The holes in the labial half of the separating blocks are enlarged so that the screw will slip in to draw it tightly together. Lastly, a slot is cut between the sections (Fig. 193) so that an instrument can be slipped in to separate the sections in the mouth. As shown in Figure 194, the machine screws will be removed

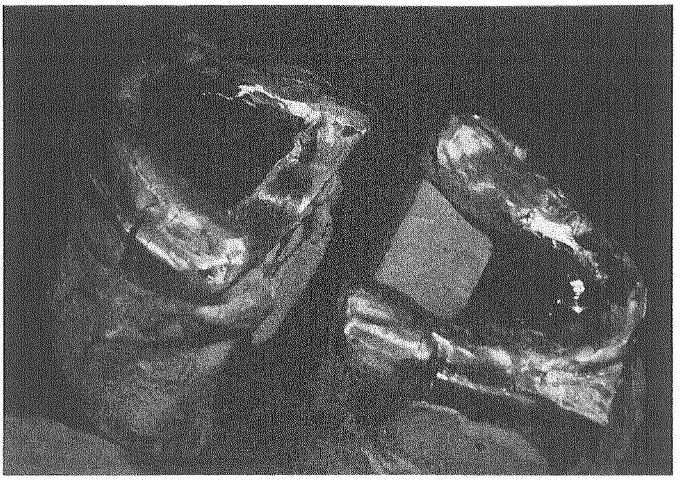


FIG. 195. Center bearing plates cast in the clutches.

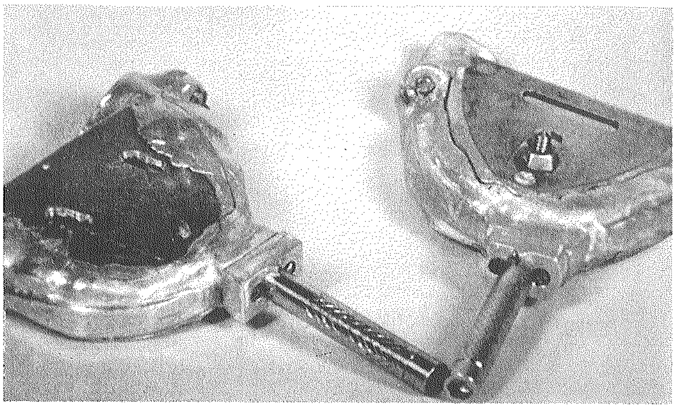


FIG. 196. Check-bite plates cast in the clutches.

after use in the mouth, and the two halves are separated. The labial flange is pried off by inserting an instrument in the slot, and the lingual section is lifted up for removal. The studs are attached, and the completed clutches are replaced on the models to check for stud alignment and clutch interferences.

If a center bearing pin and plate is to be incorporated in the clutch, it should be set in the wax pattern and cast into the aluminum.

The center bearing plates are trimmed so that each one will fit just inside the lingual surfaces of the teeth (Fig. 195), leaving a $\frac{3}{16}$-inch space between them. When the center bearing screw is inserted, it should separate the clutches enough so that they will not interfere. The head of the center bearing pin should contact the pattern on the lingual surface of the lower anteriors. It may be necessary to cut a hole in the clutch at this point to insert the hex driver to tighten the screw. The upper plate should extend at least $\frac{3}{8}$ inch in front of the bearing pin to allow for a range of movement in protrusive without moving off the plate. The lower plate must be shorter than the upper, posteriorly, so that the bulge of the tongue will seal the space. For use with the pantograph, both plates can be shortened for comfort, since there is no problem of reseating check-bites. Check-bites require the full extent of the plates (Fig. 196). The plate is heated and set into the wax of the clutch, slightly below the occlusal surfaces of the clutches. The articulator is closed and the plates are adjusted so that they are approximately parallel and separated about $\frac{3}{16}$ inch. The wax pattern of the clutches should cover the occlusal and the incisal surfaces with enough space left at the side to be able to see the separation of the bite plates.

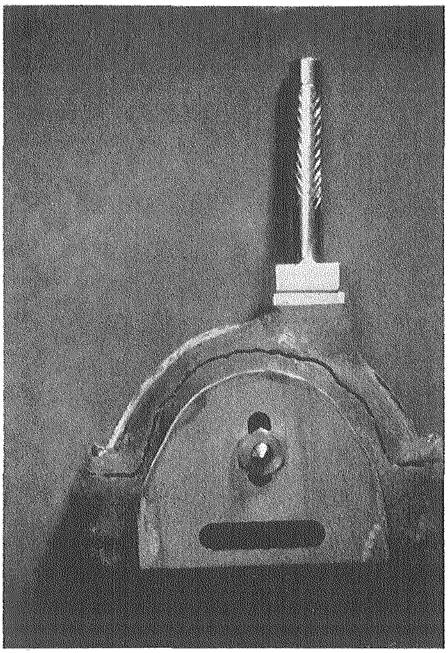


FIG. 197. A plastic clutch.

## PLASTIC CLUTCHES

Clutches made of plastic (Fig. 197) are identical in shape with those made of cast metal. However, it is necessary to use metal inserts to hold the studs and the separating screws. It is also necessary to stiffen the labial flange with a square metal bar running through the metal inserts.

The undercuts are blocked out with wax and covered with foil just as in making the pattern for metal clutches. An acrylic press is used to form a plastic wafer similar in form to an ordinary shellac base. However, the size and the shape of a shellac base are not correct for natural teeth. The press is provided with a recess for the upper on one side, and a form for the lower on the opposite face. The material used is self-curing tray material, which is coarser and stiffer than base materials. Two pieces of cellophane are moistened and one is placed on the cover and the other in the base plate former. A mix of material is made according to the manufacturer's instructions, and it is poured into the recess of the former. The cover is closed by hand pressure and squeezed until the material fills the void.

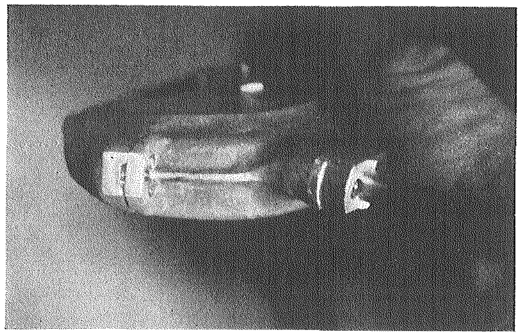


FIG. 198. The metal inserts are attached with a brush.

It is allowed to set until the plastic will no longer flow but is still soft enough not to spring back when it is pressed into place. It will have a soft, doughy consistency. The cellophane is lifted from the press with the acrylic and placed over the model. A wadded towel or a large wet viscose sponge is used to press the acrylic to place. It is adapted tightly over the buccal and the lingual surfaces of the teeth, extending up onto the mucosa, and allowed to stand at room temperature until it has set. Since the fit does not matter, it will not be necessary to rebase it for a close adaptation. When the acrylic has hardened, it is removed from the model and the cellophane is peeled off. The periphery is trimmed with coarse stones or vulcanite burs and the clutch is replaced on the model.

The metal inserts and the labial rib will be attached with the same material, using the brush technic. The $\frac{1}{16}$ inch square brass rib is shaped to fit the labial flange about midway between the occlusal surfaces and the peripheral border, extending all the way around the outside. It is luted to the clutch on each side in the bicuspid region with the brush and the acrylic to hold it in place. The groove in the stud holder insert is set over the rib and attached by painting acrylic all around it in the retention groove and on the labial flange. In a similar fashion, the separating insert is attached on each side (Fig. 198) by placing the grooves over the rib and painting acrylic over the insert to cover the retention, but leaving the screws

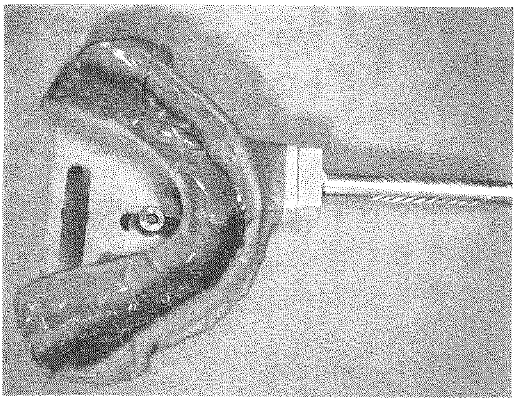


FIG. 199. The center bearing plate is attached by painting the acrylic from below.

exposed. Enough should be applied for adequate holding. The surface of the acrylic clutch is kept wet with monomer when the new material is applied with the brush.

The check-bite plates are also attached with the same tray material and a brush. The plates are cut and positioned just as for metal clutches. They are attached by painting a liberal amount of acrylic all around the plate on the underside. Enough is painted around the edge on the occlusal side to close the space (Fig. 199).

When the acrylic has set, the clutch must be sawed in half just as a metal casting is, but ordinary saws will clog and stick in the acrylic. The operator removes the screws from the aluminum inserts and saws through the aluminum with a coarse gold saw. Thin, coarse-tooth fret saw blades for sawing the acrylic may be obtained at most large hardware stores. These are thinner and wider than gold saws, but they have very coarse teeth which will not clog so readily and are hard enough to saw acrylic. Sawing is continued through the acrylic along the center of the occlusal and behind the incisal edges to the metal insert on the other side. The blade is removed, and a gold saw blade is used to cut through the other insert to meet the saw cut in the plastic. Whenever acrylic is being applied to the inserts, the machine screws must be in place to keep acrylic out of the threads. But the screws must be removed before sawing. After the clutch has been severed, the halves are reunited with the machine screws.

Acrylic clutches must be polished so that the stone will separate cleanly and reseat accurately. If desired, plastogum may be used instead of zinc oxide paste to cement them in the mouth. A thick mix is made, and the saliva is kept away from it until it has set.

The undersides of the slots in the plates must be covered to keep the plaster from running through, as the check-bites must be separated in the mouth without removing the clutches. For this purpose, three strips of phosphor bronze are provided. A strip is warmed over a flame, and a coating of Kerr's casting sticky wax is applied. While still hot, this is placed on the underside of the slot to cover it, still leaving the slot as an index to reseat the stone bite. The nut and the slot for the center bearing screw are covered with the same wax. A thin film of petroleum jelly is applied each time before the check-bite is taken.

## PANTOGRAPH CLUTCHES

When sufficient posterior teeth are present to lock the heels of the clutches securely, it is preferable to leave the center bearing pin out of the clutches and to use the center bearing plate and pin incorporated in the pantograph itself. This eliminates the danger that the patient will rock the mandible on the bearing pin. It also makes the setting of the articulator easier. Just like the patient, during the setting it will tend to rock on the center bearing pin on the return stroke. This does not affect the accuracy of the carvings, after the center bearing has been removed. The presence of the bearing pin inside the mouth causes this phenomenon.

In general, the clutches are the same as the check-bite clutches, except for positioning the stubs. To allow for the width of the center bearing plate, they are spaced wider horizontally. The lower stud is placed to the patient's right, just outside the lower bow of the articulator, viewed from above. The upper stud is placed to the left, just outside the other edge of the lower bow, so that the horizontal spacing will be sufficient to allow for the width of the center bearing plate.

For the comfort of the patient, the vertical spacing can be reduced. Each stud is placed slightly gingival to the incisal edge of the teeth, just enough not to interfere with the opposing clutch in excursion.

To avoid loosening, the lingual posterior part of the clutch must be carried beyond the gingival margin of the teeth and relieved just enough to permit placement and removal of the clutch without injury to these tissues. This is important. They are cast, split and assembled in the usual fashion.

The external center bearing plate creates more strain on the lower clutch and tends to tip it loose at the heels. Since the accuracy of the pantograph recording depends upon very precise relation, any movement of the clutch would be disastrous. Indeed, if the pantograph is recording the clutch movement, it actually can do more harm than good. It requires good molars with a normal amount of undercut to hold such clutches.

If there is any doubt about the holding of the clutch, the center bearing plate and pin should be cast into the clutch itself. If clutches have been constructed without the plate and the pin, and it develops that they will not hold in the mouth, the pin and the plate can be attached with acrylic (Fig. 200). However, it is always preferable to cast them into the aluminum. If all the posterior teeth are missing, the clutch should be cast with a saddle to fit the edentulous spaces, which should be filled with wax before the model is foiled.

The center bearing plate should be long and wide enough that the pin will not slide off it onto the aluminum casting. The average length of travel of the pin is about ½ inch with a pantograph. The pin should be placed against the lingual surface of the lower anterior teeth. To avoid excessive opening and strain on the patient, the upper plate should be slanted down and forward. Usually the front edge of the upper plate will lie slightly above the lingual incisal edges of the anterior teeth. The lower plate usually will be slightly below the incisal edge of the lower arteriors. Space is not important as long as there is room for the nut which locks the center bearing pin. The plates are made of 14-gauge hard brass or nickel silver. They should not extend back in the mouth any more than necessary, so that tongue freedom and swallowing are permitted. It is good practice to cut the back edge of the lower plate on a curve so that the two sides will extend back to stiffen the aluminum casting. The edges of the plates are waxed securely in the pattern before casting. The point of the center bearing pin should be rounded so that it will slide freely on the plate without cutting into the plate and tending to guide the patient. The casting and the slitting are carried out as usual.

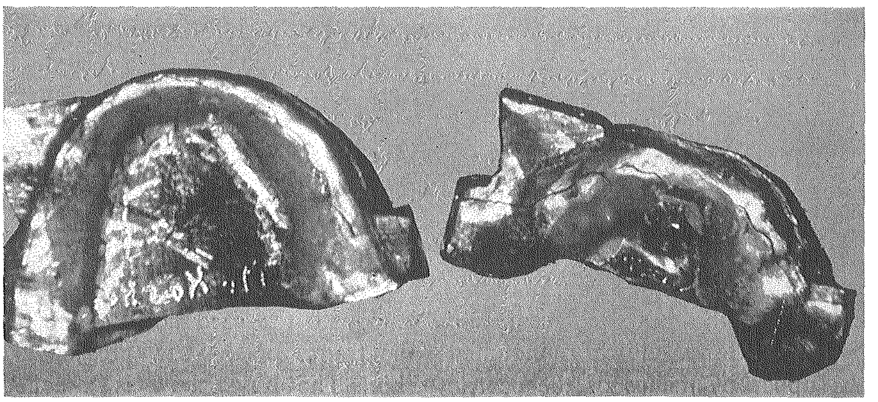


Fig. 200. Attaching the center bearing plates to the cast clutches with an acrylic material.

*Chapter* 14

# Check-bites for Natural Teeth

Records are obtained by constructing upper and lower trays, known as clutches (see Chap. 13), which can be cemented to the teeth for the construction of large, partial, fixed and removable appliances. Check-bite plates are incorporated in the clutches, and studs are attached to the fronts to hold the hinge bow. The construction of these clutches is described in Chapter 13. The hinge axis is located by attaching the hinge bow to the lower clutch, with the stylus opposite the condyle. The stylus is adjusted by watching its movement, as the mouth is dropped open and is closed with a pure hinge motion, until a point is located at which the point of the stylus remains stationary as the patient executes the pure vertical rotational motion of the condyle on the meniscus. This point is transferred to the skin with an indelible pencil, the hinge bow is removed and the point is tattooed in the skin for a permanent remounting point. Stone is then forced between the check-bite plates in each excursion successively to yield a series of check-bites in each of the excursions and the centric relation. The hinge bow is now attached to the stud of the upper clutch, with the stylus points on the hinge bow touching the axis points on the skin. The axis-orbital indicator is placed on it, the point is marked on the nose and also is tattooed as a permanent mark to establish the axis-orbital plane for subsequent model mounting. The entire assembly is now removed and transferred to a mounting frame, which provides the means of setting the articulator in correct relation to the plane of reference. The upper clutch is attached to the articulator with artificial stone (not plaster), the hinge bow and the mounting frame are removed, and the lower clutch is mounted against the upper by means of the centric check-bite.

With the clutches mounted on the articulator, the condyle path and the Bennett movement are adjusted by means of the check-bites, starting with the protrusive, and then taking each lateral bite in turn. The settings so obtained are recorded on a chart, and the clutches with their bites are discarded.

To mount models at any subsequent time, all that is required is a centric bite and a face-bow mounting. To maintain the same relationship of the models to the functions of the joint, the hinge bow and the axis-orbital indicator are again used for the face-bow mounting, on the tattoo marks, the mounting frame being used as before to establish the correct relation of the models on the articulator.

## LOCATING THE HINGE AXIS

The clutches are inserted in the mouth and, with the pin in light contact, the patient goes through all excursions. If the clutches interfere, the pin is raised enough for them to clear in all positions. Before the clutches are cemented, it must be certain that the undersides of the slots have been closed to prevent stone from running under and locking them together.

The clutches are cemented firmly to the teeth (Fig. 201) by filling them with a hard-setting zinc oxide impression paste such as Ackerman's Impression Cement. The patient holds them tightly seated by closing on cotton rolls while the cement is setting. After it is set, any excess cement which would interfere with the check-bites is trimmed away. The spacing and the alignment of the check-bite plates are checked (Fig. 202).

The upper bow is attached to the upper stud with the card holders just in front of the tragus of the ear, pressed against the skin. The hinge bow is attached to the lower stud (Fig. 203) with the point of the

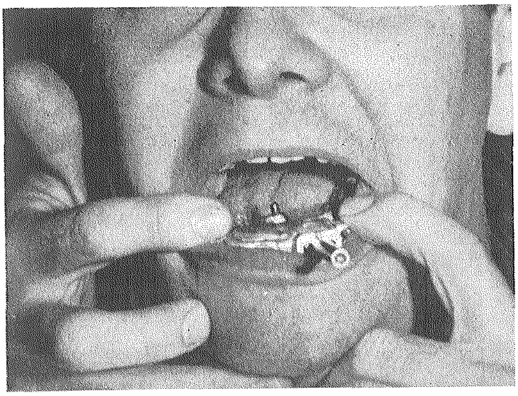


FIG. 201. Cementing the clutches.

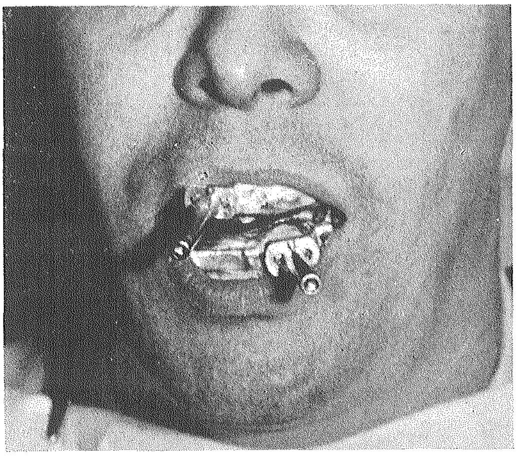


FIG. 202. Checking the spacing for stone bites.

stylus approximately in the center of the lined card. The patient practices the rotary opening and closing movement for a few minutes. As was pointed out previously, this is not a normal chewing motion. In function, it is always combined with the sliding motion. But, in order to locate the axis, it is necessary to have the patient open and close with a pure hinge movement. Some people will do it readily and others only with great difficulty. The ball of the thumb is placed on the point of the chin in order to feel the pure, easy, swinging motion required for this purpose. The patient is instructed not to make an effort to open, but, rather, to let the mouth drop open easily. At the start it should open only about a half inch. As the patient becomes accustomed to it, it is opened wider and wider until it opens about an inch. The point of the stylus is watched to see which way it moves. If the point moves down as the mouth opens, the axis is behind the point. If it moves backward, the axis is above the point. If it moves upward, the axis is in front of it. If it moves forward, the axis is below it. Usually there will be a combination of movement. If it moves down and back, the axis is above and behind. If it moves back and up, the axis is above and in front. If it moves up and forward, the axis is below and in front. If it moves down and forward, the axis is below and behind (see Chap. 6).

As the patient opens and closes, the stylus

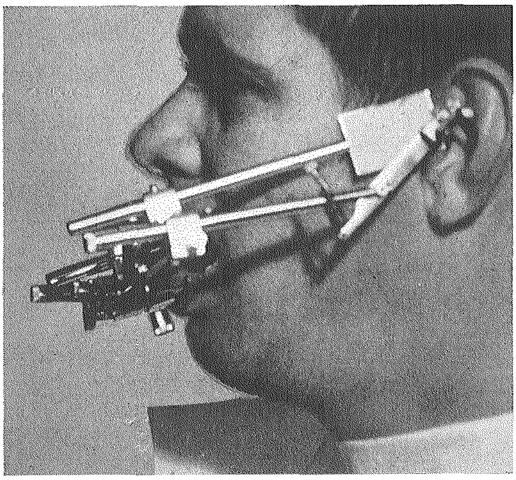


FIG. 203. Locating the hinge axis with the clutches.

is moved by means of the adjustment screws until the point of the stylus remains stationary as the mouth opens and closes. This is done on both sides.

The operator removes the card holders, seats the patient upright in the chair, applies a wet indelible pencil to the tip of the stylus, and transfers the location of the axis to the skin. This is done on both sides. The hinge bow is removed, and the hinge axis is tattooed into the skin, using English vermilion on a 3-pronged needle. The stud is separated from the lower clutch only, as it is of no further use and only will be in the way.

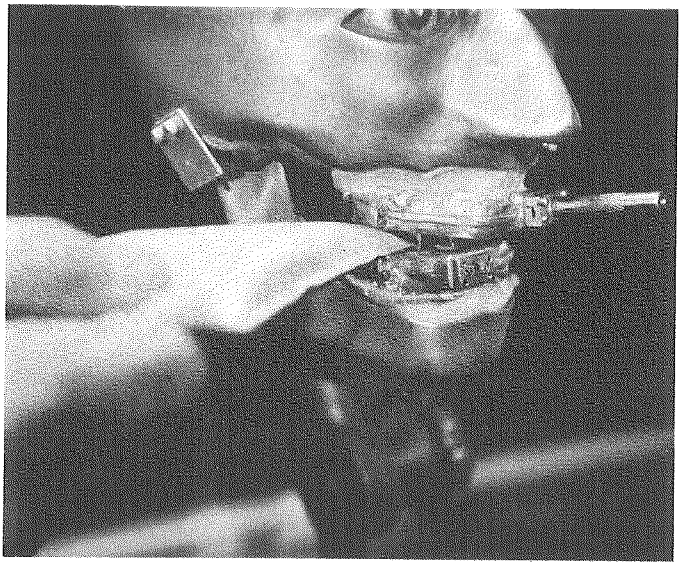


FIG. 204. The centric bite is taken first.

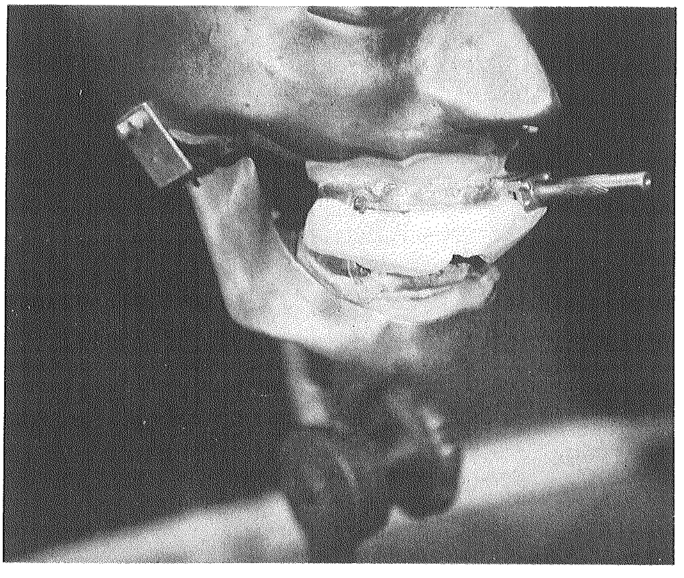


FIG. 205. Excess stone is trimmed before the model is removed.

## MAKING THE RECORDS

With a rubber abrasive wheel, the operator polishes the scratches from the upper plate where the sharp point of the central bearing pin has made contact. The patient closes and goes through repeated lateral and protrusive motions with the pin in contact. The patient opens and, with a #½ round bur in the contra-angle, a small hole is made in straight protrusive and on the widest lateral line on each side. These holes should not be at the extreme excursion—they should be scribed, as explained in Chapter 11 on Complete Dentures, to use the same angle of the condyle path. The inaccuracies inherent in this procedure when it is carried out by conventional methods are eliminated by the fact that the mounting and the setting of these check-bites on the articulator will be carried out on the hinge axis, for the purpose of recording the paths of the axis, not the positions of the mandible. Furthermore, we do not need to concern ourselves about vertical dimensions at this time, for the same reason. We can alter the vertical at a later date without affecting the setting of the articulator.

The purpose and the location of these small holes in the upper plate are to enable the patient to hold the mandible stationary in each of these positions while the check-bite is being made (see Chaps. 10 and 11). The patient practices moving the mandible until he feels the point of the pin drop into the hole, and then he holds it there. When satisfied that the patient can do his part, the operator makes the centric bite first, since that is the easiest and will accustom the patient to the procedure. A thin coat of petroleum jelly is applied to each plate.

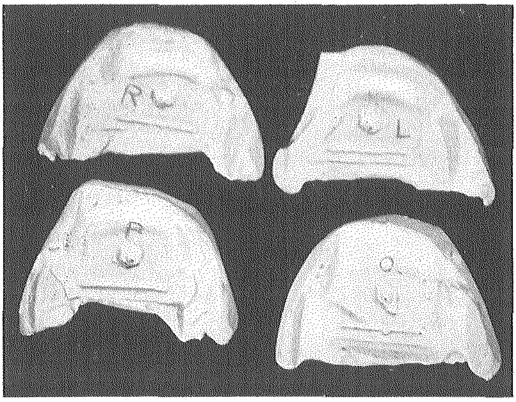


FIG. 206. The complete set of check-bites.

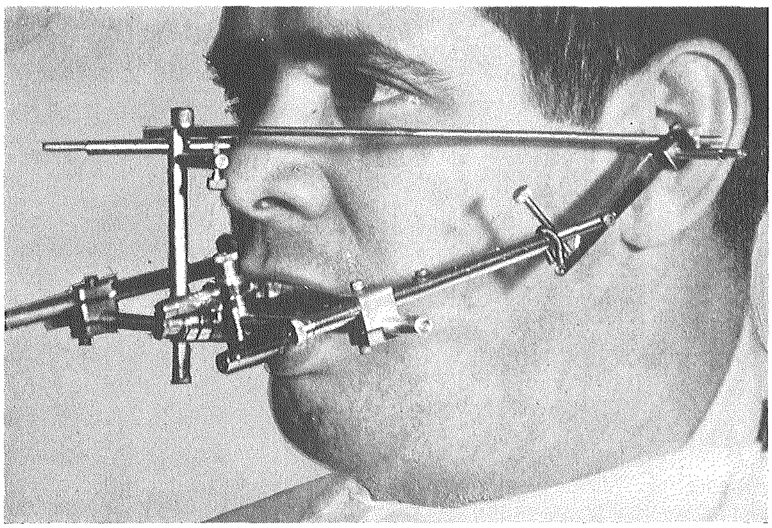


FIG. 207. Transferring the upper clutch.

As with any centric bite procedure, care must be exercised to avoid a physiologic rest position. The mandible is guided to repeated centric closures, while gentle downward and backward pressure is exerted on the chin to force the condyles up into their bracing position in the glenoid fossa. A medium mix of check-bite Greyrock is made and injected between the plates (Fig. 204). The closures are repeated several times after the stone has been injected between the plates. Then the patient holds this position with positive pressure until the stone sets. When the initial set has taken place, the operator trims away the excess stone (Fig. 205), which has run into undercuts and would hamper separation, but leaves the stone which has run over the outer edges of the clutches. This will assist in subsequent seating on the articulator. When the stone has set fully, the patient opens, and the operator carefully removes the stone disk formed by the two plates.

The protrusive and the lateral check-bites are taken successively by having the patient hold each position with the bearing pin in the correct hole while stone is injected between the plates. It is not necessary to have the patient make repeated closures, as the mandible cannot drop into rest in excursive positions. The patient is instructed to slide from centric into the correct hole before the stone is injected and to hold that position while the stone is setting. As each bite is removed, the position is marked on it with

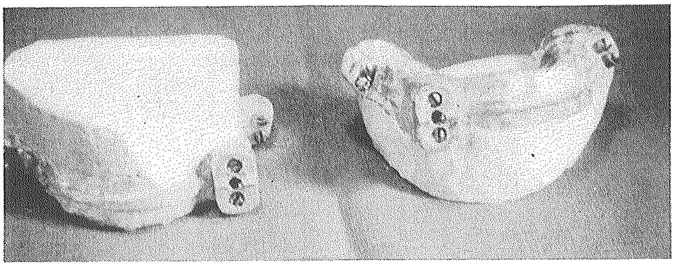


FIG. 208. The clutches are filled with stone.

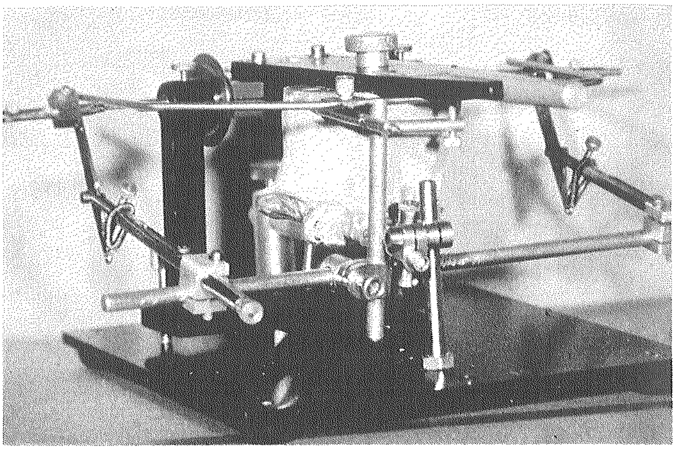


FIG. 209. The mounting frame is used to attach the upper clutch.

an indelible pencil. The bites are set aside for future use (Fig. 206).

## MOUNTING THE CLUTCHES

Now the hinge bow is mounted on the upper stud. With the patient sitting upright as before, the stylus is adjusted to touch the hinge axis tattoo mark. The axis-orbital indicator is placed on its support (Fig. 207), and the height is adjusted so that the tip of the swinging arm will contact the side of the nose opposite the infra-orbital notch. The operator marks this point with indelible pencil and tattoo the same as he does the axis. This must be done or the entire procedure will be worthless. All parts of the apparatus are locked securely, the axis-orbital indicator is lifted off, the entire assembly is removed by separating the stud at the clutch plate. The clutches are separated by removing the screws from the sides and are removed from the mouth.

The clutches are reassembled and filled with stone (Fig. 208). It is not necessary to clean out the cement. The face bow is clamped to the mounting frame. The upper clutch is replaced on the separable stud that is still attached to the face bow.

The upper clutch is attached to the upper bow of the articulator (Fig. 209) with a medium mix of Greyrock. When it has set, the face bow and the mounting frame are disassembled and the stud is removed from the clutch. The incisal pin is replaced in the articulator.

The mounting plate and the clutch are detached from the upper bow of the articulator. The centric check-bite is placed on the clutch and then the lower clutch is placed on it. The clutches are luted together on the centric bite with plenty of sticky wax or compound that is seared on. The incisal guide pin is set at 0°. The upper is replaced on the articulator, the articulator is inverted (Fig. 210), and the lower is attached with Greyrock. The centric bite is removed, and the instrument is ready for adjustment (Fig. 211).

The inherent weaknesses of the check-bites used in the past arose first and foremost from the fact that they were not related to the hinge axis. They represented static positions of the mandible rather than functional relations. Secondly, until recently, no articulator was available with a broken axis. As a result, in most cases it could not be set accurately. And last, but by no means least, since the condyle path was always on the lower and the condyle ball on the upper, the check-bites had to be taken at the precise vertical opening and cusp rise with which the case was to be finished. As a result, the check-bite in acutal practice was little better than a plain line articulator and centric bite. Two of these problems have been overcome by mounting on the hinge axis. The third and most serious drawback has been eliminated by the development of an articulator made expressly for check-bites, with a broken axis, and the condyle paths on the upper bow of the articulator.

Accurate adjustment of the articulator is accomplished by means of indicators at-

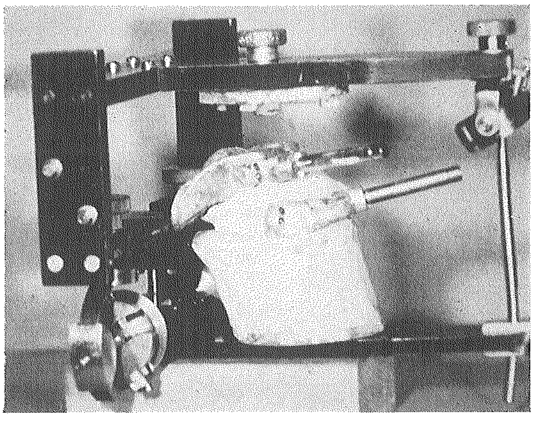


FIG. 210. The lower clutch is mounted with the centric bite.

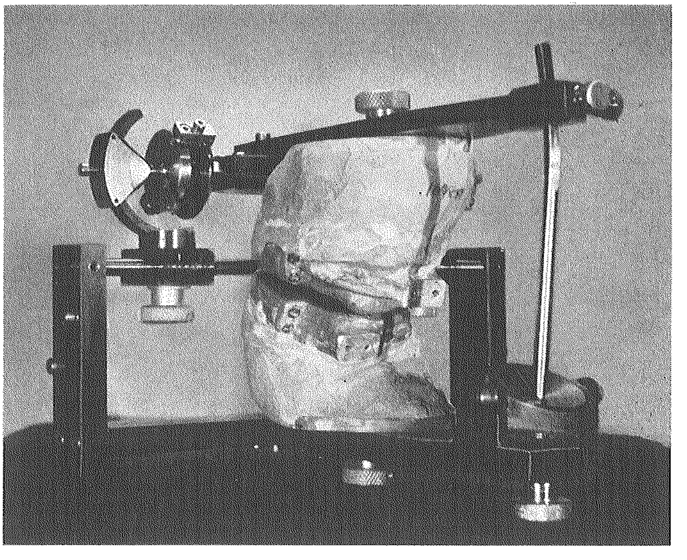


FIG. 211. Mounted clutches ready for setting.

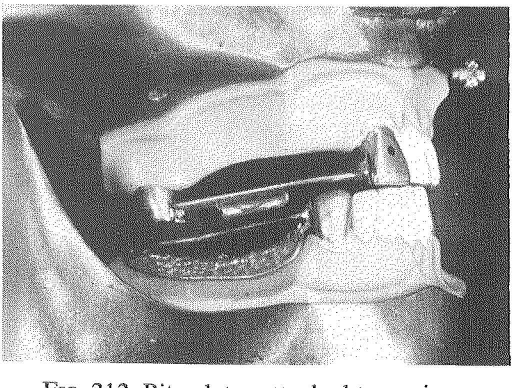


FIG. 212. Bite plates attached to copings.

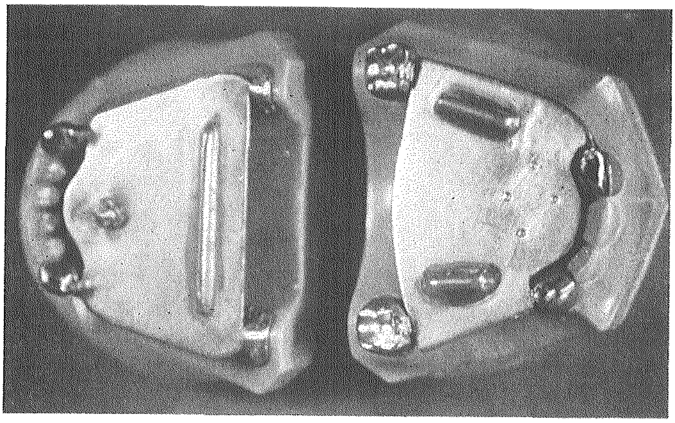


FIG. 213. Bite plates adjusted for clearance.

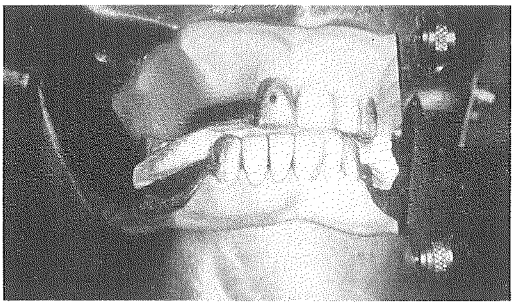


FIG. 214. The centric check-bite is taken first.

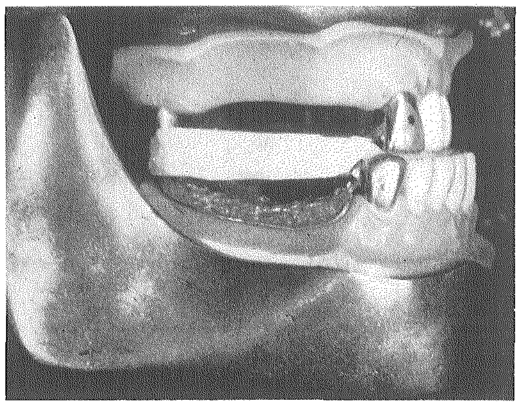


FIG. 216. The protrusive check-bite.

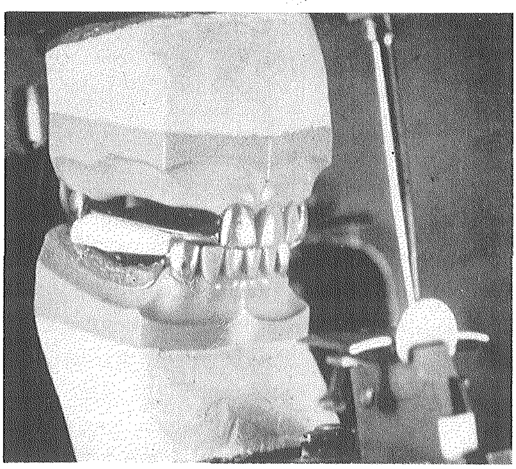


FIG. 215. The lower model is remounted in centric.

tached to it for this purpose only. These are known as "height gauges," and their use is described in Chapter 12.

## CHECK-BITES ON COPINGS

There is another method of making stone bites which is an adaptation of a method developed by Dr. Dan Grubb and Mr. Russell Jones of Cleveland. It has the merit of enabling the height gauges to be set before the check-bites are separated from the plates. It also mounts the working models with the check-bites. Because of the necessary manipulation, its use is generally limited to working models in which the prepared teeth are amalgam or copper dies.

The check-bite plates are soldered to transfer copings, cast of scrap gold (Fig. 212), fitted to enough prepared teeth to stabilize the plates. The castings are not extended the entire depth of the preparation, but cover the occlusal and enough of the

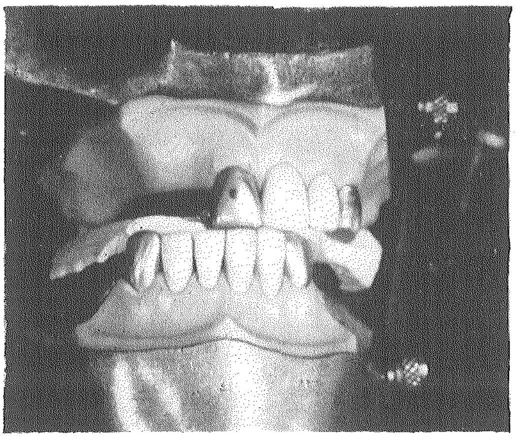


FIG. 217. The right lateral check-bite.

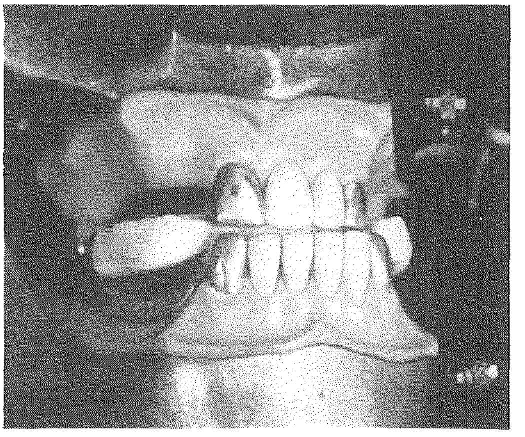


FIG. 218. The left lateral check-bite.

interproximal to stabilize them. The bite plates are cut to fit just lingual (Fig. 213) to the prepared teeth. They are soldered to the transfer copings with silver solder and small strips of brass or nickel silver. They must be rigidly connected so that pressure cannot spring the connections.

Stone bites are taken (Fig. 214) and mounted just as in the denture technic. As each bite is taken, the whole assembly is removed from the mouth to set the articulator before separating the bite. Since the working models are used for the check-bite plates, this mounting is used to construct the restoration. As before, check-bites are taken in protrusive and in right and left lateral, as shown in Figures 215 to 218.

When these check-bites are replaced on the working model to set the articulator, the operator trims away the stone which contacted the teeth and uses only the stone between the plates. The teeth on the model may interfere with the proper positioning of the check-bites.

Chapter 15

# The Pantograph

Movements of the mandible which bring about the ever-changing relation of tooth contacts result from paths of motion of the hinge axis. These functional relations can be recorded and reproduced by means of a suitable pantograph or writing apparatus, attached to the same clutches (Fig. 219) that are used to hold the hinge bow for locating the axis. When the axis has been located and marked, slide holders are placed over it and recording styli, attached to the mandible, are used to trace the functional movements. Similar slide holders, placed at right angles to the condyle path slide and paralleling the condyle path, are used to trace the side shift in Bennett movement. The Bennett movement is the

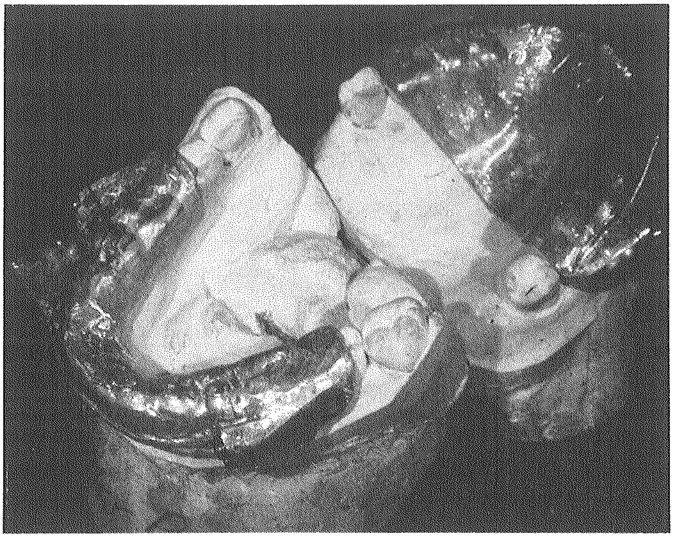


FIG. 219. Pantograph clutches are simple trays.

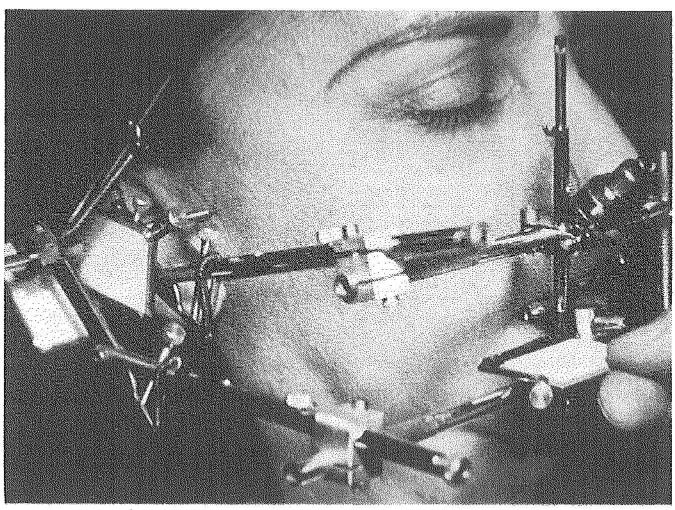


FIG. 220. The pantograph from the side.

path of the center of rotation, so it is necessary to locate these centers, just as it was to locate the hinge axis, to reproduce the result of their paths in the occlusal form of the teeth. This vertical axis (center of rotation), which, at its intersection with the hinge axis, determines the axial center of each condyle, is located by making two Gothic arch tracings simultaneously on each side of the median line. It is more accurate to make two in order to find the common center in each excursion, which could trace both of them simultaneously as it is moving across the fossa.

## GENERAL PROCEDURE

The writing apparatus shown in Figure 220 consists of upper and lower face bows clamped to the cemented clutches by means of separable studs. The upper bow carries on each side an adjustable side arm, holding two slides to record the condyle path and the Bennett movement. These slides are positioned over the axis by means of suitable pointed axis pins, so that when the apparatus is transferred to the articulator it may be positioned to its axis in the same relation as the patient's axis. The lower crossbar is equipped with two adjustable side arms which hold the recording styli to trace the paths of motion of the axis as the mandible moves. The stylus point is a microtomic lead with a needle-sharp, precisely centered point, which is held in contact with the slide by means of a very soft steel coil spring. The spring provides only enough pressure to maintain the point in contact with the slide. The lower crossbar also holds two slides (Fig. 221), placed one on each side of the median line under the corresponding upper styli, to record the Gothic arch tracings. The upper bow also carries two styli, positioned one on each side of the median line, for the Gothic arch tracings. At the mid-line of the upper bow is an adjustable ball-point center bearing pin, which rides on a plate attached to the lower crossbar. This pin and the plate are adjusted so that the patient can make free excursions without interference from teeth or clutches. When insufficient teeth are present to hold the clutches against the strain of the external bearing pin, the center bearing is included in the clutches and the external pin is removed during the recording. The slides on which the tracings are scribed are provided with tapered shoulder thumbscrews which fit into a slot so that they are precisely positioned in the slide holders. Each slide is cov-

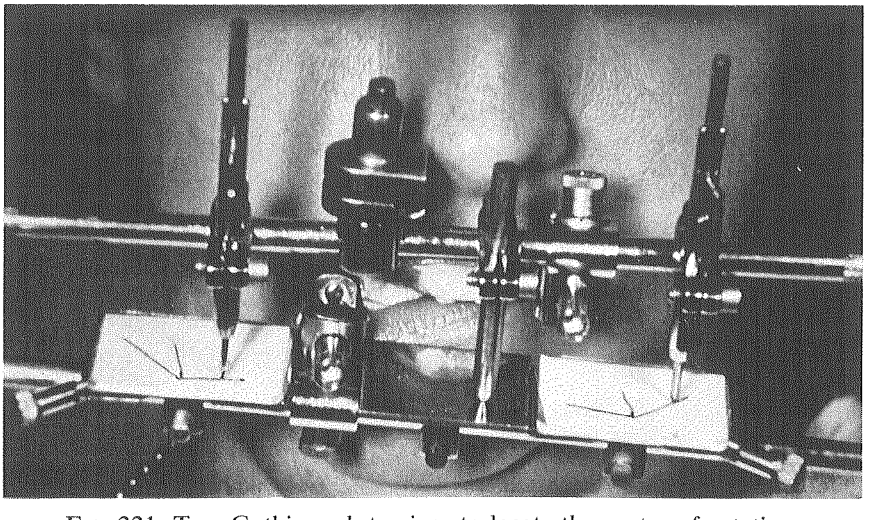


FIG. 221. Two Gothic arch tracings to locate the center of rotation.

ered with paper that is held in place with rubber paper cement.

## PREPARATION FOR RECORDING

The apparatus is assembled on the articulator in the laboratory by the technician, so that it is ready for transfer to the patient. This is done in order to avoid the necessity for major adjustments at the chair after the clutches are cemented. It is another reason why it is advisable to make an approximate hinge axis mounting of the study models be-

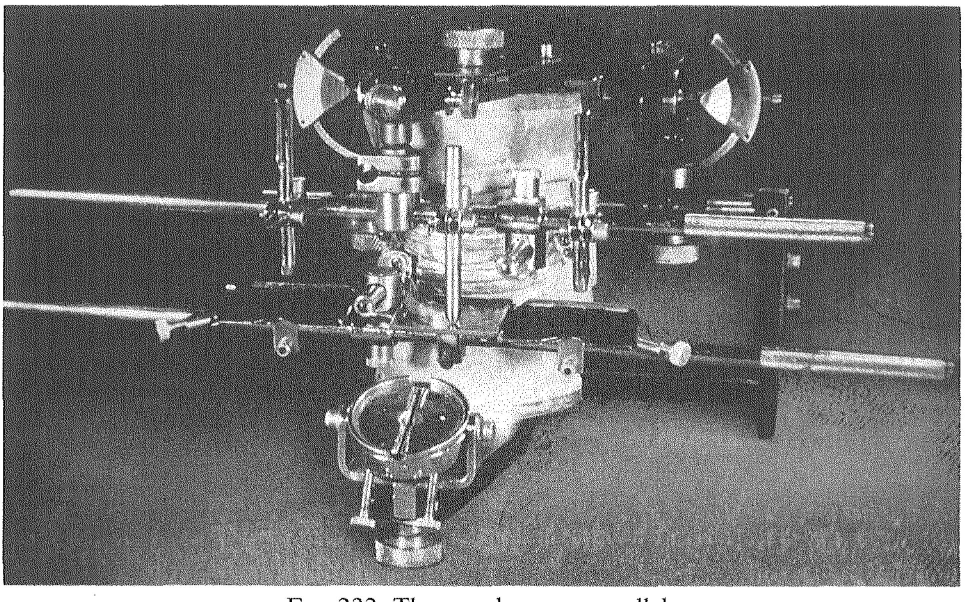


FIG. 222. The crossbars are parallel.

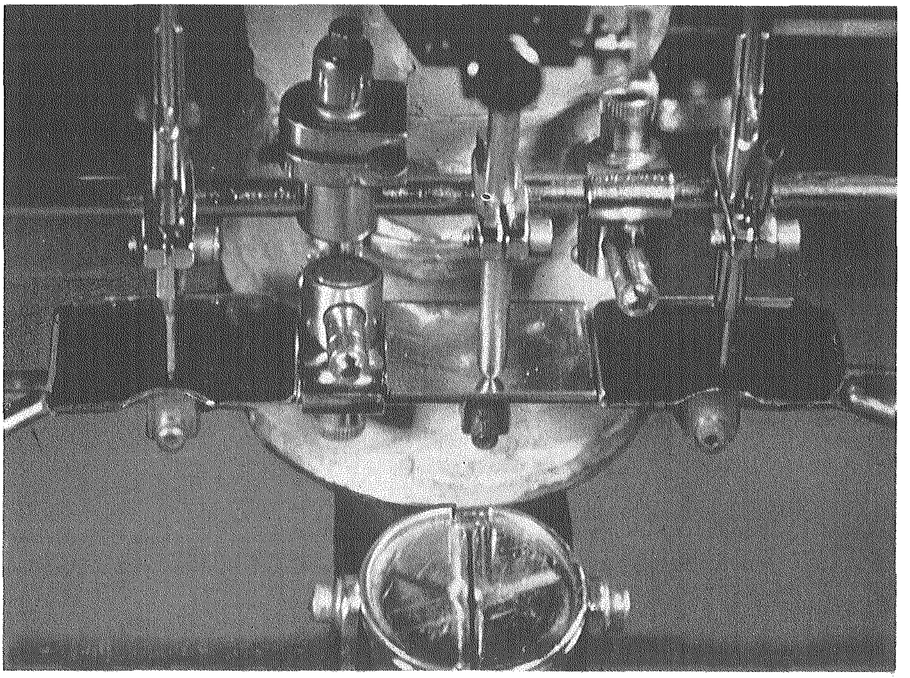


FIG. 223. Positioning the Gothic arch and the center bearing slides.

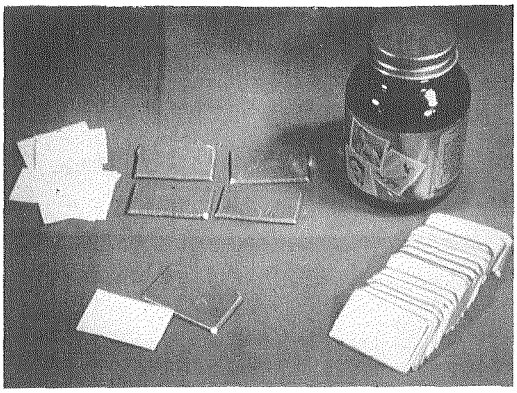


FIG. 224. Paper cemented to the slides.

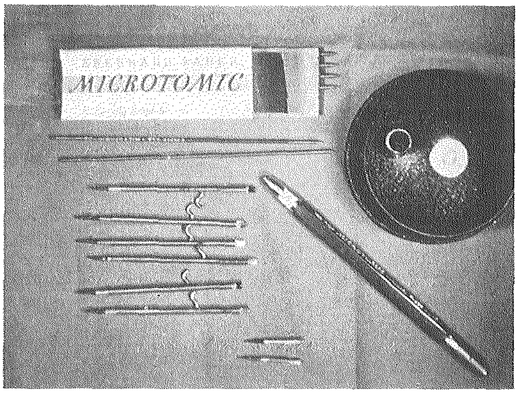



FIG. 225. The pencil tracing styli.

fore constructing the clutches. The foil and the wax are removed from the study models so that the clutches will fit the models just as in the mouth. The foil is replaced to protect the models, which are replaced on the articulator. The condyles are locked in centric with the centric locks. The clutches are set on the models and a #84 rubber band is wrapped around the upper and the lower bows to hold the articulator closed. The anterior guide pin and the guide plate are removed. The crossbars are clamped to the studs (Fig. 222) so that the ends will be equidistant from the median line. The lower bar must be a half inch in front of the stud plate to allow for future mounting after recording. They are parallel in front and above with the crossbars of the articulator. The center bearing pin is placed in the mid-line, tilted slightly so that it will be at right angles to the center bearing plate. The plate in turn is tilted slightly upward at the back (Fig. 223), approximately an average anterior guidance, with the pin resting slightly in back of the front edge. The Gothic arch slide holders are placed one on each side of the center bearing plate, parallel with it and as close to the mid-line as practical. The Gothic arch styli are positioned (Fig. 223) so that the point of the stylus will fall in the mid-line of the plate, slightly behind the front edge and at right angles to the writing surface. The stylus tubes on the upper bow are adjusted so that the stylus will be parallel with the center bearing pin, with the lower end of the tube about a half inch above the slide holder. The slide holders and the center bearing plate are then adjusted. This may require one of the crossbars to be moved forward or back. The slide holders and the styli for the condyle paths are best adjusted on the patient after the clutches are cemented. The crossbars are now removed from the clutches by means of the separable studs.

A special gummed paper is used for the tracings. The gummed surface adheres tightly to the rubber cement used on the aluminum slides but peels off readily after use like Scotch tape. This paper is cut in pieces which will cover the tracing surface but not the edges of the slides. A margin of $\frac{1}{16}$ inch is left all around (Fig. 224). The cement used is rubber cement for paper, obtainable in stationery and photographic supply stores. The aluminum slide is coated with the rubber cement, and the paper is pressed quickly into place. It dries quite rapidly, but it is usually advisable to have the slides prepared well in advance so that the paper is sure to be dried thoroughly.

The stainless steel tracing stylus is drilled at the end to receive a sleeve which holds the tracing lead (Fig. 225). Each of these is a sliding fit in the other, that is, the lead is a sliding fit in the sleeve, and it, in turn,

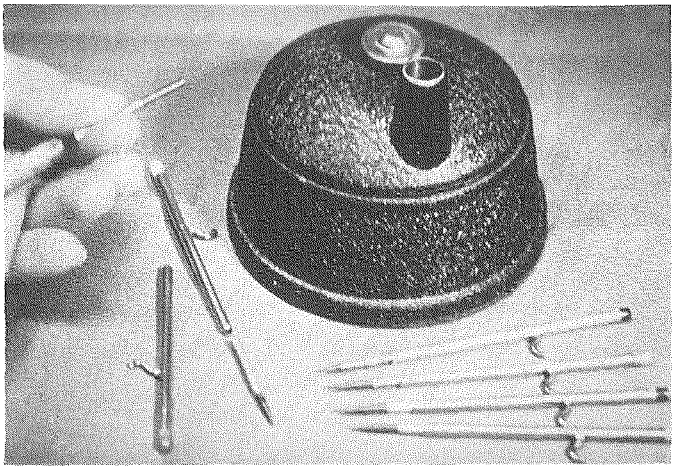


FIG. 226. Fastening the pencil in the sharpening holder.

FIG. 227. Centering the point of the pencil.

is a sliding fit in the stylus. The styli are ground and polished stainless steel. The stylus should drop freely in its tube with no bind of any kind. Any trace of grit or gummy oil can cause it to bind. Before each use, each tube is cleaned with a pipe cleaner. Each stylus is wiped clean, and just a film of the spindle oil that is supplied with the articulator is applied.

The lead bushings are cadmium-plated brass, which has been accurately drilled and reamed to hold Eberhard Faber Grade 2B microtomic lead. Other grades and makes will not fit. This lead has been selected because it will mark without heavy pressure and has sufficient strength to hold a needle-sharp point during writing. Occasionally the plating on the outside of the lead bushing may be tight enough to require polishing with a rubber wheel so that it will slide easily in the stylus. If it is too loose, it may be held in the stylus with a small amount of the rubber cement that is used on the tracing papers.

The leads should be prepared and set in the styli beforehand, so that no time will be wasted while the patient is in the chair. A lead holder is used to hold the lead to sharpen it in the Sharpoint. It has two chucks, one in the point and the other under the plastic cap on the end. The larger of the two chucks is used for this purpose.

The operator pushes a piece of lead into the larger hole in the lead bushing and breaks it off so that about 3/8 inch projects beyond the sleeve. The bushing is inserted into the lead holder so that the end of the metal is even with the end of the chuck (Fig. 226), with only the lead protruding. The chuck is locked securely, and the lead holder is placed in the Sharpoint. The lead holder is grasped firmly with the fingers so that it does not turn in them (Fig. 227) but does rotate in the sharpener as it is rotated. The sharpener is turned until the lead has a needle point, at least 1/4 inch longer than the sleeve. Now the chuck of the lead holder is loosened and the lead is shaken into the palm of the hand to avoid breaking the sharp point. The bushing is inserted in a stylus, being pushed into place so that the metal bushing projects about ¼ inch, and the lead about another ¼ inch, for a total length of about ½ inch. When inserted in the stylus, the whole assembly should be approximately the same length as the ball-point steel stylus. This is not critical, but it should not vary more than 1/16 inch either way. All the styli should be prepared but not set in the tubes until the operator is ready for the tracing.

The slides also should be prepared in advance by cutting and cementing the paper. This paper has a surface texture which will enable the lead to write with a minimum of pressure. The gummed side is applied dry over a coating of rubber cement. If the gummed side is wet when applied to the slide, it will adhere so tightly that it will be difficult to remove if it is necessary to change paper during the recording. The paper is cut ⅛ inch shorter than the slide. A coat of rubber cement is applied to the slide, and the paper pressed to place immediately, leaving a margin of 1/16 inch at each end. The excess cement is wiped from each end of the slide. If it is necessary to replace the paper, it can be ripped off readily and a new piece applied.

The springs should be checked to see that they are all in position. These springs have been carefully made and tested for correct tension. The spring tension will not affect the recording if the apparatus is properly assembled as follows: The tension of the condyle path recording is determined by the length of the pencil point and the position of the tube in the clamp. The tube should be clamped so that the end of the tube toward the point is ½ inch from the inside of the rocker-arm clamp on the sidearm. The sidearm should be positioned so that the Bennett movement stylus falls halfway between the inner and the outer edges of the slide (Fig. 228) and at right angles to the slide. The slide holder itself should be positioned so that the Bennett slide is approximately parallel with the condyle path. The Gothic arch stylus also should be at right angles to the

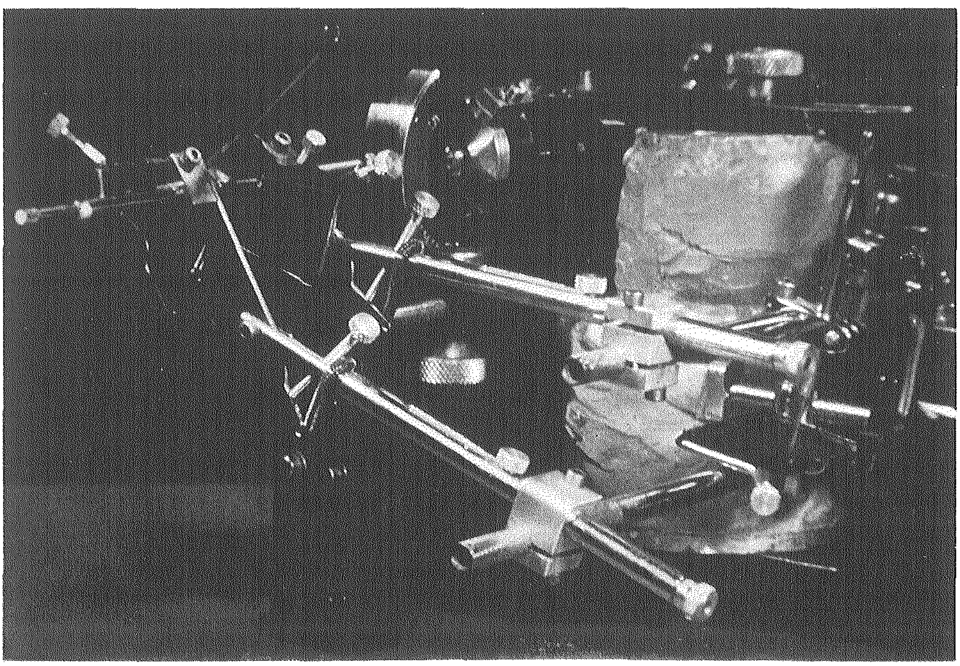


FIG. 228. The position of slides and stylus tubes for condyle and Bennett tracings.

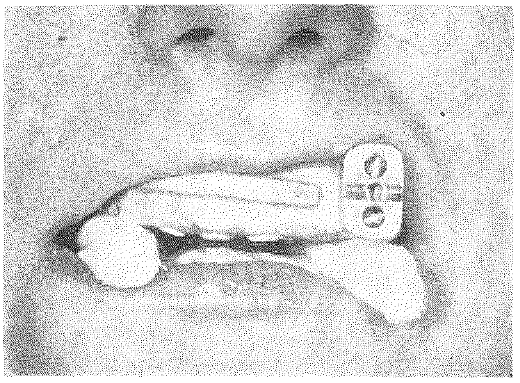
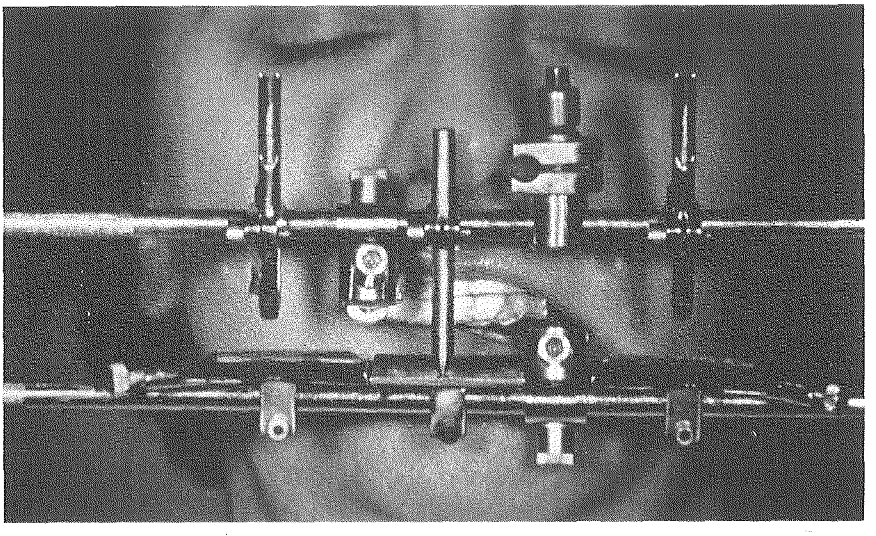


FIG. 229. Cementing the clutches.

FIG. 230. Crossbars attached to the clutches.



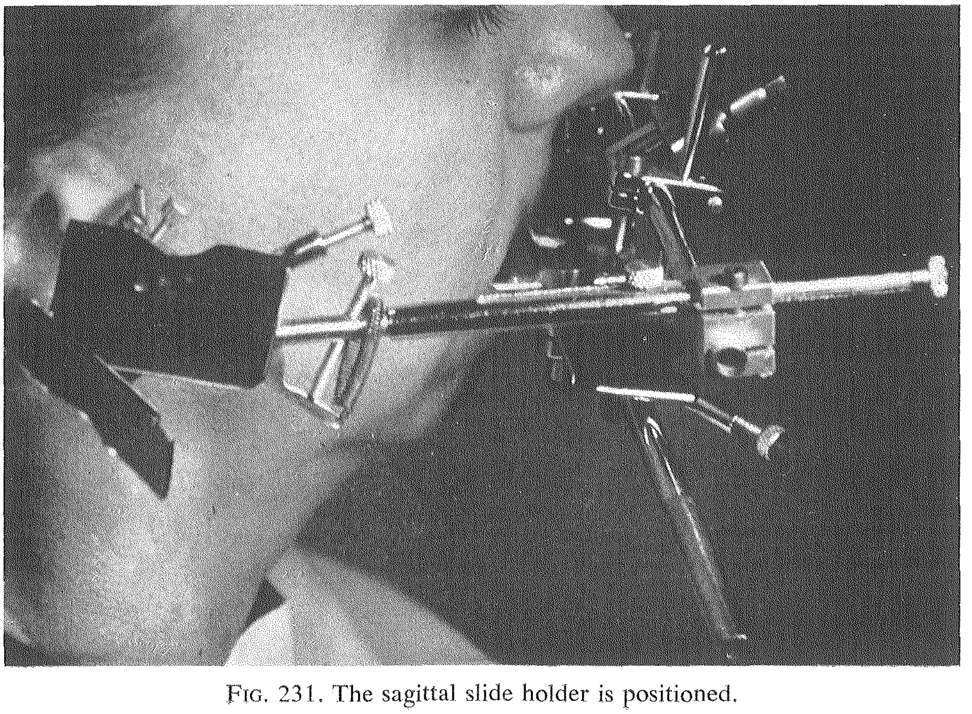


FIG. 231. The sagittal slide holder is positioned.

slide and about ⅛ inch from the front edge. All these adjustments can be made using the ball-pointed steel styli so as not to break the lead points.

## MAKING THE REGISTRATIONS

The value of pantograph recordings lies in the precise tracings which provide the means of forming occlusal relationships which will function in perfect harmony. To maintain this accuracy, the apparatus must be rigidly fixed to the teeth and must maintain a stable relationship throughout the recording. Cementation of the clutches is a very important step. The cement used must set hard and still be tough enough not to break and allow the clutches to loosen. Zinc oxide impression paste is the best material for this purpose. Not all the materials of this type possess the necessary rigidity. The paste materials, though easier to handle, generally lack this quality. Powder and liquid materials such as Ackerman's Impression Cement, or Zorite, set harder and tougher. A material with a medium setting time should be selected, so that it can be mixed quite heavy and still have adequate working time. It is well to cover the stud plate with sheet wax so that the paste will not smear on it and prevent accurate seating of the stud. The clutches are filled and seated firmly in the mouth. A cotton roll is placed on each side over the posterior teeth (Fig. 229), and the patient bites on the rolls until the paste has set. It is important that the clutches are well seated posteriorly and, if the cotton rolls are too far forward, this may tip the heels of the clutches up. This would cause interference in the excursions and necessitate opening the bite to an uncomfortable degree to allow freedom of movement.

When the cement has set, the excess is chipped away so that it will not break off and bother the patient. It is removed with a Vacudent. The cement must be well set before the crossbars are attached by means of the separable stud (Fig. 230), just as they were assembled on the study models. If the clutches have been constructed and cemented with reasonable care, the crossbars should

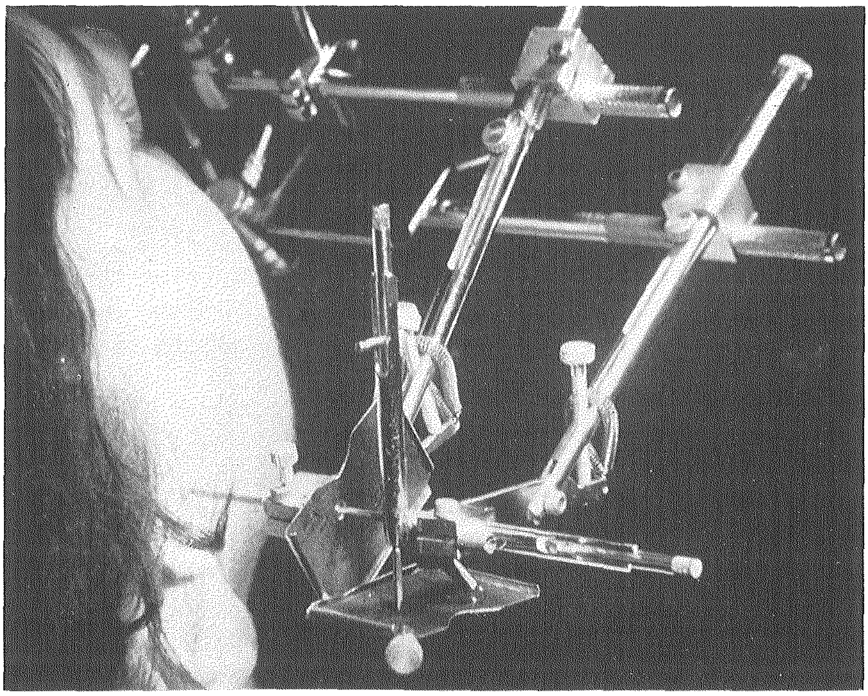


FIG. 232. Adjusting the tracing styli.

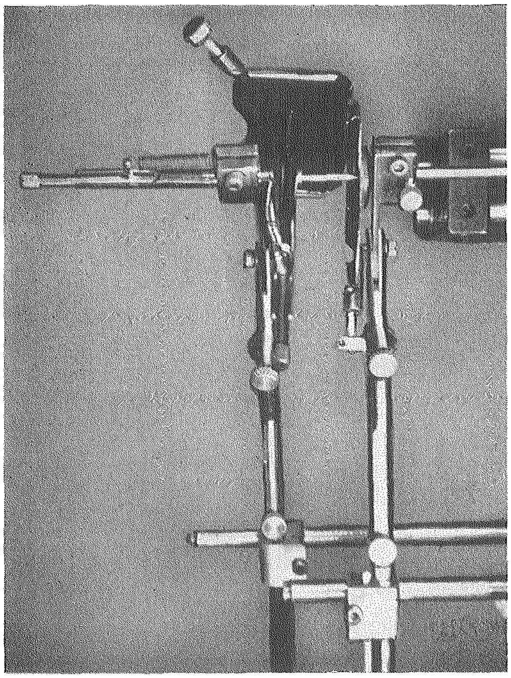


FIG. 233. The Bennett path stylus is centered over the slide holder.

parallel each other roughly. They need not be precisely parallel, as long as the styli are positioned so that they will not move off the slide holders. If it is necessary to reposition a crossbar, the stud must be separated when loosening and tightening the universal clamp or it may loosen a clutch.

When positioned on the patient in centric relation, the point of each Gothic arch stylus should be just behind the thumbscrew which holds the slide in position. This will allow a full range of movement without having the stylus travel beyond the slide and breaking the pencil point. The center bearing pin should be adjusted so that it is centered just behind the front edge of the bearing plate and separates the clutches so that the patient can slide freely in all directions on the bearing plate without having the clutches collide and bump.

The hinge axis is located first by attaching the flags to the upper crossbar and pressing tightly against the skin just in front of the tragus of the ear. The hinge bow sidearm is attached to the lower crossbar, and the axis is located as usual. With the patient seated upright in the chair, the skin is marked with indelible pencil.

Now the hinge bow is replaced by the slide holders and the recording styli. With the patient again seated upright, the slide holders are adjusted (Fig. 231) so that the axis pins will just contact the hinge axis points on the skin. The sidearms are locked securely, particularly the clamp around the knurled end of the crossbar. The thumbscrew is locked in the sidearm extension rod so that the slide holder cannot rotate. The rocker-arm screw is tightened with the angle wrench.

The operator slides the patient back to centric and, while holding the center bearing pin in contact (Fig. 232), attaches the lower sidearms with the stylus tubes. The rocker arm is closed almost all the way, but not enough to lose the spring tension on it. This will aid in seating the slides. The condyle stylus is positioned by inserting a steel stylus to aid in centering it. The stylus should be placed over the axis pin, and the Bennett stylus should center over the slide holder mediolaterally (Fig. 233), about ¼ inch from the top edge of the slide. The stylus tubes are turned so that the Bennett stylus will be at a right angle to the slide holder. As before, all the clamps and thumbscrews are locked securely.

## TRACING THE PATHS

The operator attaches a set of slides and places the pencil styli in their tubes. The springs are attached to the studs, and the patient is instructed not to open. He should hold the center bearing pin in firm contact but not bite hard. A chew-in tracing (Fig. 234) is made first to study the patient's behavior and to detect any unusual characteristics. Some patients do not use the full Bennett movement on every stroke, but it is very important that it be recorded to the fullest extent. A "chew-in" will reveal it, since at some time during this the patient will use his full Bennett movement. This would also show up on the later check, but recording it now may save the annoyance of making more tracings. From the chew-in, the operator can see the full Bennett shift and determine whether or not the patient is recording it on the tracing slides. The patient is instructed to slide the mandible in every direction he can without any guidance from the operator. If he records all his paths, the Gothic arch slides will show diamond patterns, and the condyle path tracing (Fig. 235) will be completely filled in between protrusive and lateral excursions. The top edge of the condyle tracing will be his straightest protrusive, and the bottom edge his widest lateral stroke. The Bennett slide tracing also will be filled in between protrusive and lateral, and, again, each border represents an extreme range. The Bennett movement of the working side will be the tracing behind the centric point, and the tracing in front of centric will correspond to the working tracing on the other side. On the condyle path slide there also will be a tracing behind and above the condyle path tracing. This is the vertical component of the Bennett movement. Since the tracing is being pantographed outside the center of rotation, it always will appear on the slide behind the centric point. This does not mean that the condyle has gone back. The actual path will be disclosed later when the articulator is being set.

The styli are raised and turned in order to lock them out of contact with the slides. The slides are removed and replaced by a fresh set. Each movement will be traced now as a separate path, but *each path must be traced simultaneously on all six slides.* A slide from one set cannot be mixed with slides from another set, because the patient never uses the same protrusive path twice in succession. (The Bennett movement is the

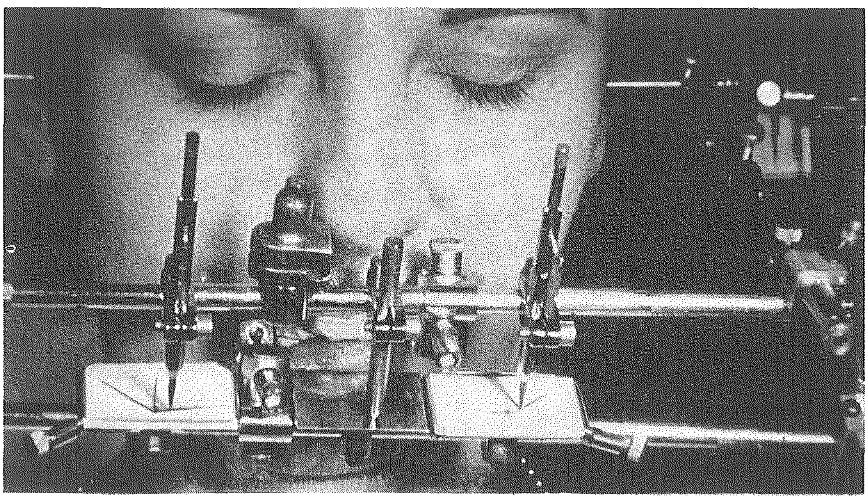


FIG. 234. A Gothic arch chew-in tracing.

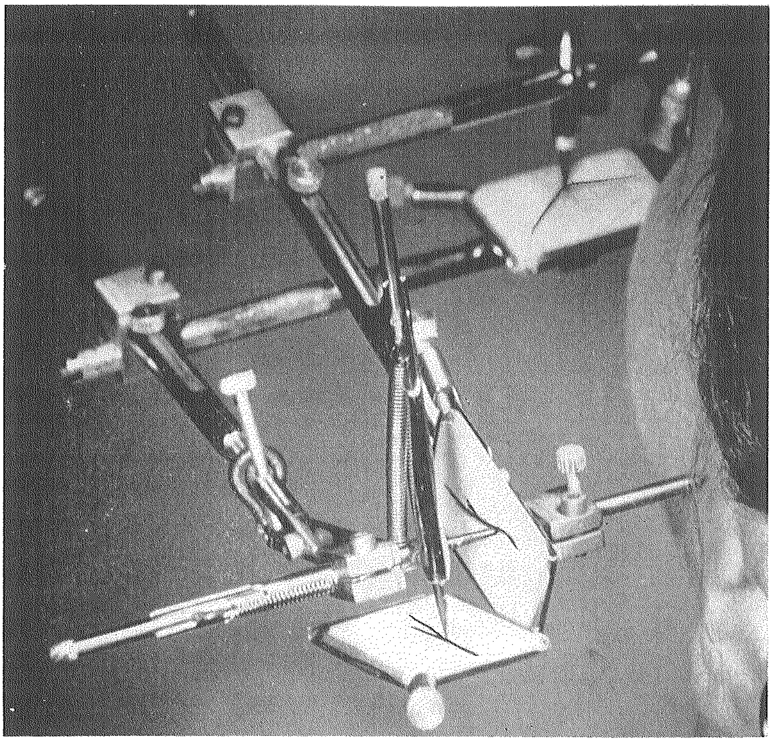


FIG. 235. Condyle and Bennett path chew-in.

difference between the protrusive and the balancing condyle path.) A setting made from one set of slides will follow another set provided that they are all replaced as a set, but a tracing cannot be made on one slide and then on another, successively. During any recording all six styli must be tracing together.

It is imperative also that each tracing start from centric, and that the styli be exactly on the starting point each time. So, before each tracing, the patient is instructed to protrude and retrude to centric, and checked to see that all styli are on the original starting points.

To make the tracing, before the pencils are placed in contact with the slides the patient is asked to protrude and, as he retrudes, the mandible is guided back and held in centric. The patient is warned not to open. The styli are released, and the patient is told to slide his mandible forward and hold it. The styli are withdrawn and locked, and the patient is returned to and held back in centric. Again the styli are released and checked to see that they are all on the starting points. The finger is removed from the chin, and the patient is instructed to slide to one side and hold it.

Again the styli are withdrawn and locked out of contact. The patient now is told to slide back, but, before the other lateral tracing is made, he is again protruded and retruded and held in centric while the styli are released. They are checked again to see that they are all on the same starting point. Now the patient is instructed to slide to the other side (Fig. 236) and hold it. The styli are withdrawn and locked. In making these records, the terms "right" and "left" are avoided, since they confuse some people. A patient will start in the wrong direction and suddenly realize it. Then he will try to correct the mistake and spoil the tracing.

Tracings always are made from centric out —never the reverse. On the outward stroke

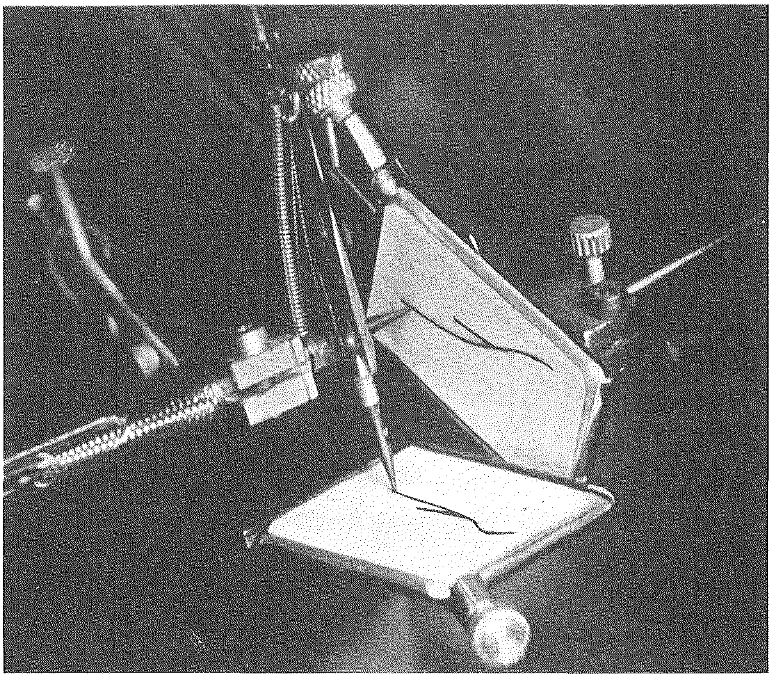


FIG. 236. Condyle and Bennett path tracings.

the external pterygoids are functioning actively and holding the condyles well up on the slope of the eminentia in its functioning range. On the return, the external pterygoids are not in active function, and many patients will not return along a pure path. They are very likely to swing over into a lateral protrusive and return.

Aberrations of various sorts sometimes appear. These are unusual and are not a significant problem. However, errors in registrations can produce aberrations which may deceive the inexperienced operator. For example, on rare occasions the condyle will start out by rising instead of traveling down. Usually this can be set correctly later on by the axis tilt and the Bennett grinding. However, the same appearance can be produced by an artifact that is caused by rocking on a misplaced center bearing pin, and in that case it cannot be set by adjustment as it is not a true path of combined actions. When such a path is observed during registrations, the operator should check carefully to make sure that it is a true path. To do this, all the styli except the condyle pencils are retracted. The patient is instructed to open and move forward, and the operator watches to see whether or not he produces the same curve.

There are a few patients who drop into rest at the end of each stroke and then lift the condyle again to start the next stroke. They are difficult to handle, particularly in locating the axis. I have seen one particularly loose-jointed elderly patient return to rest from the end of each stroke and then lift the condyle to start the next stroke. In some patients with peculiar Bennett paths the protrusive and the balancing condyle paths may cross each other. All these aberrations can be observed and noted at the time of making the registrations.

The patient with temporomandibular joint and muscle spasm problems will not give a good record at the start of treatment. The registration is taken as accurately as possible, but with the knowledge that a better record will be obtained after the temporaries have been in place and are remounted (as described in Chapter 22 on Temporary Res-

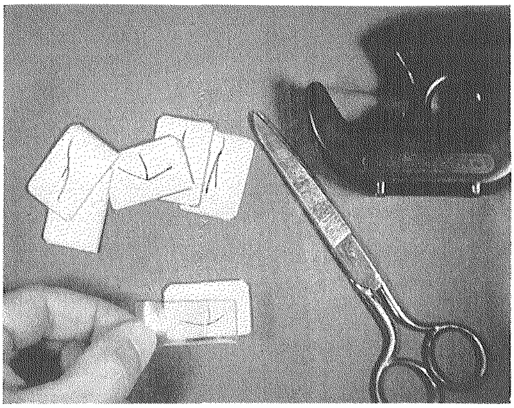


FIG. 237. The slides are covered with Scotch tape.

follows all of them. The operator must be sure to number the sets so that slides from different sets cannot become mixed and produce a hopeless situation. For example, it is impossible to follow Bennett slides from two sets with different protrusives. The slides are covered with Scotch tape (Fig. 237), extending beyond the paper to the metal at the ends of the slides. The pencil styli are replaced by steel ball-point styli. One set of slides is placed back on the patient and, without guidance, the operator checks to see that the patient follows all six in every excursion (Fig. 238), the only exception being the protrusive line on the Gothic arch tracing. The patient will not follow the same protrusive path repeatedly, but that may be disregarded for the moment. If he failed to record his full Bennett movement, that will show up on this recheck, as the steel stylus will travel outside the Bennett tracing on the working side as the patient keeps repeating the stroke.

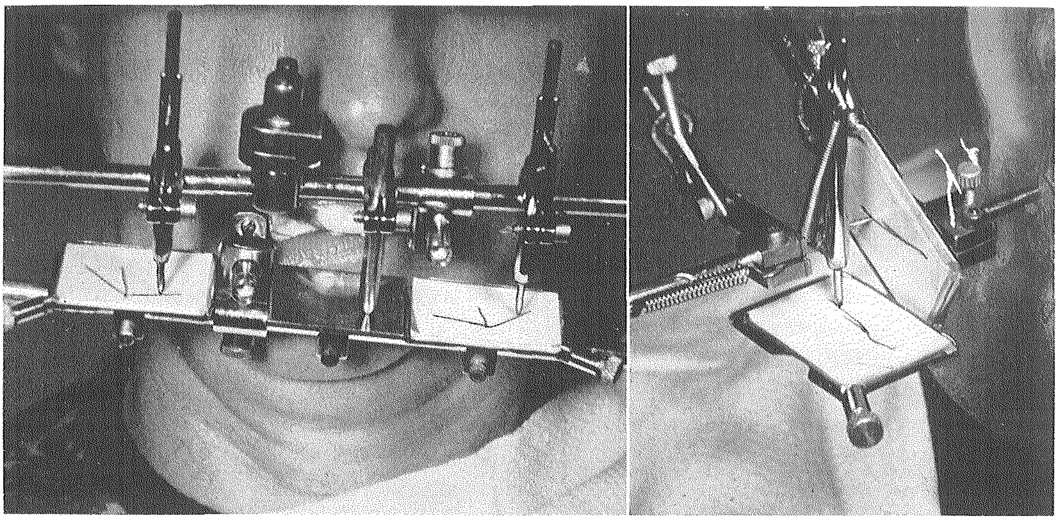


FIG. 238. Checking the tracings with steel styli.

torations), and until no further change is observed and the patient is symptom-free. After several months, a new registration is made, new models are mounted, and the case is recarved from the start. Usually it will be found that the later registration shows more Bennett movement than the first. It appears probable that during the Bennett movement the condyle slides on the meniscus and impinges on the non-pressure-bearing area to cause the painful symptoms.

## CHECKING THE TRACINGS

Usually three sets of tracings should be taken and checked to see that the patient

## DISMOUNTING THE PANTOGRAPH

All three sets of slides are checked in the same fashion, and one set is left in place to check the patient while the apparatus is being locked and removed. On each crossbar, just

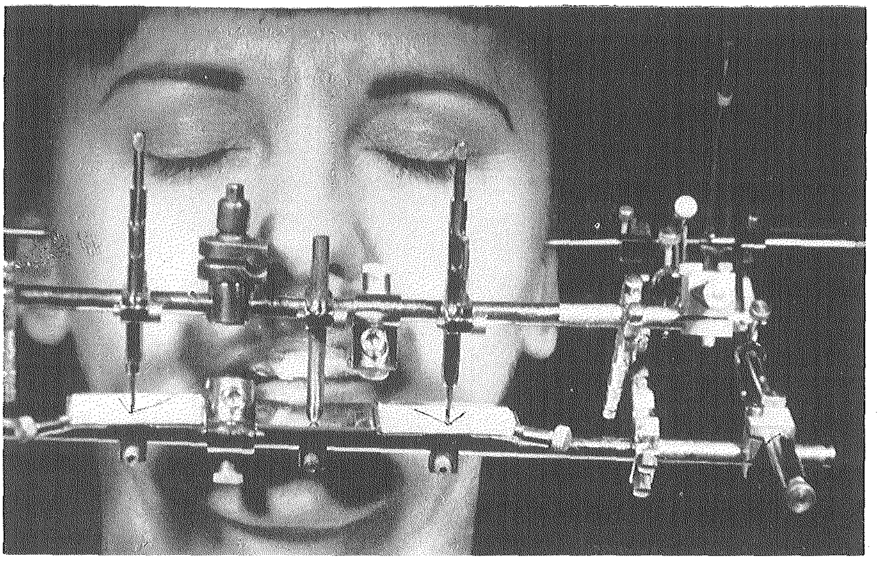


FIG. 239. Vise grips are clamped to the crossbars.

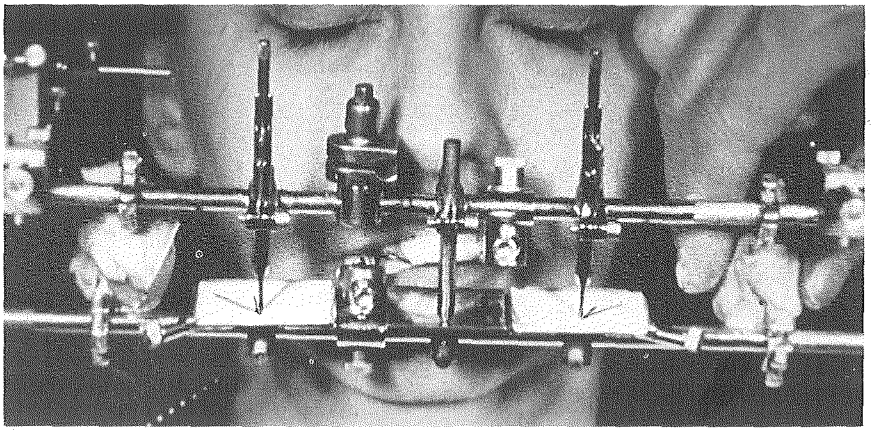


FIG. 240. Locking the vise grips with stone.

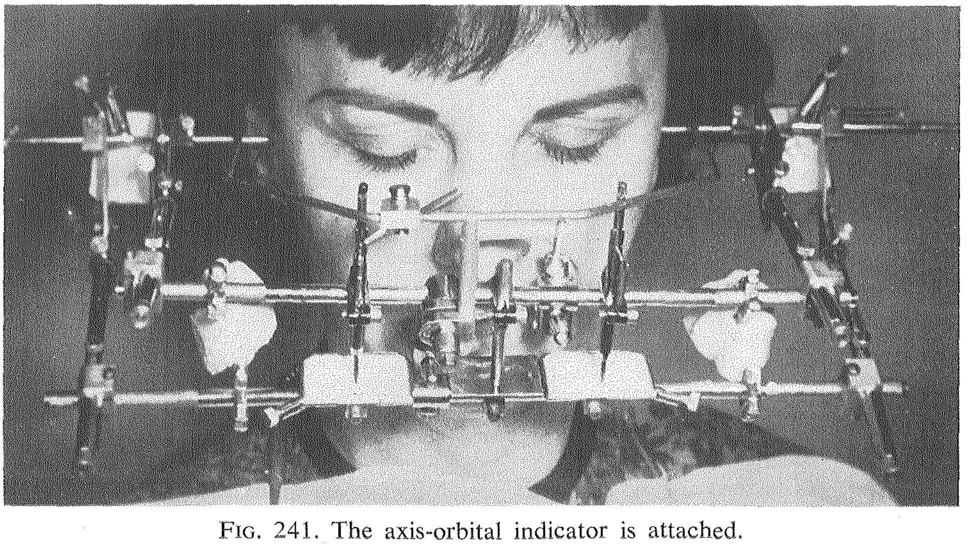


FIG. 241. The axis-orbital indicator is attached.

inside the sidearms, a vise grip is locked (Fig. 239). The upper one should point back and down, at about a 45° angle, and the lower one up and back, so that they cross each other but do not touch. The patient is guided to centric and held there. The vise grips are locked securely. A putty mix of fast-setting Greyrock is made and placed over the vise grips (Fig. 240) to lock them together. The patient is held in centric until the stone has set. The operator checks to see that all the styli are on the starting points of all the tracings.

Now, the orbital indicator is attached and adjusted on the nose tattoo (Fig. 241), just as for a face-bow mounting. The separable studs are unscrewed and the whole pantograph is removed as a unit (Fig. 242). Care must be taken not to squeeze the sidearms and throw the styli out of position. If this should happen after mounting, it will do no harm. The styli can be readjusted to the slides, but the slides must not be readjusted to the styli. Since the slides are the path of motion, it will not change the path if a stylus is readjusted once it has been mounted. But if this should happen before mounting, there would be no way to determine which had moved: the slides or the styli.

The pantograph is mounted, using the mounting frame, in the same way as the transfer bow, with the axis pins in position and the orbital rest in the indicator. However, a special heavy vise grip is provided to hold the pantograph on the mounting frame. This is clamped to the stud just in front of the clutch, behind the crossbar, and then locked in the universal clamp of the mounting frame.

The pantograph is attached to the mounting frame before the clutches are reattached. The clutches are assembled (Fig. 243) and filled with stone. The upper clutch is attached to its stud, which, in turn, is attached to the upper bow of the articulator (Fig. 244). In mounting the lower clutch, no attempt should be made to invert the articulator. It is attached by placing stone on the mounting plate and closing down into it (Fig. 245). The anterior guide pin should be set at zero. The operator should check to see that the mounting has not thrown the styli out of ad-

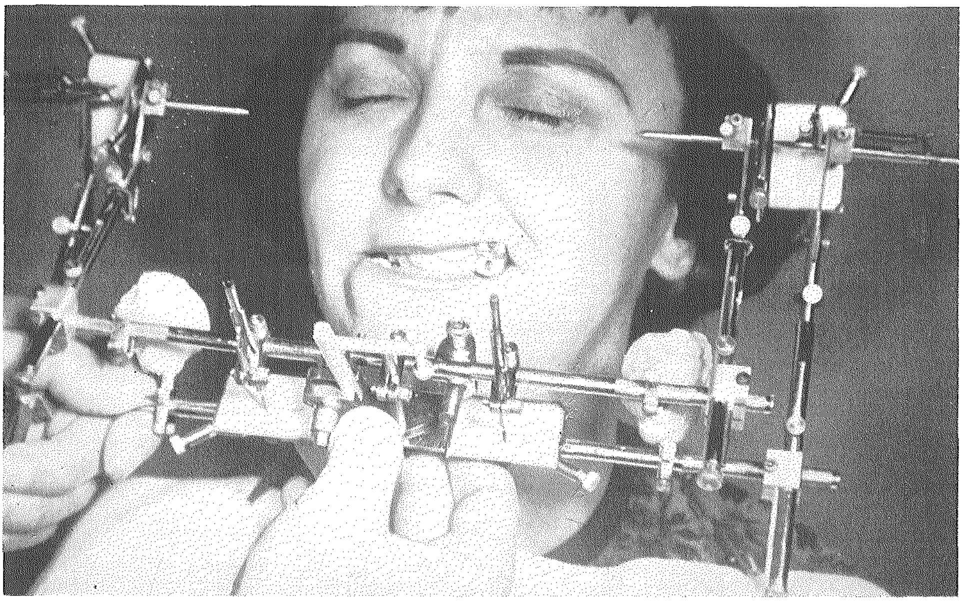


FIG. 242. The pantograph is removed by separating the studs.

FIG. 243 (*Right*). The clutches are filled with stone.

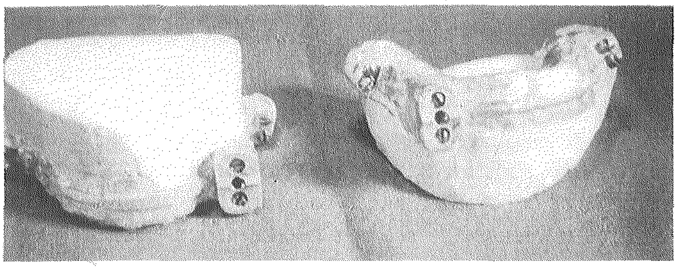
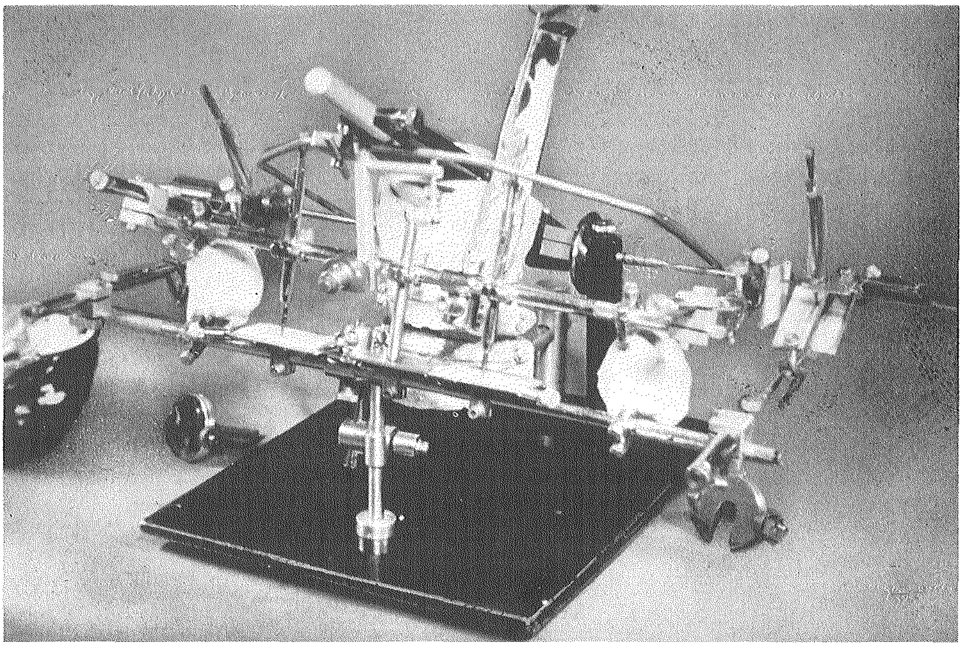


FIG. 244 (*Below*). Mounting the pantograph on the upper bow.



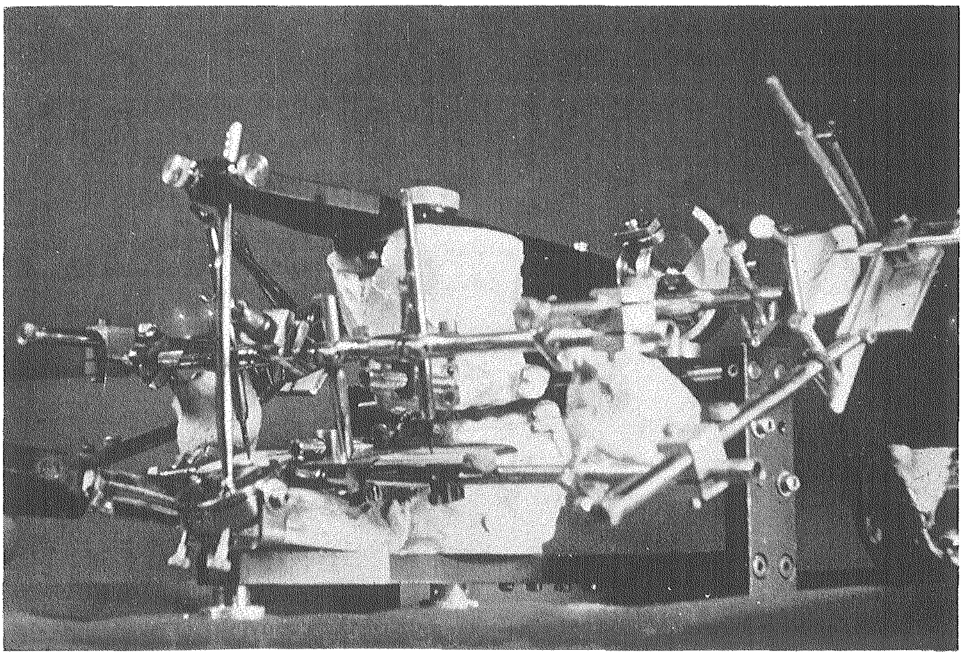


FIG. 245. Mounting the lower clutch.

justment, and wait until the stone is set thoroughly.

Now the vise grips are unlocked and removed. The anterior guide pin is raised until it is out of contact with the plate, so that it will not influence the settings of the articulator.

## ADJUSTING THE ARTICULATOR

The pantograph is essentially a 6-pointed compass, scribing arcs from moving centers. It makes no difference whether the slide or the pencil point does the moving. The end-result is the same. It should be kept in mind that, since all the scribers (moving parts) are on one bow, any adjustment of the instrument to make it follow a given scribed line must affect all the lines, but in varying degrees. The purpose of adjustment is to place the centers and their paths in such positions that all six scribers will follow the scribed lines simultaneously, that is, will scribe the same lines as the patient. When the instrument is moved, it must be remembered that the working condyle must be kept tightly seated and the upper bow kept against the Bennett guide on the working side.

Certain paths and positions will have more effect than others and so should be adjusted first. However, since subsequent adjustments will alter the first setting to some extent, at first they can be approximated but not finalized, that is, the first adjustment will be gross and will not require subsequent gross changes. Refining will become necessary as the adjustment proceeds and becomes more correct for the subsequent setting. Thus, adjustment is a gradual process of refinement.

No attempt should be made at the outset to set each adjustment for the full curvature of the path that is being followed. All the paths will be curved in varying degrees, but some of the curvature will result from other settings. The operator starts by setting the angle and the positions of the centers. It is customary to mount with a ¾-inch curved

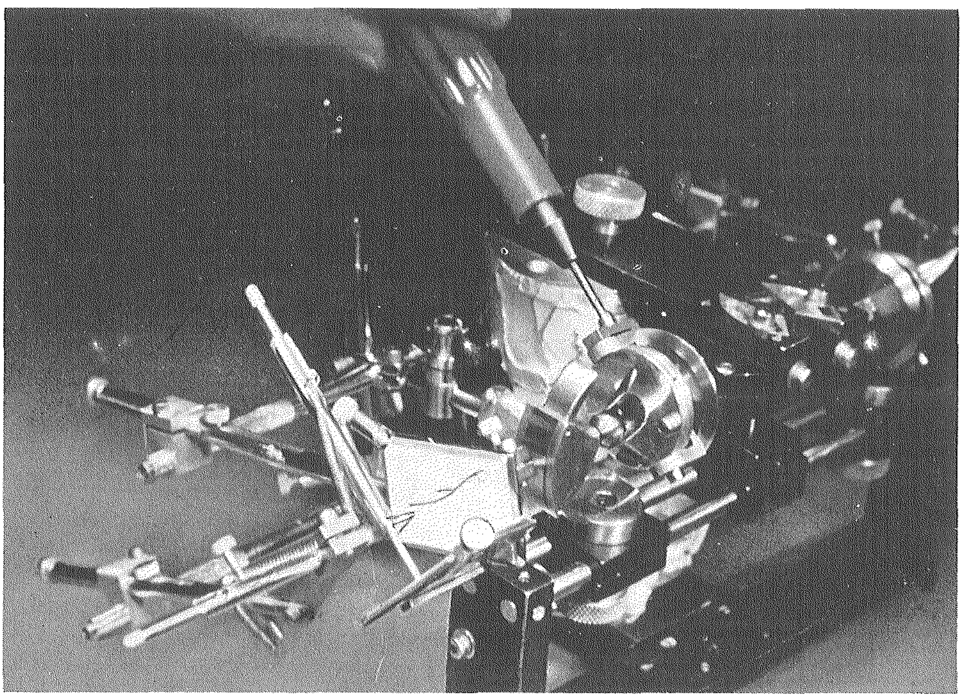


FIG. 246. Setting the angle of the condyle path.

condyle path, since this is a good average for preliminary use.

The angle of the condyle path (Fig. 246) is set so that, on the balancing stroke, the steel stylus will meet the end of the condyle path tracing. If the stylus is below the line, the angle is too steep; if it is above, the angle is not steep enough. It may pass above or below the curve of the path from centric to the end, and this will be corrected later by changing to a different curve. No attempt should be made at this time to set the curve, because subsequent changes will alter it.

Next, the intercondylar distance is set by simultaneously moving out the entire condyle path assembly (Fig. 247) and the entire condyle assembly. The upper and the lower intercondylar distances must be kept iden-

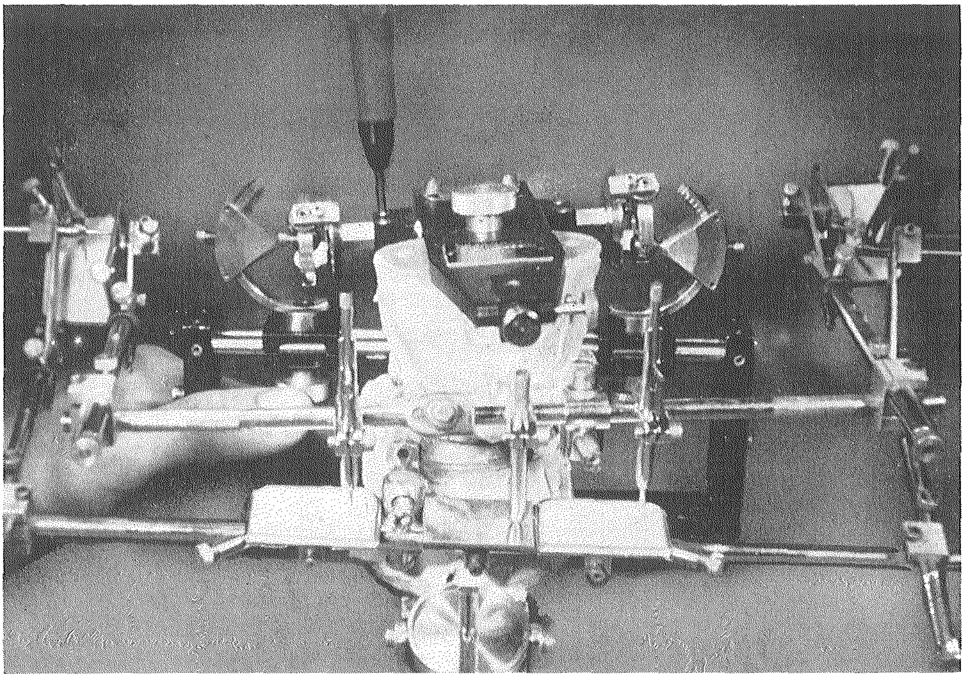
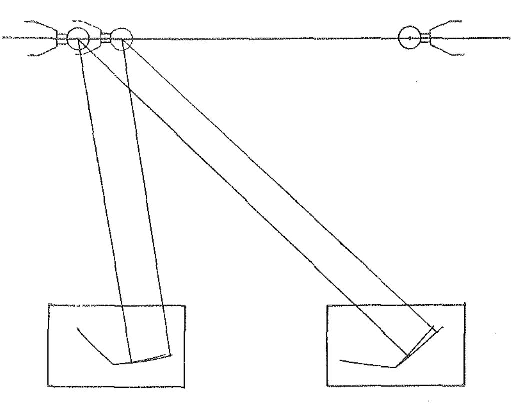


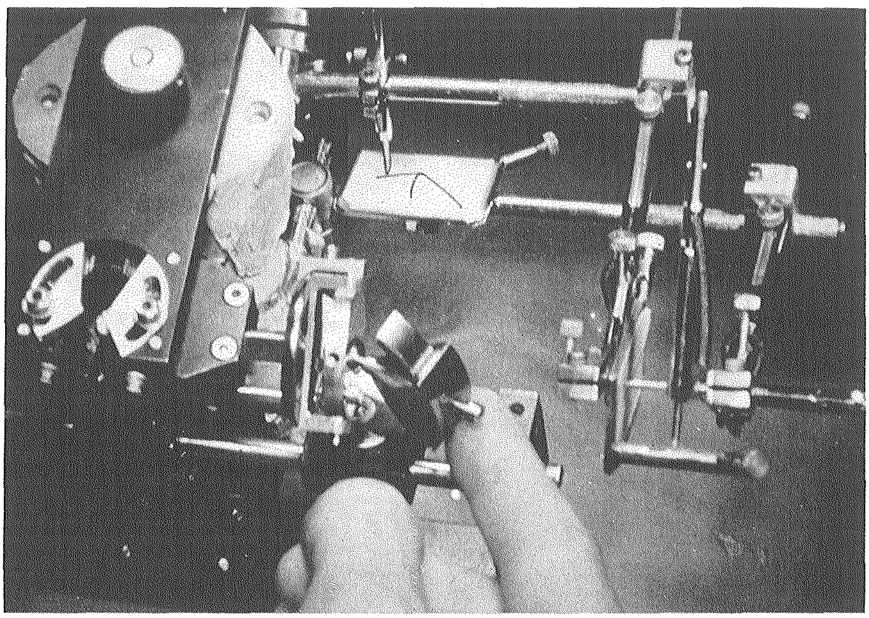
FIG. 247 (*A, above; B, below*). Adjusting the intercondyle distance.



tical. On the working side, the intercondylar distance is determined by the dual Gothic arch tracings. As the upper bow is moved to the operator's left, which would be the patient's right lateral excursion, the two styli on the Gothic arch tracings are watched. There are two adjustments of the intercondylar elements to be made: the distance apart, and the axis rotation in lateral excursion. Changing the intercondylar setting on one side will have more effect on the tracing of the other side. Rotating the axis (Fig.

248) will have more effect on the same side than on the other one. As the upper bow is moved to the left, the stylus on the patient's left Gothic arch tracing is watched. If the stylus scribes an arc outside the Gothic arch, it means that the intercondylar setting on the patient's right must be increased (Fig. 247 B). If the stylus scribes inside the tracing, the intercondylar distance must be decreased. The intercondylar distance is set to the end of the line. It is not necessary to be concerned about the curve at this time. Now the operator observes the stylus on the same side—in this case, the patient's right. By rotation of the axis, the stylus can be adjusted to follow this line. If the stylus is scribing outside this Gothic arch (Fig. 248 B), the axis must be rotated forward so that the working condyle will go back in lateral Bennett movement. If it falls inside the Gothic arch, then the axis must be rotated back, so that the condyle will slide forward as it moves laterally.

Both these paths will be altered to some extent by the Bennett movement, so this is the next adjustment. The amount of the Bennett movement is established by the adjustment of each Bennett guide on the working stroke. The lock screw (Fig. 249) is loosened and the Bennett guide is rotated. It is adjusted so that, in the full working stroke at the end of the Bennett tracing, the stylus is on the end of the line and the guide is in contact with the center post. The vertical part of the Bennett movement is adjusted by tilting the axis



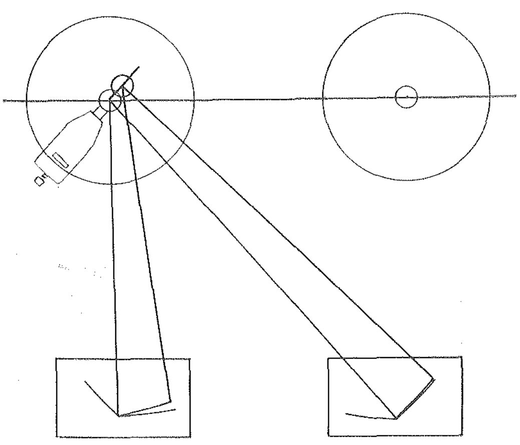


FIG. 248 (*A, above; B, below*). Rotating the axis.

bearing. On the sagittal condyle path slide, the line scribed behind the centric point indicates the vertical component of the Bennett movement. The axis is tilted up or down (Fig. 250) until, in the full working range, this stylus is likewise on the end of the line.

The Bennett movement is the most irregular of all the paths of motion. It is almost

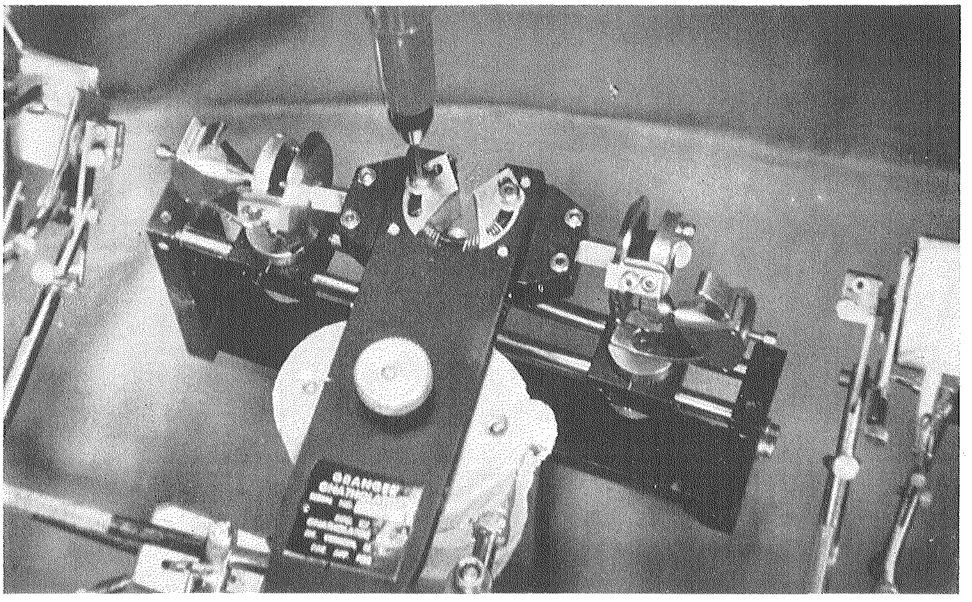


FIG. 249. Adjusting the Bennett guides.

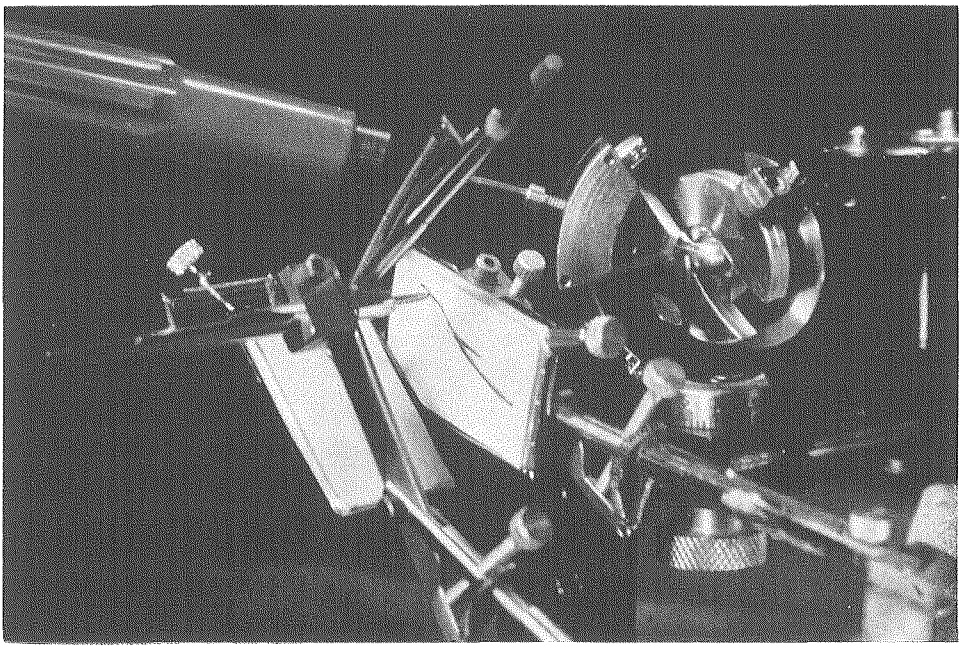


FIG. 250. Tilting the axis.

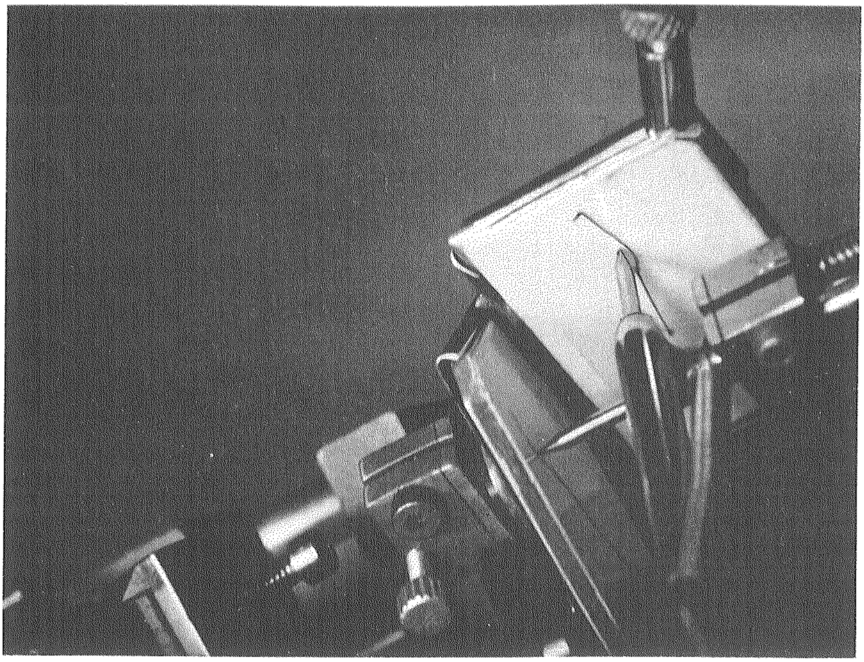


FIG. 251. The stylus does not follow the Bennett path.

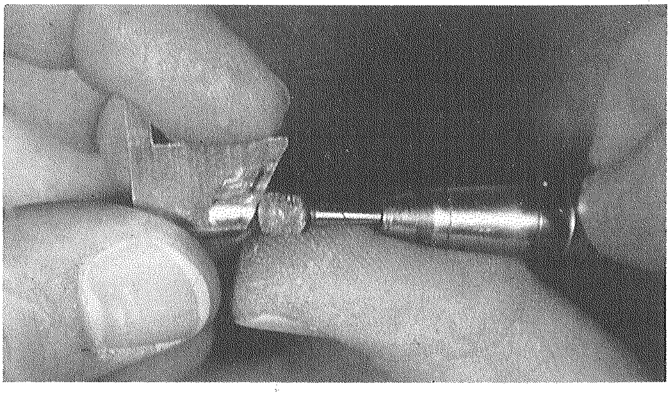


FIG. 252 (*Left*). Grinding the path in the Bennett guide. (*Below*). The stylus follows the line after grinding.

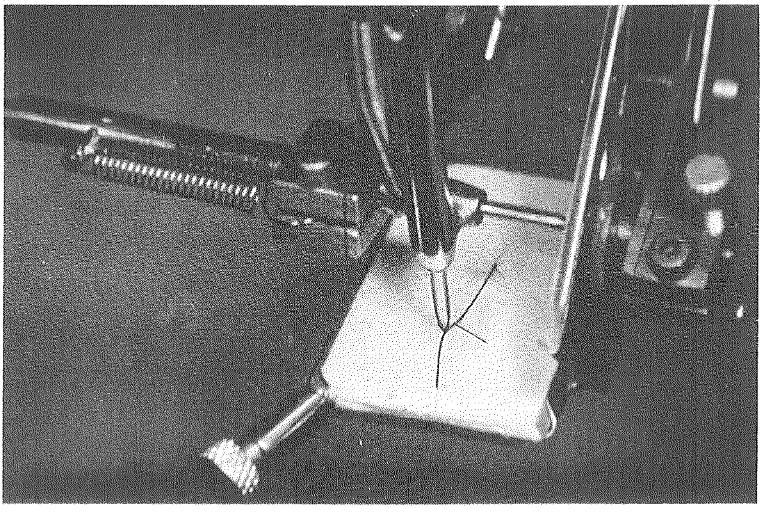
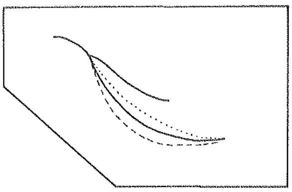
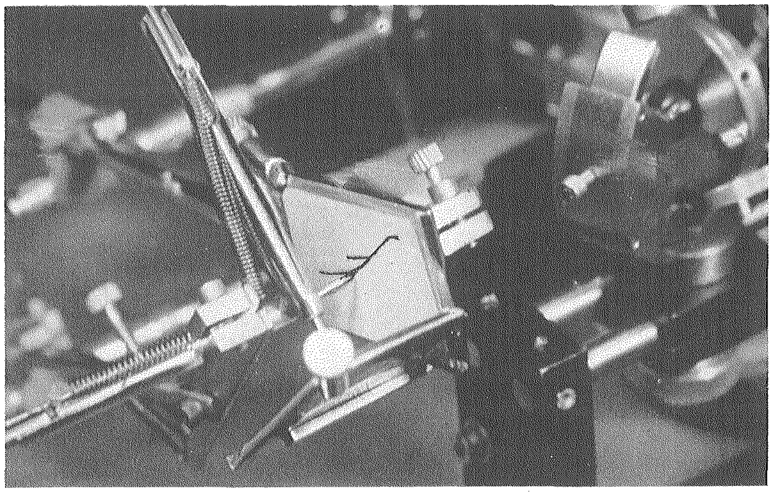


FIG. 253. Adjusting the curve of the condyle path.

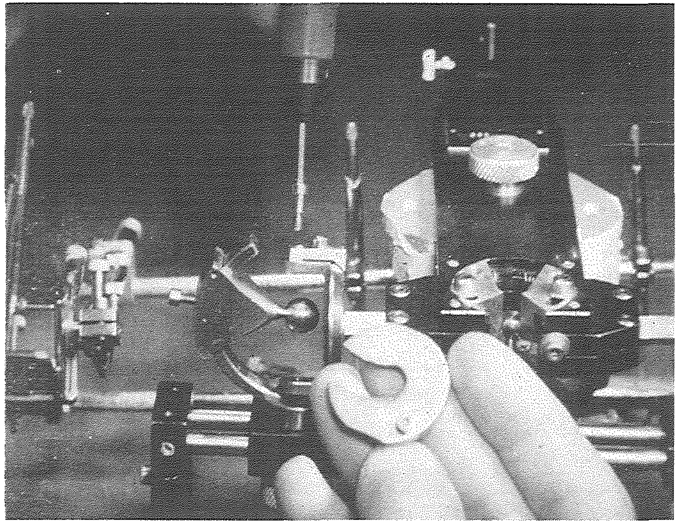


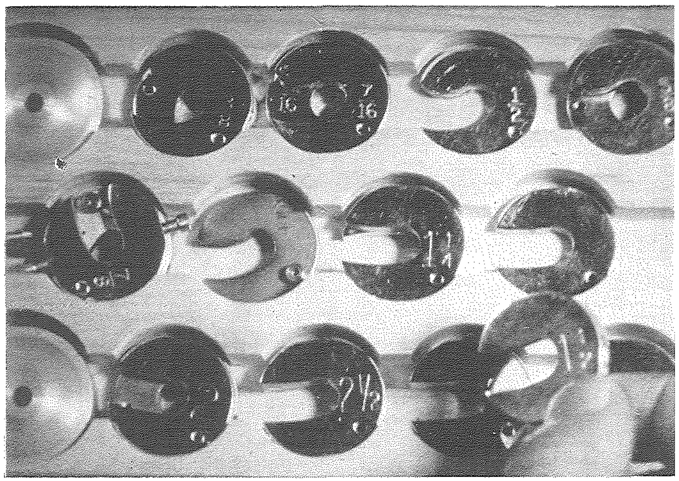


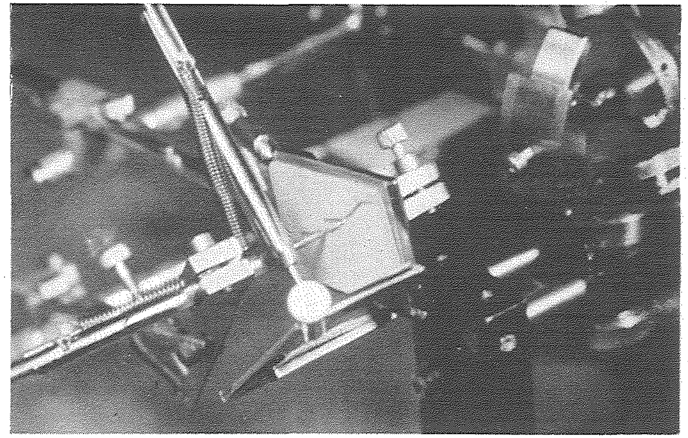
always necessary for the Bennett guides to be ground to the actual shape of the path in order to reproduce that path (Fig. 251) between centric and the extreme lateral. After the angle which determines the lateral distance of the Bennett path has been set, the path is ground from centric out to the end of the tracing. This is accomplished with small wheel stones in a handpiece (Fig. 252). The back of each guide, behind centric, is curved to fit the post so that it will always return to centric, regardless of the grinding. Since this curve is behind centric, there cannot be any reason to grind it. The grinding must be done with small stones so that, in those cases requiring deep grinding close to centric, the centric contact of the guide and the post will not be destroyed. The gross grinding can be done by watching the bright marks on the metal as the guide rubs the post in lateral excursion. The guide is removed and some grinding is done. No attempt should be made to finalize it at once. It is returned to the instrument, locked at the same angle, and checked. As the grinding proceeds, the cuts should be wide vertically, since subsequent changes in the curve of the condyle path will slightly alter the path of the post on the Bennett guide. The necessity for regrinding can be avoided if the original grinding is from the bottom edge of the guide to about halfway up the guide. A ¼-in. wheel-shaped carborundum stone is good for this purpose.

As the grinding more nearly follows the path, it becomes more difficult to know exactly where to grind. This can be marked on the guide by using tissue-thin typewriter carbon paper, interposed between the guide and the post with the waxed side toward the guide. After a piece has been placed between the two, the bow is moved only as far as is necessary before the stylus meets the scribed line. If, inadvertently, the guide is ground too much, the operator closes the angle slightly and grinds more from the rest of the path. The end-result is the same and this avoids ruining a Bennett guide. When completed, the Bennett stylus on the working side and the Bennett stylus on the other side, following the balancing path, both should follow their respective lines. This is important, since it determines the timing of the Bennett movement and its relation to the occlusal form of the teeth.

The grinding of the Bennett guides usually will require some slight readjustment of the intercondylar width, and should enable the Gothic arch styli to follow the curve of these lines. This readjustment will not alter the grinding of the Bennett guides. In making intercondylar adjustments, it should be remembered that the upper and the lower elements always must be precisely aligned at







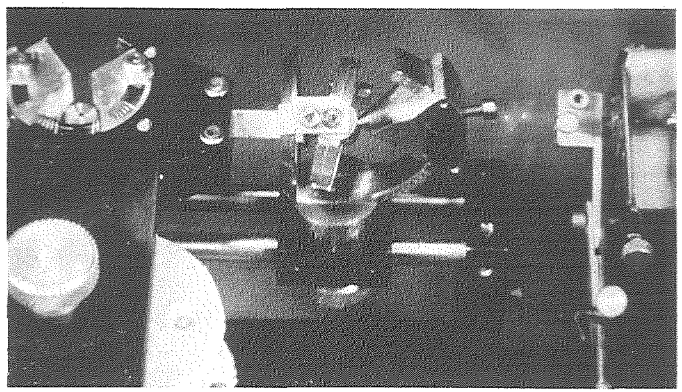
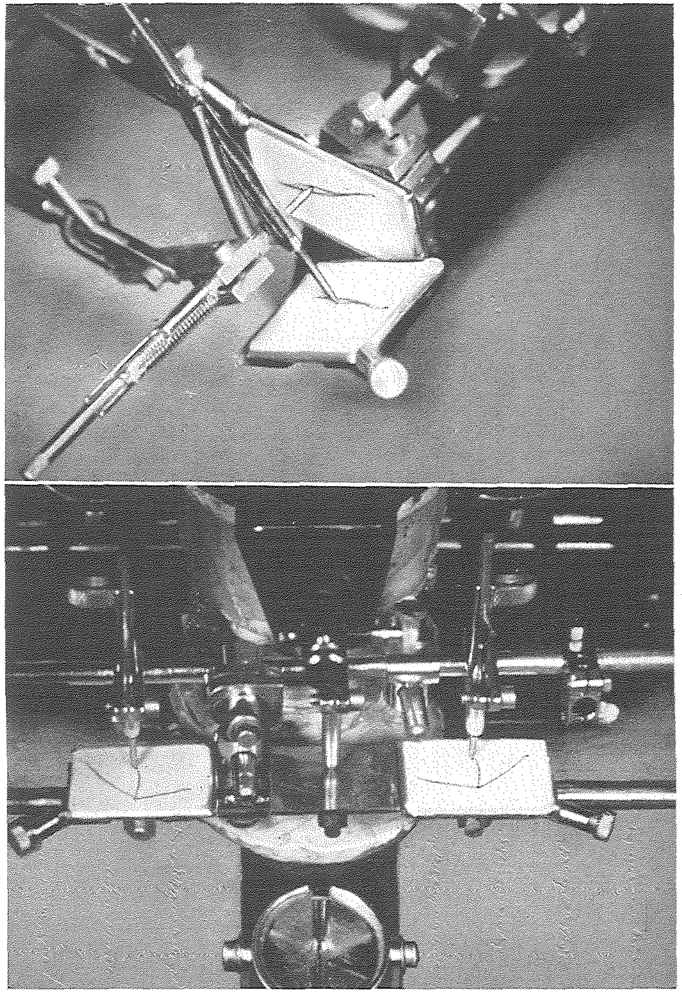
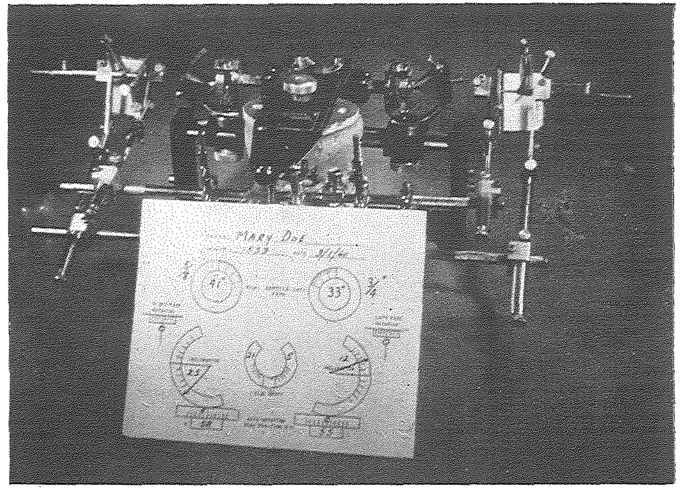


FIG. 254 (*Top, left*). Changing the condyle path.
FIG. 255 (*Bottom, left*). Various radii of condyle paths.
FIG. 256 (*Top, right*). With the proper curve, the stylus follows the curve.
FIG. 257 (*Bottom, right*). Rotating the condyle path on its axis.





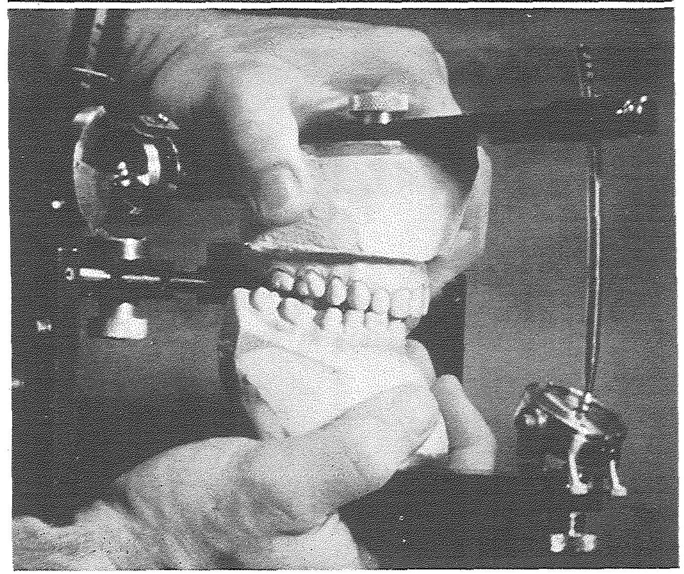



FIG. 258 (*Left, top and bottom*). Checking all the paths at once.

FIG. 259 (*Top, right*). Recording the articulator settings.

FIG. 260 (*Bottom, right*). The study models are mounted for diagnosis.

the same distance. If they are not, the centric relation will be changed.

All the previous adjustments will affect the angle and the curvature of the condyle path to some extent. For example (Fig. 253), the curve frequently will start with a small radius and then straighten out. This occurs as the axis is shifting sideways in the Bennett movement, and the axis is tilted so that the resultant curve is a combination of all these movements. The last step is to correct this curvature by replacing the condyle path by the correct one. If the stylus follows a path above the tracing, a smaller radius is required; if the stylus goes below the tracing, a larger radius is required. This is a trial-and-error process. The condyle path is changed (Fig. 254) by removing the two shoulder screws and sliding the path out of the back of the path holder. Various curves (Fig. 255) are tested until the stylus follows the curve (Fig. 256).

On rare occasions, it is possible that an abnormally wide mandible will require more width than the upper bow will accommodate. Although the author has never found it necessary to use them, two spacers are provided which will increase the upper intercondylar width 10 mm. on each side. They are used by removing the path holder and placing the spacer over the shaft. Then it is replaced with the spacer between the path holder and the angle index. This increases the upper calibrations by 10 mm., so it should be read as that much more. For example, a reading of 55 mm. on the square shank actually would be 65 mm.

The final adjustment is rotation of the condyle path in its holder (Fig. 257). This also is seldom necessary. It is used when there is unusually wide divergence between the protrusive and the balancing condyle path. The path can be turned by loosening the path-holding screws and rotating it in or out. When this is done it will be necessary to change the angle, and sometimes the curve. This is a difficult adjustment and should not be used unless it is absolutely necessary. It should not be used to attempt to compensate for something which was not done properly. Finally, all six styli are checked (Fig. 258) to see that they will follow their respective tracings simultaneously. The settings are recorded (Fig. 259) on a chart for future use.

### Step Procedure

1. Set the angle, but not the curve, of the condyle path.
2. Set the intercondylar distance on the working side to the Gothic arch tracing on the balancing side.
3. Set the axis rotation on the working side.
4. Set the angle of the Bennett guides.
5. Set the axis tilt to the vertical portion of Bennett on the condyle slide.
6. Grind the Bennett guide.
7. Reset the intercondylar width.
8. Correct the angle of the condyle path.
9. Correct the curve of the condyle path.
10. Rotate the condyle path on its axis, if necessary.
11. Record the setting on the chart.
12. Mount the study models.

When the articulator has been adjusted to the satisfaction of the operator, the clutches and the pantograph are removed and disassembled. If possible, it is desirable to leave the articulator set and to mount the study models (Fig. 260) to avoid any error in unsetting and resetting it.

*Chapter* 16

# Articulation of the Teeth

While reading this chapter, it is almost essential that the operator have at hand a set of properly articulated teeth to refer to, rather than trying to visualize them in his mind. It is as difficult to describe articulation as it is to describe a color without seeing it.

It would require a complete volume and countless illustrations to give all the minutiae of detail that enter into articulation. Here we have the bare essentials. The rest can be learned from the study of natural teeth and mouth function. Articulation is the dynamic anatomic relation of teeth in every possible contacting position. Balanced occlusion is the static relation of teeth at a given stage of articulation which makes contact between their opposing anatomically related parts.

The cusps, the sulci and the fossae of the teeth that will function properly in any given mouth are the resultant of a number of variable factors, viz., the condyle path, the Bennett movement (which, of course, is part of the condyle path), the plane of occlusion, the curve of Spee, and the anterior guidance or combined overbite and overjet. Because of the infinite variety of possible combinations of these factors, cusp height and form vary widely among individuals. However, under any given, fixed set of these factors, there is only one set of cusps which can work. By varying one or more of the factors which are not anatomically fixed, within the limits imposed by the mouth under treatment, it is possible to exercise some degree of control over the average and the relative cusp heights.

The relation of articulating surfaces to each other through the whole range of functioning movement follows a basic ideal pattern. Here again, practical variations in the position of teeth in the mouth and relative to each other will compel some compromise between what we conceive to be theoretically ideal and what we find possible in actual practice. It will be necessary in a large percentage of cases to "warp" the occlusal aspect of the tooth relative to the remaining anatomic crown, in order to maintain a proper articulating relationship of the cusps to their opposing members.

Before we can make an intelligent compromise to secure the best possible result under the conditions imposed by the malformations found in practice, we must first have a clear understanding of the ideal cusp relation: how cusps and sulci work with each other through all the functioning range, and how we could proceed to measure and carve the cusps to fit a given set of factors. We are attempting to set down here the systematic routine by which the cusps relate to each other and to the opposing fossae. It is quite apparent that there are several possible ways in which this could be accomplished, using almost any cusp as a starting point to "chase" the rest. The particular order which we are following here to develop the final complete articulating surface is merely a logical sequence which has been found in practice to be easy to follow.

The tips of the cusps will determine the form of the surfaces over which they glide between centric and the various possible paths that the teeth can follow. These surfaces in turn will form their apposing and opposing parts. First let us try to visualize an ideal pattern of tooth form and articulation. One of the difficulties in attempting to describe the relationships is the lack of commonly accepted terms descriptive of each part of the cusps and the various contacting areas of the teeth. As used here, the *inner* aspect of a cusp refers to that part which

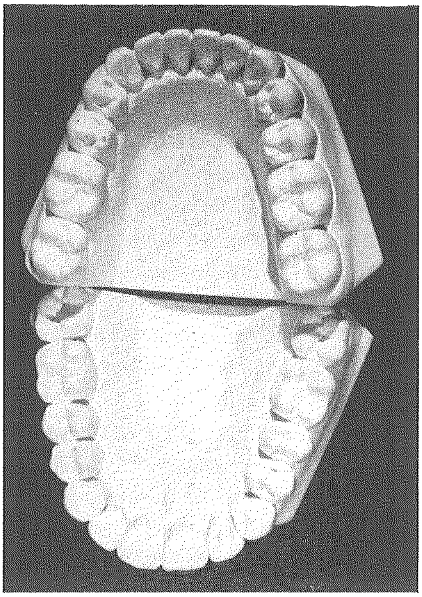


FIG. 261. The occlusal form of the teeth.

slopes toward the center of the tooth. The *outer* aspect refers to that part which slopes away from the center of the tooth. While there is no doubt that a better scientific nomenclature can be devised, it is hoped that the terms used here will be descriptive enough to serve the purpose of giving a mental image of the part described.

## CUSP RELATIONS

If we examine the occlusal aspect of an upper and a lower set of posterior teeth which can articulate (Fig. 261), we see that certain inherent characteristics are always present. The upper bicuspids are, roughly, truncated triangular in form. If we bisect the base of the triangle, the lingual cusp is seen to lie slightly mesial to the buccal cusp, that is, viewed from the buccal aspect, the tip of the lingual cusp will be slightly in front of the tip of the buccal cusp. The upper molars are trapezoid in form, and a line drawn from the tip of a buccal cusp to the tip of the corresponding lingual cusp shows an abrupt change of direction from that of a similar line drawn across the bicuspids. The line of the bicuspids is lingually anterior, that of the molars lingually posterior. As a result, the contact point of the first molar and the second bicuspid is located farther toward the buccal, with a wide embrasure lingually. The buccal cusps divide the teeth equally, whereas the mesiolingual cusps cover about two thirds of the lingual width mesiodistally. The tip of the mesiolingual cusp will fall on a line perpendicular to the buccal surface and starting on the sulcus between the buccal cusps. The crest of the mesiolingual cusp is continuous with the transverse ridge. The crest of the mesiobuccal cusp arises from the central fossa. The crest of the distobuccal cusp is continuous with the transverse ridge. The distolingual cusp is considerably smaller than the others, and the crest of the cusp arises from the sulcus crossing the transverse ridge.

The lower first bicuspid, and sometimes the second, is a truncated triangle. The lower molars, and usually the second bicuspid, are roughly square. The buccal cusps of the lower bicuspids occupy somewhat more than half the buccolingual width of the teeth. The lingual cusp of the lower first bicuspid is a large cingulum. The lingual cusp of the second bicuspid may or may not be divided by a fissure. From a functional standpoint, it makes no difference. The buccal and the lingual cusps of all the lower teeth lie opposite each other buccolingually. The crest of the mesiobuccal cusp of the lower first molar arises from the sulcus connecting the mesial fossa with the central fossa. The distal or fifth cusp is smaller than the rest, and lies at the angle of the distobuccal line. The sulcus between the distobuccal and the distal cusp is continuous with the central fossa.

The distal incline of the upper buccal cusps is slightly longer than the mesial incline. On the lower buccal cusps, it is the reverse. The marginal ridges of all teeth are rounded on both sides, so that the contact point is well below the crest of the marginal ridges, and the embrasure thus formed resembles a sulcus. The mesial and the distal fossae are roughly triangular in form, with their apices joining the sulci between the cusps, which appear as if folded into the sulci. The cusps should all present a full, rounded appearance, rather than looking like a series of ridges between grooves. They are all parabolic in form, the upper buccal and the lower lingual having somewhat less curvature. Seen in buccolingual cross section, the upper lingual and the lower buccal surfaces round off from the tip of the cusp, since these are contact areas in articulation, that is, these surfaces are a part of the cusp—the articulating area extending from the tip of the cusp. The upper buccal and the lower lingual surfaces drop quite sharply from the tip of the cusp, as there is no way for these areas to contact in function.

In centric occlusion (Fig. 262), the lingual incline of the upper canine lies in contact with the tip of the lower canine. The tip of the lingual cusp of the upper first bicuspid rests in the embrasure formed by the distal marginal ridge of the lower first bicuspid and the mesial marginal ridge of the lower second, or on the marginal ridge of the first bicuspid. The mesial and the distal inner aspects of the upper lingual cusp make point contacts with the corresponding distal inner aspect of the buccal cusp of the lower first bicuspid and the mesial inner aspect of the buccal cusp of the lower second bicuspid. The lingual cusp of the upper second bicuspid makes similar contact with the distal of the lower second bicuspid and the inner mesiobuccal of the lower first molar. The mesiolingual cusp of the upper first molar rests in the central fossa of the lower first molar, in point contact with the inner aspect of the lower molar cusps. The distolingual cusp of the upper first molar rests in the embrasure between the lower first and second molars or the mesial fossa of the second molar. The upper second molar rests in similar contact with the lower second and third molars, if they are present.

The upper buccal cusps all rest in the corresponding spaces between the lower buccal cusps. The crests of the cusps are not in contact, but the inner aspect of the upper buccal cusps makes point contact with the rounded outer aspect of the lower buccal cusps. For example, the mesio-inner incline of the buccal

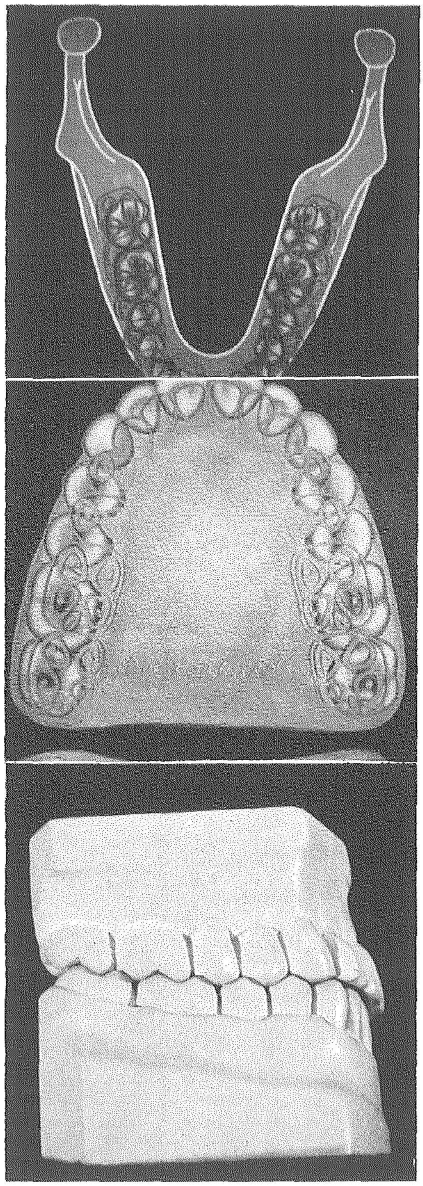


FIG. 262. Centric contacts of the teeth.

cusp of the upper first bicuspid makes a point of contact with the disto-outer incline of the buccal cusp of the lower first bicuspid; the disto-inner incline of the same buccal cusp of the upper first bicuspid lies in contact with the mesio-outer incline of the buccal cusp of the lower second bicuspid. All the upper and lower buccal cusps make similar contacts with their opposing members. The transverse ridge of the upper molars rests in the sulcus be-

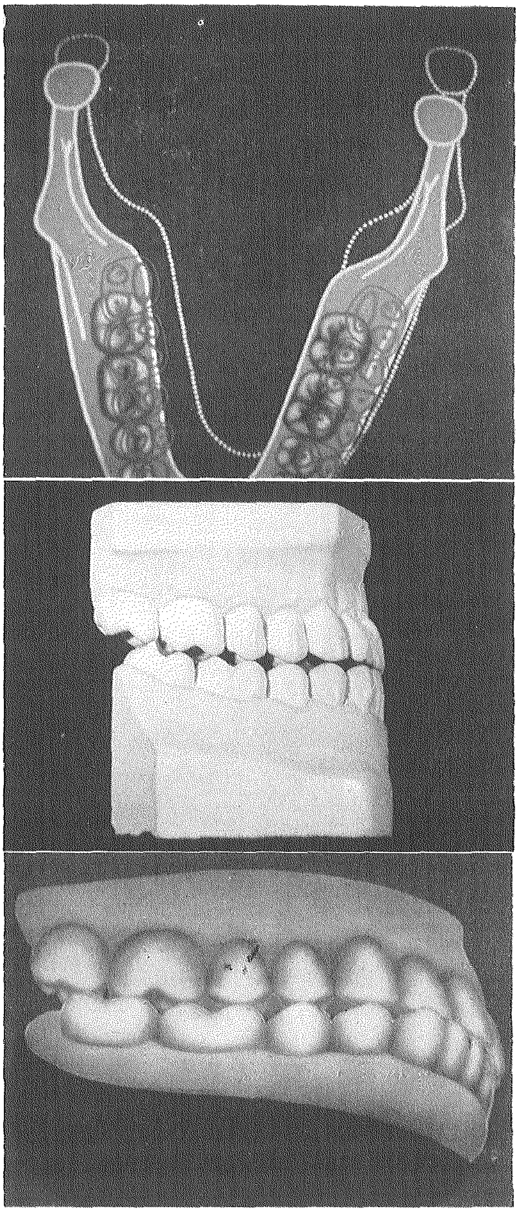


FIG. 263. Lateral protrusive cusps tip-to-tip.

tween the distobuccal and the fifth cusp of the corresponding lower molars.

The tips of the buccal cusps of the lower bicuspids and the mesiobuccal cusps of the molars rest in the embrasures of the upper marginal ridges. The distobuccal cusps of the lower molars lie in the central fossae of the upper molars. The distolingual marginal ridge

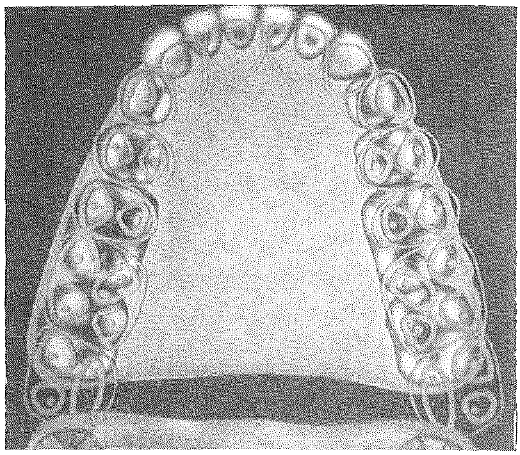


FIG. 264. Lateral protrusive contact seen through lower and upper teeth.

of each lower molar rests in the sulcus between the lingual cusps of the upper molars. The lingual cusps of the lower teeth make point contact with the rounded outer lingual aspect of the lingual cusps of the upper teeth.

The form and the position of the cusp between its tip and the sulcus will be determined by the opposing related cusp as it travels over the contact area in each of its possible paths from centric to the extreme excursion. Thus, the first consideration is correct tip-to-tip relation in each of these possible positions of the mandible.

When the teeth are in lateral protrusive relation (Fig. 263), the cusps on the working side are tip-to-tip. If we look through the upper teeth (Fig. 264), we see that on the nonworking side the cusps are over the sulci. In this position we cannot have bilateral contact. In straight protrusive (Fig. 265), the tip of each lower buccal cusp is in contact with the crest of the parabolic curve of the opposing buccal cusp (Fig. 266) in its inner aspect as it curves from the tip of the cusp to the central sulcus. Since the height of the lower buccal cusp cannot be changed without destroying its lateral protrusive relation and, therefore, the tip of the upper buccal cusp, it automatically will dictate the form of the crest of the curve of the upper buccal cusp. Once the tips of the lower buccal cusps have been

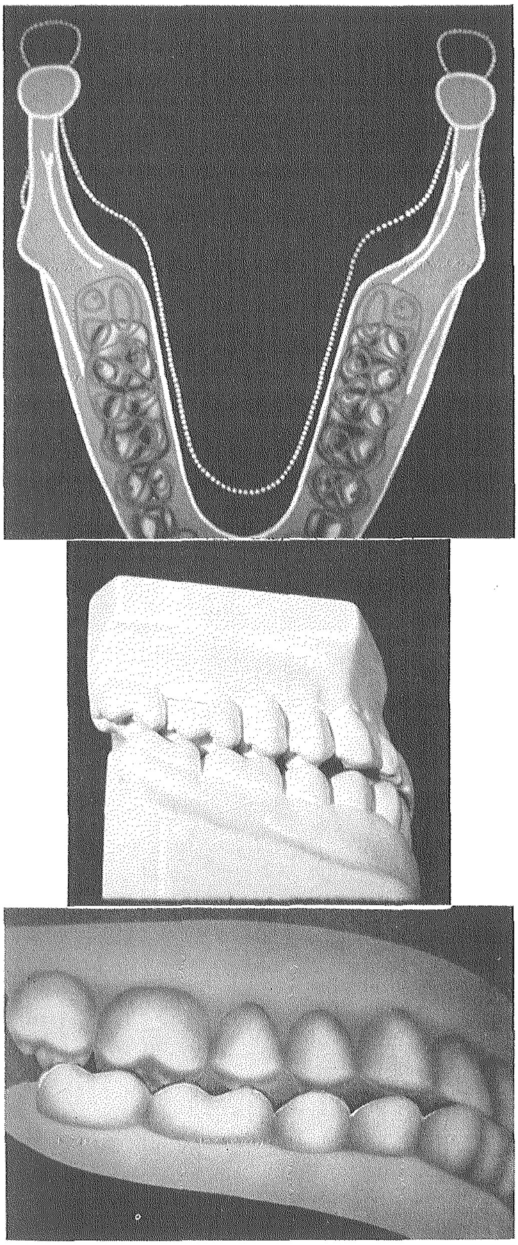


FIG. 265. The protrusive relation.

established, they will determine the tips of all the other cusps. Therefore, if conditions require a change in any of the lower buccal cusps, it will be necessary to alter all the other cusps to a corresponding degree.

## INTERMEDIATE SURFACES

The tips of the lower buccal cusps, gliding from centric to protrusive and lateral protru-

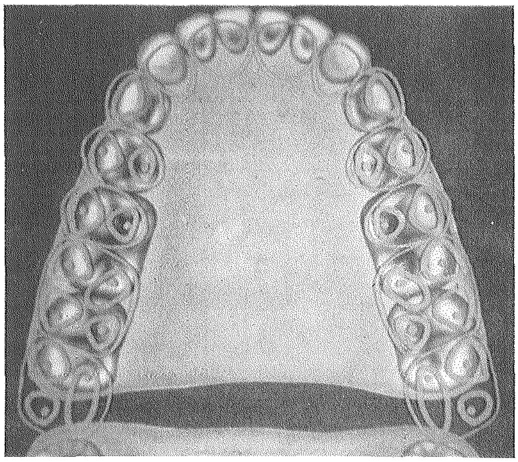


FIG. 266. Protrusive contacts viewed through the upper teeth.

sive, also will determine the mesiodistal slant of the distal inner aspect of the upper buccal cusps, but not the buccolingual form of these cusps. The distal incline of the upper buccal cusps in turn will determine the mesial incline of the lower buccal cusps. The buccolingual form of this mesial half of the inner aspect of the lower buccal cusps will be shaped by the action of the tips of the upper lingual cusps as they travel over these contact areas from centric while the condyle moves forward in the balancing position (Fig. 267). The height and the position of the tips of the upper lingual cusps are determined by the contacts that they make at the extreme of the excursion in the balancing position. The tip of the lingual cusp of the upper first bicuspid makes contact with the tip of the buccal cusp of the lower second bicuspid, and the lingual tip of the upper second bicuspid makes contact with the tip of the mesiobuccal cusp of the lower first molar. The mesiolingual cusp of the upper first molar rests in the sulcus between the distobuccal and the distal cusps of the lower first molar. The distolingual cusp of the upper first molar meets the tip of the mesiobuccal cusp of the lower second molar. The upper second molar articulates in the same manner as the first molar by its action with the lower second and third molars. The distolingual cusp of the upper second molar fre-

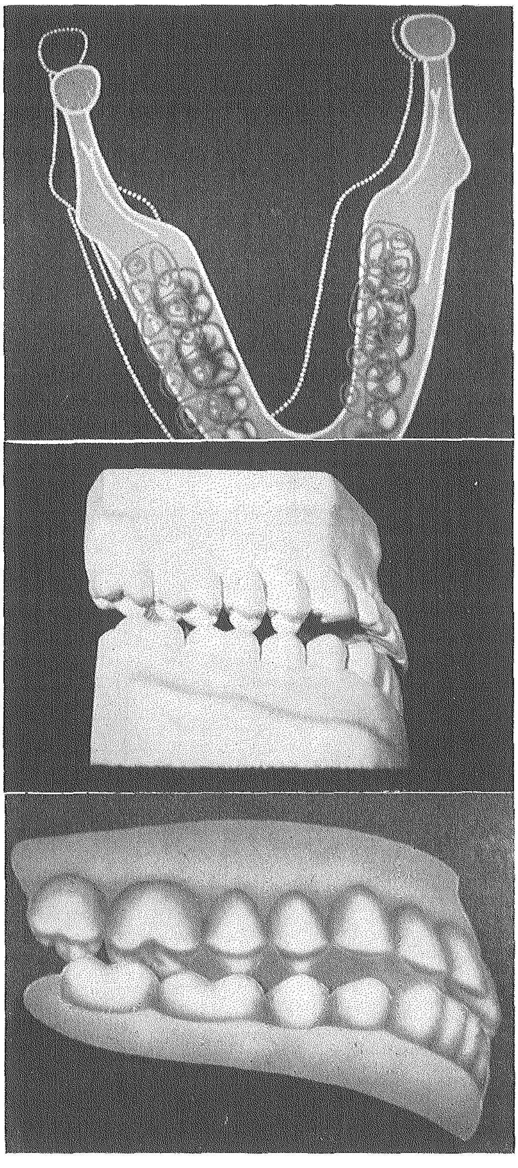


FIG. 267. The balancing relation.

quently is missing, because it has no action unless the lower third molar is present.

The mesial inner aspect of the buccal cusp of the lower second bicuspid and the mesiobuccal of the first molar glide around the lingual cusps of the upper bicuspids as they travel from centric to the extreme balancing position (Fig. 268), that is, as the other side of the mouth goes into its working bite. The

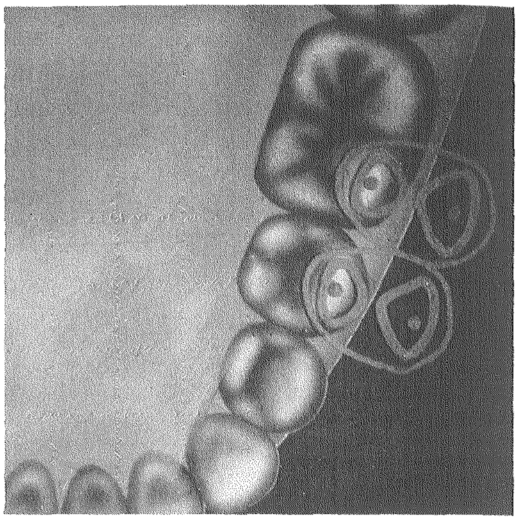


FIG. 268. The balancing relation of the bicuspids viewed through the upper teeth.

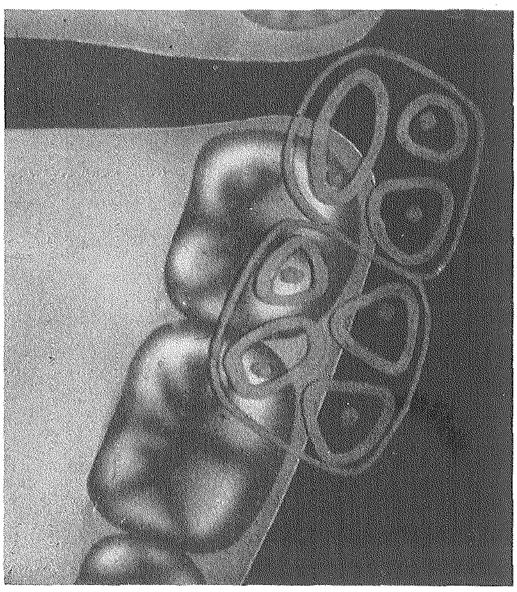


FIG. 269. The balancing relation of the molars viewed through the upper teeth.

distal inner aspect of the distobuccal cusp of the lower first molar and the mesial aspect of the distal cusp (Fig. 269) contact the sides of the mesiolingual cusp of the upper first molar as its tip glides through the sulcus between these cusps in balancing position. The mesial outer aspect of the lower buccal cusps

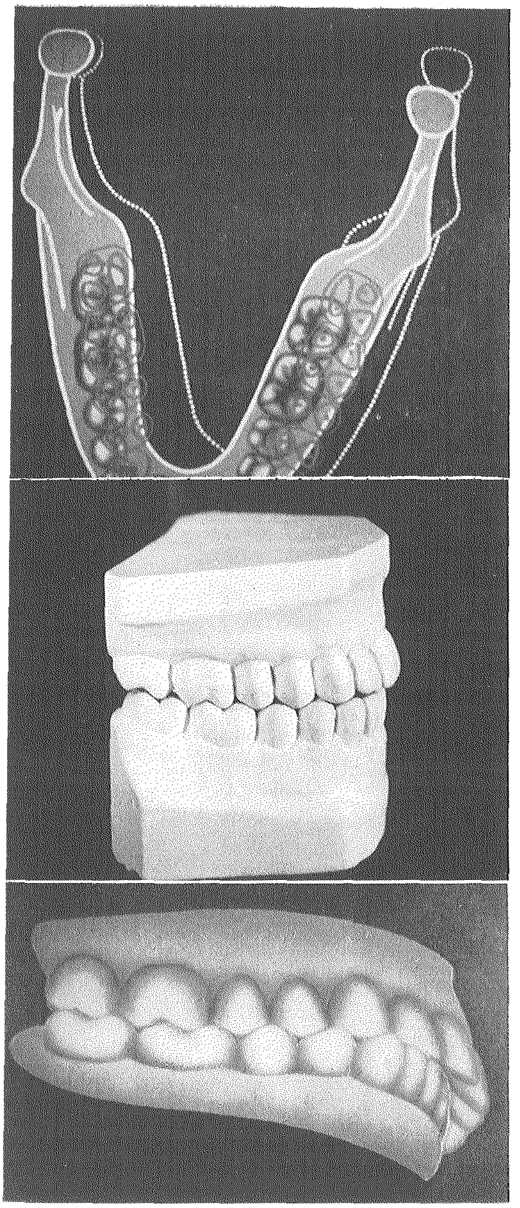


FIG. 270. The working relation.

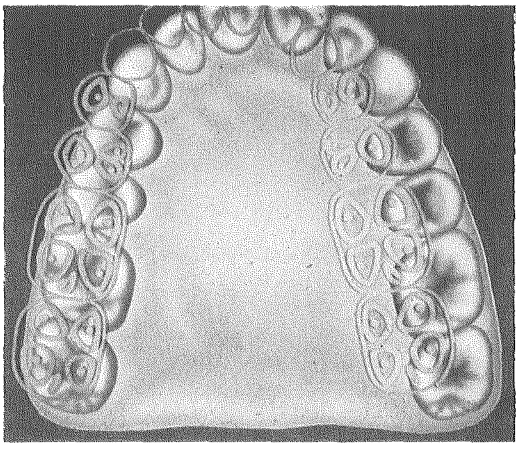


FIG. 271. The working and balancing contact viewed through the lower teeth.

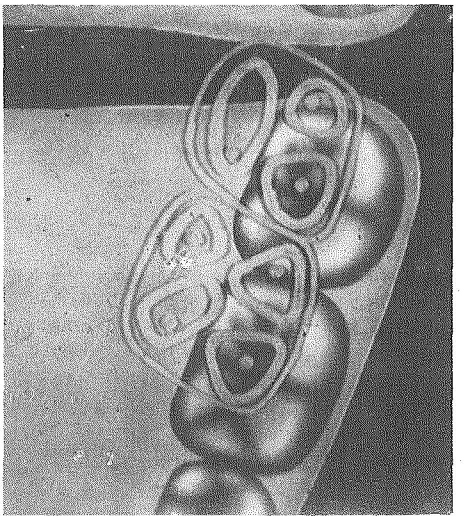


FIG. 272. The working relation of the molars viewed through the upper teeth.

and the distal inner aspect of the upper buccal cusps glide between each other (Fig. 270) as the mandible moves in lateral excursion on the working bite. The mesial inner aspect of the upper buccal cusps and the distal outer aspect of the lower buccal cusps (Fig. 271) glide over each other on the pure working bite only. The mesial inner aspect of the upper lingual cusps is formed by contact with the distal inner aspect of the lower buccal cusps as they glide around each other in the balancing path. The lower lingual cusps are formed by the path of the upper lingual cusps as they pass between them on that same working bite (Fig. 272). Last of all, the marginal ridges and the fossae of the teeth will depend upon the previously formed

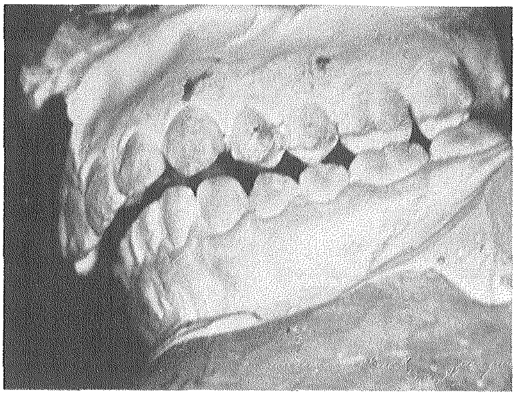


Fig. 273. Models in centric of a case that required extreme warping.

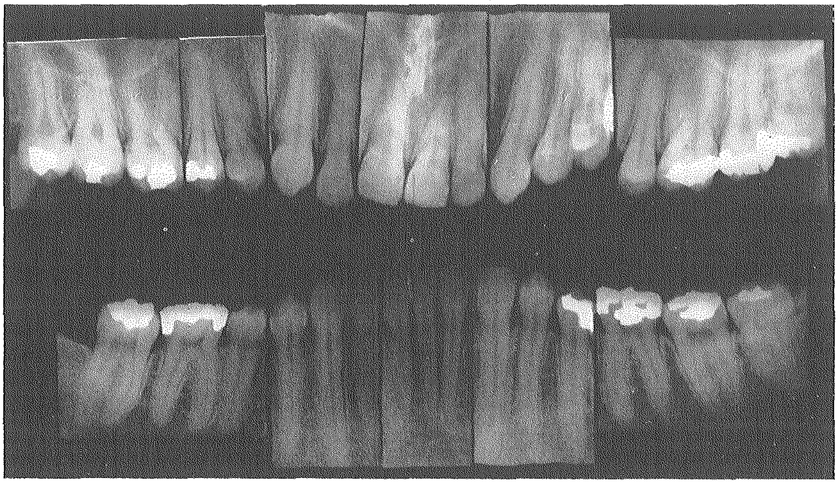


Fig. 274. Roentgenograms before treatment.

cusps. While these contact areas in centric are an important feature of a physiologically correct articulation, they cannot be established until the cusps have been formed, since they will be determined by the location of the cusps as they contact the opposing teeth in centric relation.

## WARPING CUSPS

In practice it is seldom possible to achieve this ideal relationship completely. The cusp relations relative to each other should closely approximate the ideal, but their relation to the long axis of the tooth usually will require some alteration in the placement of the cusps. This is referred to as "warping the cusps." In the majority of cases, the vertical relation of teeth opposing each other is such that the tips of the cusps will not fall in normal relation to the crowns of the teeth. Usually the warping is more in mesiodistal relation than in buccolingual position. If the teeth do not interdigitate, the upper cusps will fall more mesial or distal than normally, and the lowers, vice versa.

Mesiodistal warping does not present as much of a problem as buccolingual malrelations. Here, it is necessary to make a choice between that which is best from the standpoint of bone structure and that which best maintains the equilibrium of the entire dentition. Usually this means striking a happy medium, and becomes a matter of judgment based on mounting, roentgenograms and clinical examination.

A case that required extreme warping is shown in Figure 273. The patient was a young woman in good health and with good oral conditions. The teeth on the lower left had developed considerable mobility, yet the roentgenograms (Fig. 274) showed good bone level, and the tissue conditions were good. In this case it was decided that good function of the entire mouth was the most important consideration, so the cusps were warped buccolingually as well as mesiodistally. This was kept

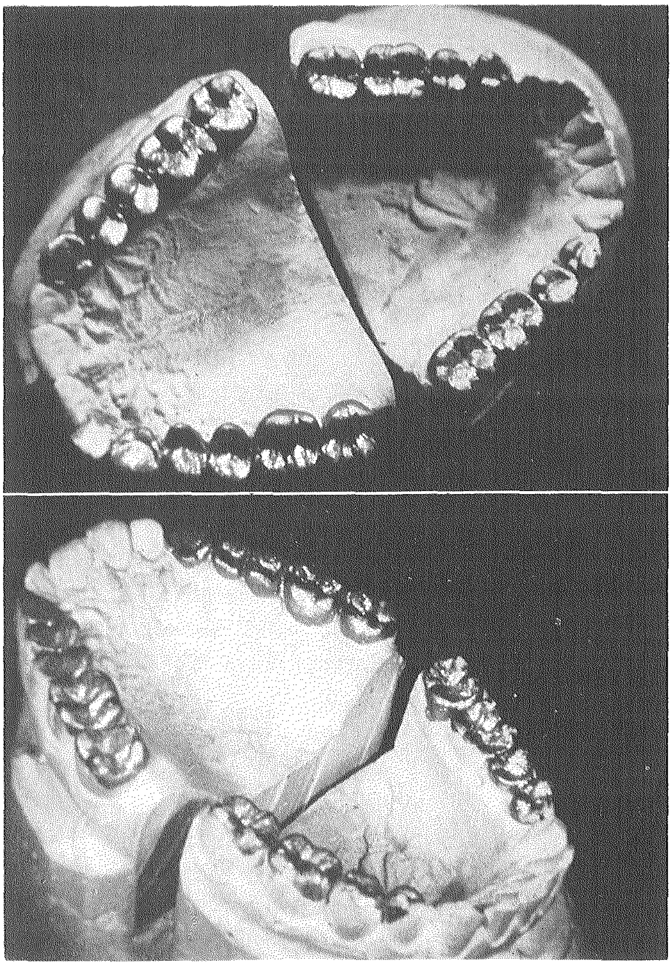


FIG. 275. Warped cusps.

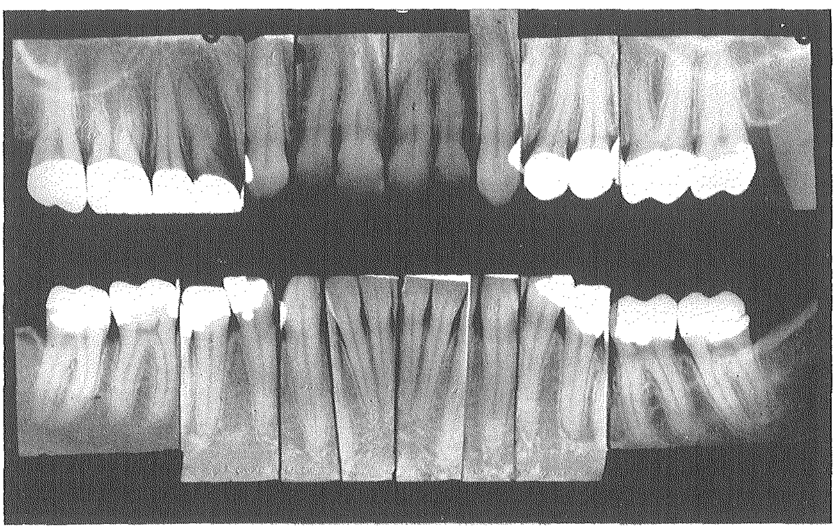


FIG. 276. Roentgenograms taken 10 years after treatment.

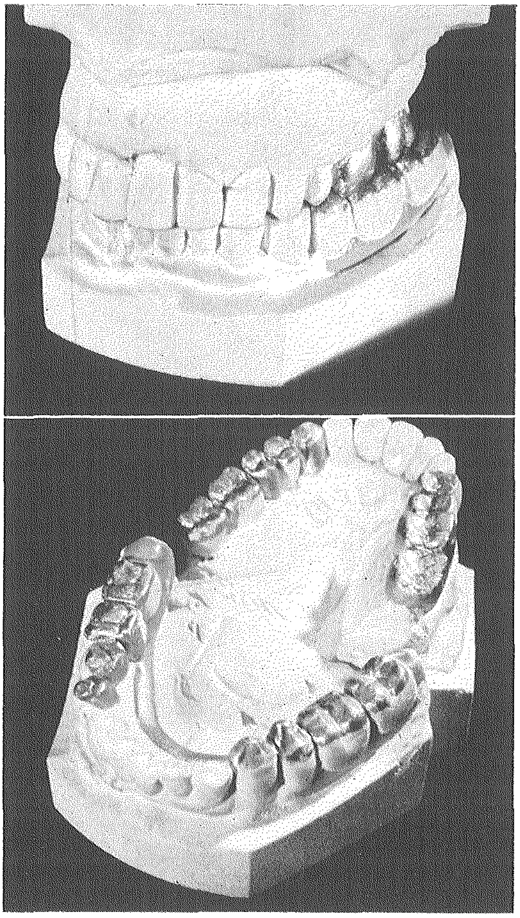


FIG. 277 (*A, top; B, bottom*). A crossed bite problem.

to a minimum by sacrificing some of the balancing range and concentrating on a good working balance. As seen in Figure 275, the lower buccal cusps are at the distobuccal limit of the crowns, and the upper lingual cusps are at the extreme mesiolingual of the upper teeth. This case was treated in 1940, before the days of acrylic veneers, and porcelain veneer crowns on such a case would hardly have been practical. Today it would be treated with veneer crowns and would present a somewhat less distorted appearance, but functionally the cusp-to-root relation actually would be the same. The roentgenograms (Fig. 274) show the bone picture in 1940. In spite of the clinical mobility, the bone level presents good conditions for regeneration. Evidence of this is seen in the roentgenograms that were taken 10 years later (Fig. 275).

## THE CROSSED BITE

The posterior crossed bite and edge-to-edge bite present an individual problem. The tooth relationships and the joint movements require each case to be developed on its own merits. Various expedients have been suggested, such as reversing the upper and the lower teeth. This does not work well except for centric occlusion.

In general, the best solution has been to form the upper teeth to resemble normal occlusals closely and to develop lowers to work with them. The paths of motion and the method of forming them against each other are the same, but the positions of the teeth in each excursion are different. As a result, the lower teeth will present a very abnormal occlusal form not resembling natural teeth. In function they will contact in the same excursions, but not in the same tooth relations.

A case that presents all these problems in one mouth is shown in Figure 277. The bicuspids are edge-to-edge, with a severe cross bite on the molars, and, in addition, the whole lower is one cusp distal on both sides. As the occlusal view shows (Fig. 277 B), as the cross bite becomes more severe, the lower buccal cusps become wider and wider buccolingually, while the lingual cusps become narrower and the central fossa moves farther toward the lingual. Contrary to what might seem good theoretically, the upper lingual cusps fall more to the lingual on the teeth, in order to avoid an edge-to-edge bite and permit them to contact in excursion. This results in a lingual overjet of the upper teeth. In Figure 277 A (centric occlusion), the lower buccal surfaces are curved toward the lingual as far as possible to minimize the buccal overjet and the buccolingual width of the lower

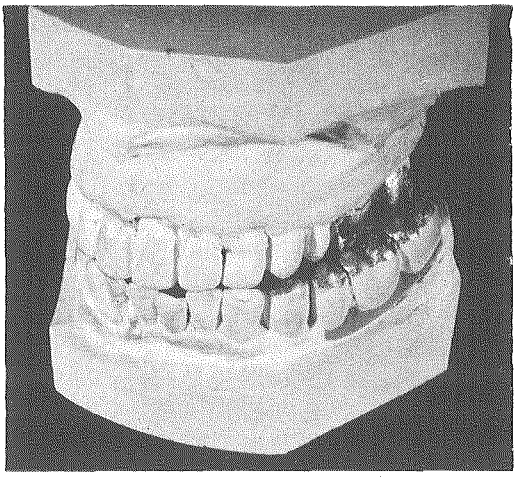


FIG. 278. The protrusive bite.

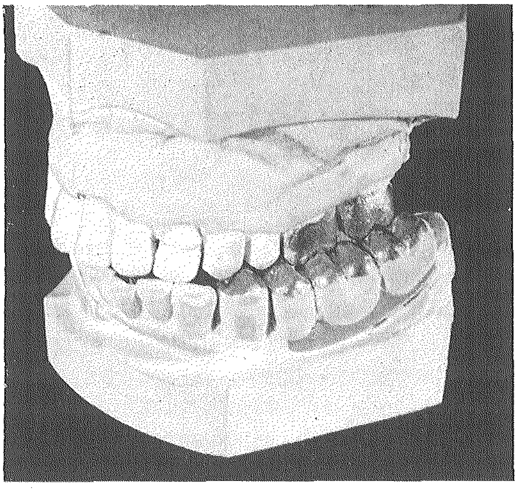


FIG. 279. The working bite.

buccal cusps outside the upper, since they cannot meet in functional contact.

The buccolingual width of these buccal cusps will be determined by the protrusive position (Fig. 278), with the tips of the upper buccal cusps in contact with the crest of the lower buccal cusps. This is an exact reversal of the normal relation. In working relation (Fig. 279), the cusps pass each other, but only the buccal cusps are in contact as the upper lingual cusps move inside the lowers. In balancing relation (Fig. 280), the upper lingual cusps glide up on the lingual inner slope of the lower buccal cusps.

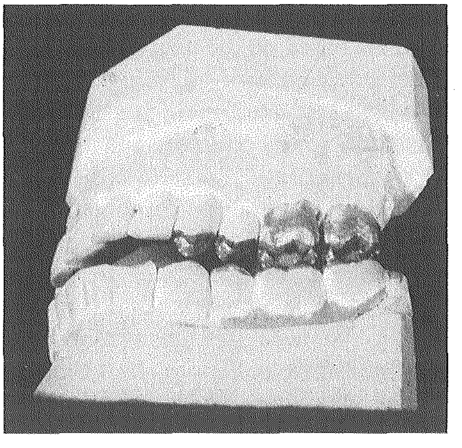


FIG. 280. The balancing bite.

The difference between an edge-to-edge and a full crossed bite is essentially a matter of degree. As the teeth come closer to edge relations, the lower buccal cusps narrow, the central fossa comes closer to the long axis, and the lingual cusps become wider. The mesiodistal widths vary only slightly from the normal.

*Chapter* 17

# Relating Occlusal Surfaces

This chapter is intended as a guide to learning how wax is handled to develop a functional articulation of cusps on the posterior teeth. Whether or not these cusps, properly developed by this or any other system, will function in the patient's mouth the same way as they do on the articulator is dependent upon the degree of accuracy with which the articulator used will reproduce the changing relationships of the patient's mandible and maxillae during functional excursions. This statement is based on the assumption that the technical procedures of adjusting the articulator, taking bites and mounting the models are based on sound concepts and have been properly carried out.

There is no way to predetermine the cusps that will be produced by the conditions present in a given case. This can be learned only by actually forming the cusps and then bringing about the necessary change in one or more of the factors (Chap. 19) which are under the operator's control, in order to produce the desired result. While the same end-result is required whether we are dealing with wax carving or porcelain teeth, the methods by which we arrive at it are somewhat different. In wax carving it is possible to follow the building of the cusps in a more logical sequence, as they form each other. It is imperative that the student master the carving of a full set of articulating teeth in wax, in order to understand the complete dynamic picture, before attempting to articulate porcelain teeth. By the addition and the removal of wax, it can be seen readily how the cusps do form each other, and how changes in one necessitate changes in the others. Before we consider how changes in various factors bring about changes in the cusps, let us consider the actual forming of the cusps, step by step, in a theoretically ideal case.

It will be quite apparent that the experienced operator can form more than one part of each cusp at a time, but for the neophyte it is better to learn how to form each aspect of each cusp as a separate operation.

As a preliminary step, the cavity preparations on the mounted models are filled with carving wax to form a solid block to which wax can be added as the cusp development progresses. This preliminary waxing should not encroach upon the space that will be occupied by the cusps.

The system outlined here is presented primarily to show the orderly relation of the interdependence of cusps and how one cusp can form another through proper wax manipulation. The actual order in which the formation of these cusps is extended is detailed in the drawings in Chapter 18. It starts with the location of the positions of the tips of the buccal cusps of the upper and the lower posterior teeth. After these cusp tips are properly positioned they are used to form areas of other cusps and to locate other cusp tips. These newly formed areas or cusp tips, in turn, are used to form more areas, and so on, until all the cusps have been formed. It should be apparent that this kind of system requires that the first step, namely, locating the tips of the posterior buccal cusps, be executed with great care and precision, as the positions of these tips control the development of the rest of the cusps. Any errors in this first step will result in abnormally shaped and improperly functioning cusps.

## DETERMINING CUSP HEIGHT

The first step is to form the tips of the buccal cusps, tip-to-tip, in lateral protrusive.

A small cone of wax—the point of which will represent the tip of a lower buccal cusp—is formed on each lower tooth of such a height that in lateral protrusive position it will allow for a cusp of equal height on the opposing tooth, i.e., it is half the height of the space available in lateral protrusive. When this wax is thoroughly hardened, a drop of wax is placed to form the tip of the upper cuspid, the lower wax is lubricated, and the articulator is closed in lateral protrusive relation, so that the hardened wax representing the tip of the lower first bicuspid will form the tip of the upper cuspid in the soft wax. In like fashion, a drop of wax is placed on the buccal of the upper first bicuspid, the opposing second bicuspid is lubricated, the articulator is closed in lateral protrusive relation, and the hardened wax on the lower is allowed to form the tip of the upper in the soft wax. When the upper wax has hardened, the articulator is opened and the excess wax which was forced out of the upper is carved away. Before closing in centric, it must be ascertained that there is sufficient room in the opposing wax that the tips so formed will not be destroyed by closing. If such is not the case, the wax should be softened where it opposes the tip, and the articulator closed in centric to allow enough room that the tips will not be lost by subsequent manipulation. The tips of all the buccal cusps are formed in the same manner. In each subsequent step, every time that wax is added and the instrument is closed to form the wax, after the wax has made contact the articulation is carried through all its excursions to force out the excess wax so that it will not interfere later in another excursion. Also, a careful check must be made each time to be sure that excess wax does not build up in centric. A check also should be made to be sure that the condyles are seated and the anterior guide pin is in contact with the plate. The next step is forming the crests of the upper buccal cusps in straight protrusive. As we have already seen, the tips of the lower buccal cusps will determine these. Since the lower buccal cusps are now fixed by the contacts in lateral protrusive, the upper buccal cusps in protrusive must conform to them. The operator places a drop of wax on the lingual of the upper cuspid above the tip, lubricates the lower, and closes in straight protrusive. This is held until the wax is hard, and then tested in centric closure to be sure that there is enough room for the added wax. In the same manner, wax is added to form the crest of the buccal cusp of the upper first bicuspid, and the articulator is closed in protrusive so that the tip of the lower second bicuspid forms the arc of the parabolic curve of the upper cusp between lateral protrusive and protrusive. This is tested again in centric, and all the upper buccal cusps are formed in a like manner.

The mesiodistal slope of the distal half of the upper buccal cusps is formed by the tips of the lower buccal cusps as they glide over the uppers from centric to protrusive and lateral protrusive. The operator adds wax to the distal slope of the upper first bicuspid buccal cusp, closes in centric, and carries the articulator through the excursions from centric to protrusive and lateral protrusive. Each of the upper buccal cusps is formed in the same manner. It will be apparent that the experienced worker can perform this and the preceding step in one operation.

The distal half of the upper buccal cusps, of course, will determine the mesial slope of the lower buccal cusps. After the uppers have been established so that they remain in contact through all the protrusive ranges, the lowers are formed against them by adding wax and again moving the articulator into protrusive and lateral protrusive.

## INTERMEDIATE SURFACES

The preceding operations will form the tips and half of the mesiodistal slope of the buccal cusps. They will not form the buccolingual curve of the cusps. To form this, it is necessary first to build the tips of the upper lingual cusps in the balancing position, when the other side is in extreme lateral excursion. The operator builds a cone of soft wax to form the tip of the lingual cusp of the upper first bicuspid, lubricates the lower, and closes in the balancing position, so that the tip of the buccal cusp of the lower second bicuspid will form the tip of the lingual cusp of the upper first bicuspid. The articulator is opened without being allowed to move into centric. The lower is softened where the newly formed cusp will make contact in centric, and the mesial inner aspect of the buccal cusp of the lower second bicuspid. A drop of wax is added so that there will be sufficient to contact the upper lingual cusp through its whole range. The articulator is closed in centric and moved into the balancing position, so that the tip of the upper lingual cusp will form the buccolingual curve of the inner mesial half of the lower buccal cusp. While the wax is still soft, the articulator is moved into working bite, protrusive and lateral protrusive in order to wipe away the excess wax which was squeezed out by the balancing movement, and which, when hardened, might interfere with the other movements. The articulator is opened and this excess is carved away from the lower. The tip of the lingual cusp of the upper second bicuspid and the mesiobuccal cusp of the lower first molar are formed with each other in the same manner. To complete the two upper lingual cusps on their inner aspect, wax is added to this portion of the cusps, the lower is lubricated, and the articulator is closed in centric and carried through all its excursions. The operator must make sure that no wax has accumulated on the lingual occlusal of the lowers to destroy the upper lingual cusps when the models are moved into the working bite.

The mesiolingual cusps of the upper molars present a slightly different problem. In straight protrusive the lingual cusp contacts the distal or 5th cusp of the lower molar. But, in the balancing position, the same upper lingual cusp moves through the sulcus between the distobuccal and the distal cusps. Thus, the upper lingual cusp and the lower distal cusp must be formed with each other in step, that is, one cannot be used to form the other in the same fashion as the bicuspids are used. The tip of the upper mesiolingual cusp, when viewed at right angles to the buccal aspect of the tooth, will be seen to fall approximately between the tips of the buccal cusps, varying somewhat with the mandibular movements in an individual case. Wax is added to the upper molar in the position of the mesiolingual cusp, and the articulator is closed in centric and moved to the balancing position. The excess wax which was forced out on the lingual side of the cusp is separated and trimmed away, as it would prevent the formation of the lower distal cusp and the sulcus in the balancing position. Now the operator adds wax to the lower molar in the position of the distal cusp, closes in centric, and moves into straight protrusive. While the wax is still soft, the operator returns to centric and then moves into the balancing position. If the upper lingual cusp wipes away the soft wax of the lower distal cusp in the balancing position, some of the lingual side of the upper cusp is carved away, and the operation is repeated.

The distolingual cusp of the upper molar is formed with the mesiobuccal cusp of the lower second molar in the same fashion as the lingual cusp of the upper second bicuspid was with the lower first molar. Both lingual cusps of the upper second molar are produced in a like manner; the distolingual is usually rudimentary or entirely missing.

The distal inner aspect of the upper buccal cusps is formed now by adding soft wax, closing in centric, and moving into all the working positions, so that the mesial slope of the upper remains in contact through this range. After the excess has been carved away from the upper, the outer mesiobuccal aspect of the lower is formed by adding wax and repeating the last excursion.

It now remains to complete the mesial inner aspect of the upper buccal cusps and the corresponding distal outer aspect of the lower buccal cusps. The mesiodistal width of each of these is generally somewhat less than half the cusp. The operator adds wax and carves the distal slant of the lower buccal cusp to meet the base of the next distal cusp. The outer aspect is not built yet. Wax is added to the upper, and the models are moved from centric to the working bite. They are chilled and the excess wax is trimmed away. Now wax is added to the lower outer aspect, and the articulator is closed in centric and moved again into the working position. Now the operator adds soft wax to the mesial inner aspect of the upper lingual cusp and carries it through all the ranges.

Finally, the operator adds wax to make the lower lingual cusps, closes in centric, and moves into the working position. The lower lingual cusps are formed by the outer aspect of the upper lingual cusps, as the mandible moves into the working position in lateral excursion, and make very light point contacts. The operator then tests for interference in protrusive and lateral protrusive.

After the cusps have been formed to articulate in all positions, it is possible to complete the opposing fossae and sulci where they make contact with opposing cusps in centric. It is best to do this one cusp at a time. The wax of the cusps must be well chilled and lubricated. The operator adds wax to the opposing surface, closes in centric, and then carries through all excursions to wipe away the excess which will be forced out. If some high spots develop during the final filling process, and it is not readily apparent where wax should be taken off, talcum powder is dusted over the teeth with a large camel's-hair brush. The operator closes in centric and carries through all excursions. The talc will be rubbed off where the wax makes contact. Before deciding where to remove wax, the operator should test in all positions. When the correct spot has been located, the operator softens that area, closes in centric, and again moves the articulator in all positions.

The teeth now have to be carved so that at all times they will make point contacts, gliding on each other, and not flat planes. These will be constantly changing points, so that, through a given excursion, the line described will appear as a changing curve. In any given position, the contact would be represented by two concentric curves. The fossae, the sulci and the marginal ridges are carved so that they make definite positive contact, but the cusps are not locked into them. They appear to be folded in upon themselves. The opposing tip does not fit down into the depth of the recess, but has a rounded top which makes contact with the side of the fossa. The cusps, as they meet in a tooth to form a sulcus, and as they meet opposing each other, appear as would a series of ball bearings in contact with each other, except, of course, that they are not perfect spheres. In carving the teeth to produce such an effect, it is necessary to test them constantly in their working relations to be sure that no necessary contacting surface is lost in the process.

## COMPLETE DENTURES

The mouth functions in the same manner with or without teeth. Properly formed cusps do not compel the mouth to function in any prescribed manner. They merely follow the jaw movements. Thus, the articulation of artificial teeth must be exactly the same as that of natural teeth in order to maintain stability of the denture bases. But, since we cannot add and carve porcelain readily, as we can wax, the method of setting the teeth is somewhat different. Because the whole articulation of each tooth must be developed as it is set when porcelain is used, the operator requires a complete understanding, which can be gained only by the wax carving. Porcelain teeth cannot be developed a cusp at a time.

At present, there are no teeth being manufactured commercially which will articulate. A considerable amount of carving is necessary to produce the required form.

In order to assure a sufficient bulk of material to work with, it is wise to start with large size teeth with deep sulci. It is easier to carve the porcelain from the sulci out than to carve down into the sulci to produce cusps, although it usually will be necessary to do some carving in the sulci. In most manufactured sets of teeth, the bicuspids are too narrow buccolingually, and it will help to mix sets when possible, taking bicuspids from a larger set.

Before attempting to produce the required articulation, it is absolutely essential that the bases be mounted in accurate relation on the articulator. To determine this, the teeth are first set up to a simple centric closure. They are tried in the mouth to test for stable position and, at the same time, to check on the esthetic effect. The correct form, shade, size and position of the teeth all should be established before the operator starts to grind and carve the posterior teeth. If the centric closure is not correct, the upper base will "skid" slightly as the mouth is closed in centric. This must be eliminated completely before the teeth can be articulated.

Most of the carving of the porcelain teeth will have to be done with small knife-edge stones in the handpiece, because it is usually necessary to make many small changes on the inner aspect of the occlusal surfaces. The stones are kept well lubricated and, before the set-up for processing is finally completed, the ground surfaces are polished with rubber wheels, knife-edge hard felt wheels and a suitable abrasive.

After the correct setting of the anteriors and accurate centric have been established, the lower posterior teeth are removed from the base and then are set back one at a time as the correct articulation is established for each before another one is set. Of course, as articulation develops, it will be necessary to shape and tip both the tooth being set and the opponent that is already in place. But, if one jaw is set up, it helps as a guide to maintain the curve of Spee and the plane of occlusion. Generally it is preferable to start the setting of the teeth with the first molar. Let us assume that the upper teeth have been set to what appears to be the correct esthetics and plane of occlusion, with the curve of Spee established with a BOG plate. There appears to be no advantage in the use of a semaphore and dividers to form the curve of Spee.

As with wax carving, first the cusps are established in correct tip-to-tip relation, with the curve of the cusps and centric following in order. But in this instance all the cusps on each tooth have to develop more or less simultaneously and completely before the next tooth is set, that is, each tooth is completely carved and articulated with its opponents as it is set, and it is adjusted to all excursions before the next tooth is set. For example, we could not establish all the buccal cusps in correct relation and then proceed to make the lingual cusps work with them. Perhaps it would be more accurate to say that, while it could be done in that fashion, it would waste a considerable amount of time and would require unnecessary work in carving the final arrangement.

In order to set the tooth in its correct vertical relation, it is set first in centric, even though we know that in most cases it will have to be changed. Then the cusps are tested for height, in each of the extreme excursions, by opening the articulator and then closing successively in each one of the extreme positions. The closed instrument must not be moved from centric to each of the excursions. Usually one or more cusps will be too short, and it is necessary to reduce the other cusps sufficiently to establish the correct relative heights. Then it will be necessary to raise the tooth in the wax to bring the tips of the cusps up to contact. But now, of course, it will be high in centric, so the operator must be careful that the articulator does not close in centric and force the tooth back into the wax.

When the cusps have been established in their correct tip relations, the tooth is waxed securely in place with a hard-setting wax. Then, keeping the tooth well lubricated with cold water to prevent the heat of grinding from softening the wax, the cusps are carved as they travel over the tips from the extreme positions to centric. For this purpose, a rather hard, thin, articulating paper which will not mark too easily will work best. A paper that is too thick and soft will leave marks in spots where the teeth do not actually make positive contact, and the carving will not be satisfactory. A dry, hard paper will show only the points of actual contact. The operator should not try to carve too much at one time, that is, he should not try to carve the full distance of any given excursion of the tip over a cusp with only one mark of the paper for guidance. For example, suppose that we are trying to carve that portion of the lingual cusp of the upper first bicuspid and of the buccal cusp of the lower second bicuspid as they travel over each other from the balancing position to centric. We have already established the correct tip relations in the extreme position. The articulator is started back toward centric. If the cusps interfere and lift the anterior guide pin out of contact with the plate, the jackscrew should be adjusted in the condyle path of that side to hold the articulator at that position. Now the operator opens the articulator, places a piece of articulating paper between the teeth, and lightly taps the teeth together in that position. With a small stone, the porcelain is ground wherever the tips have made contact with the opposing surfaces. Of course the tips of the cusps should not be touched. This process is repeated until the articulator will close in that position. Then the jackscrews are unscrewed lightly, and the same thing is done on the next part of the cusps. The operator continues all along the length of the cusp in the same manner until the articulator finally closes in centric. Of course, if the cusps are short and fail to make contact at any point, it is apparent that the rest of the cusps will have to be reduced and the tooth will have to be raised to bring it up to contact. Each of the other cusps is done in the same manner in its various excursions. If properly carved, the cusps on the instrument should glide upon each other just as though two flat surfaces were being slid together in the operator's hand. There should not be any feeling of having to push the cusps over each other or of having to guide the instrument. The cusps merely remain in contact as they follow the movements of the articulator.

When the finished setup is removed from the articulator and put together in centric, it should have a definite seat. The two sets should not go together with a sloppy fit so that they slide around. Nor should they be locked together. They should go together in every position with a firm, definite seat, with no lateral play or slide. Otherwise, when they come together in the mouth the base will skid. The same is true for natural teeth when the case is finally adjusted.

Adjusting any case, whether gold restorations or porcelain teeth are involved, is handled in very much the same manner as carving porcelain teeth. First the cusps are tested in their tip relations at the extreme of each excursion. If a point is found at which the tip of the cusp is too high, the cusp must be tested in every position to determine which tip to reduce. When the cusps have been adjusted properly to their tip relations, the rest of the cusps are carved to work with them in the same manner that the porcelain teeth were formed. As before, the last step is adjusting centric.

The foregoing is by no means a complete description of all the aspects of correct articulation. It is presented primarily to establish a step routine for the purpose of being able to visualize how cusps relate to each other and being able to judge what is wrong with an articulation which is incorrect in some respects. It must be supplemented by a more complete study of tooth form and function and their relation to mouth function.

*Chapter* 18

# Developing Functional Occlusion

The procedure outlined in Chapter 17 is intended to convey the method of relating cusps with wax to produce a harmonious relationship. However, if each step is taken in its proper order, errors in cusp placement can be avoided. The most difficult of the initial steps is spacing the cusps correctly so that, in the various excursions, each cusp will travel around or between its fellows to produce a passive contacting relation rather than an active guiding surface and possible lateral stresses.

The following step procedure has been developed especially to help the beginner to avoid common errors. The steps are the same in the drawings, but they are not in the same order. The red area indicates the placement and the amount of wax for that step. On each subsequent drawing of that cusp, the part that has been formed in the previous step is filled in in black—the black outline indicates the areas that have been formed in the previous steps.

The development of the form and the position of all the posterior cusps has been completed. It is necessary now to refine the shapes of the cusps and carve in the anatomic features such as the fossae, the sulci and the supplemental grooves. This process is essentially one of carving down into the sulci and the fossae areas with the point of a small, sharp carver. Care must be exercised while this is being done to make sure that none of the areas of the cusps and the marginal ridges is carved away that must make contacts with the opposing cusps during the various functional excursions and in centric occlusion.

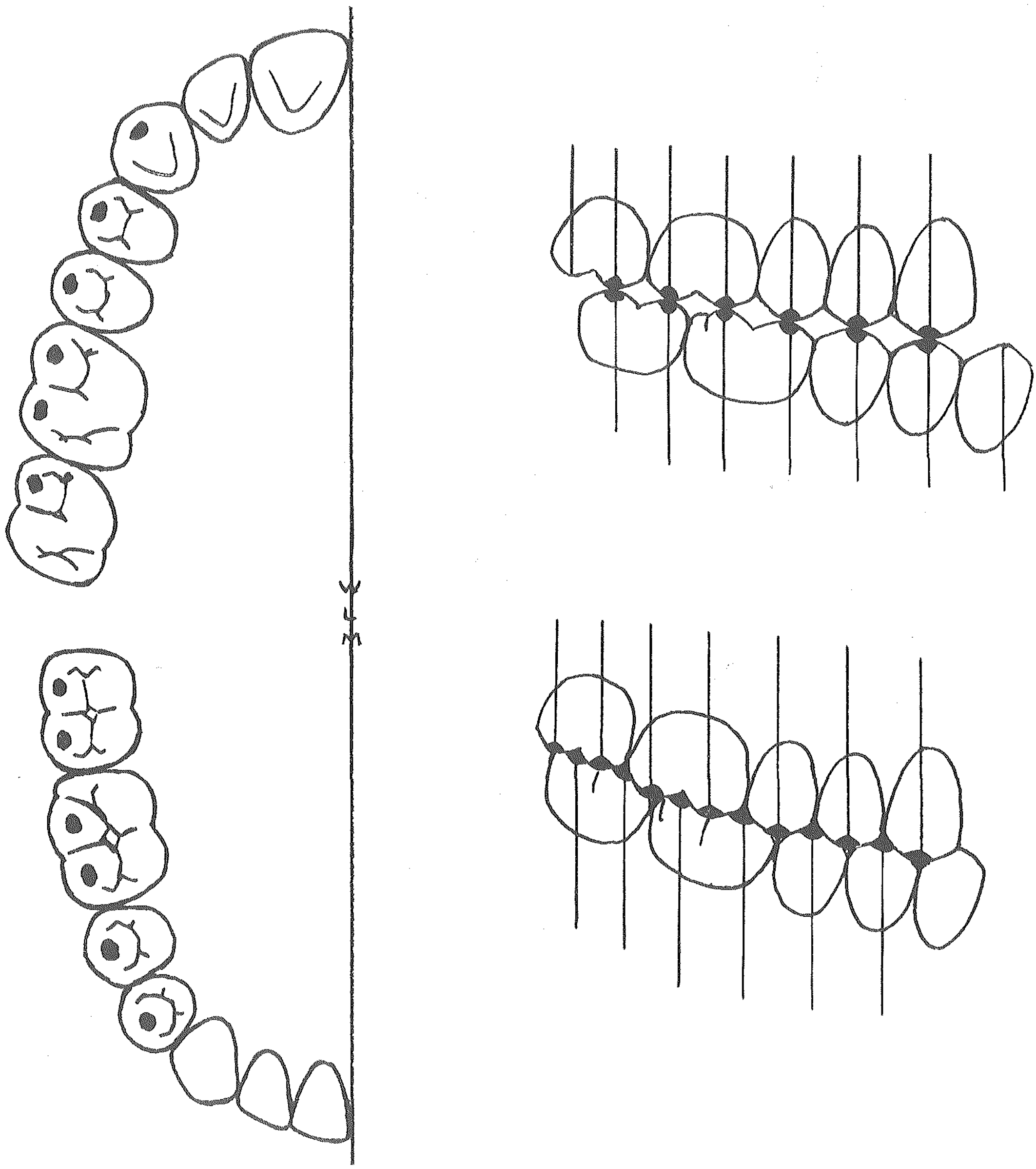


Fig. 281. The positions of the tips of the buccal cusps of the upper and the lower bicuspids and molars and the upper cuspid are established, with the following points being kept in mind:

1. In the lateral-protrusive relation, the upper posterior buccal cusp tips are directly over the lower posterior buccal cusp (*top, right*).

2. Cusp tips that are tip-to-tip in the lateral-protrusive relation must pass between each other in the working excursions (*bottom, right*).

3. The mesiodistal cusp width decreases posteriorly.

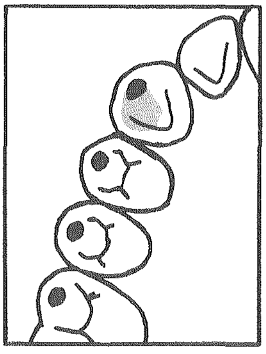


FIG. 282. The distal inner incline of the upper cuspid is formed by the tip of the buccal cusp of the lower first bicuspid. Protrusive to centric, lateral-protrusive to centric and working to centric excursions are used.

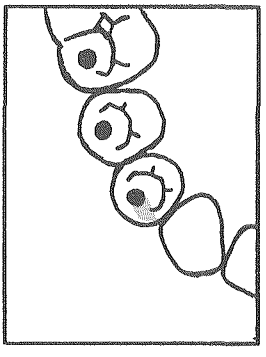


FIG. 283. The mesial incline of the buccal cusp of the lower first bicuspid is formed by the distal incline of the upper cuspid. Protrusive to centric excursion.

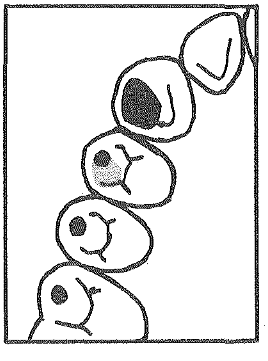


FIG. 284. The distal inner incline of the buccal cusp of the upper first bicuspid is formed by the tip of the buccal cusp of the lower second bicuspid. Protrusive to centric, lateral-protrusive to centric and working to centric excursions.

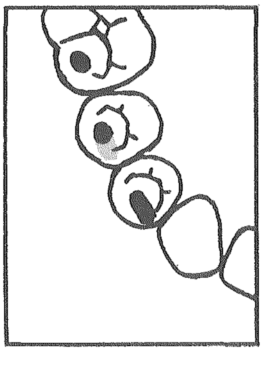


FIG. 285. The mesial incline of the buccal cusp of the lower second bicuspid is formed by the inner distal incline of the buccal cusp of the upper first bicuspid. Protrusive to centric excursion.

FIG. 286. The tip of the lingual cusp of the upper first bicuspid is located against the mesial aspect of the tip of the buccal cusp of the lower second bicuspid in the balancing relationship.

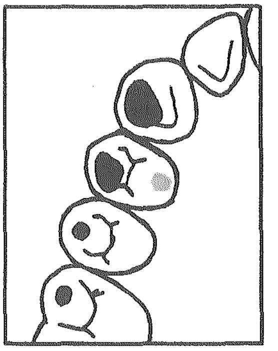


FIG. 287. The mesial inner incline of the buccal cusp of the lower second bicuspid is formed by the tip of the lingual cusp of the upper first bicuspid. Balance to centric excursion.

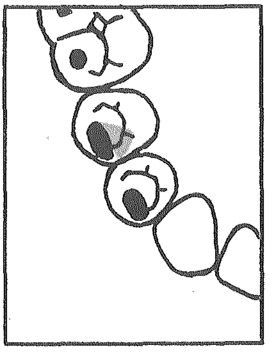


FIG. 288. The distal inner incline of the lingual cusp of the upper first bicuspid is formed by the inner mesial incline of the buccal cusp of the lower second bicuspid. Balance to centric excursion.

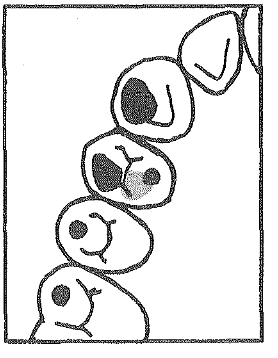
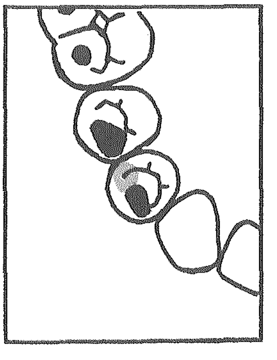


FIG. 289. Wax is added and carved to shape the distal slope of the buccal cusp of the lower first bicuspid. This slope is shaped to meet the bottom of the mesial incline of the buccal cusp of the lower second bicuspid.



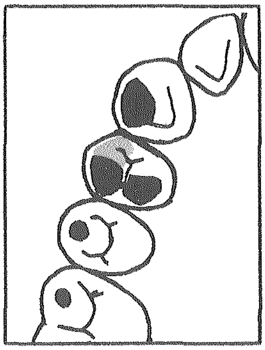


FIG. 290. The mesial inner incline of the buccal cusp of the upper first bicuspid is formed by the distal slope of the buccal cusp of the lower first bicuspid. Working to centric excursion.

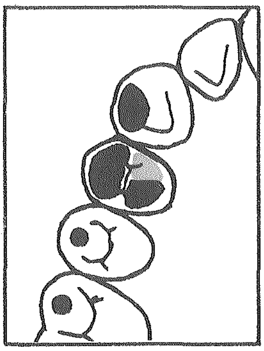


FIG. 291. Wax is added and carved to shape the inner mesial incline of the lingual cusp of the upper first bicuspid.

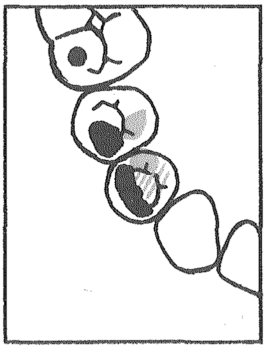


FIG. 292. The distal inner incline of the lingual cusp of the lower first bicuspid is formed by the lingual cusp of the upper first bicuspid. Working to centric excursion.

The mesial inner incline of the lingual cusp of the lower second bicuspid *also* is formed by the lingual cusp of the upper first bicuspid. Working to centric, lateral-protrusive to centric and protrusive to centric excursions.

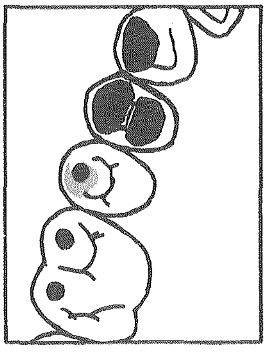


FIG. 293. The inner distal incline of the buccal cusp of the upper second bicuspid is formed by the tip of the mesial-buccal cusp of the lower first molar. Protrusive to centric, lateral-protrusive to centric and working to centric excursions.

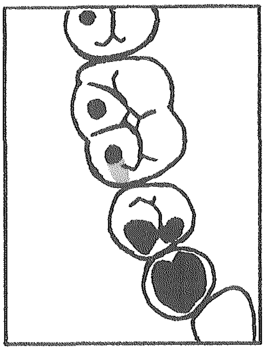


FIG. 294. The mesial incline of the mesial-buccal cusp of the lower first molar is formed by the inner distal incline of the buccal cusp of the upper second bicuspid. Protrusive to centric excursion.

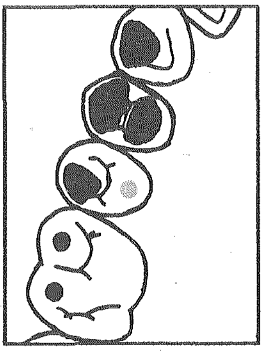


FIG. 295. The tip of the lingual cusp of the upper second bicuspid is located against the mesial aspect of the tip of the mesial-buccal cusp of the lower first molar in the balancing relationship.

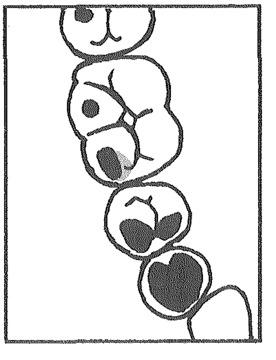


FIG. 296. The mesial inner incline of the mesial-buccal cusp of the lower first molar is formed by the tip of the lingual cusp of the upper second bicuspid. Balancing to centric excursion.

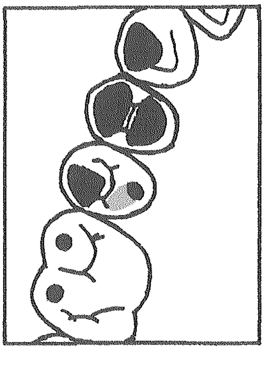


FIG. 297. The distal inner incline of the lingual cusp of the upper second bicuspid is formed by the inner mesial incline of the mesial-buccal cusp of the lower first molar. Balancing to centric excursion.

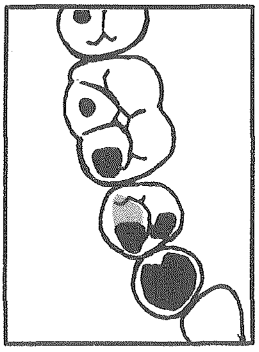


FIG. 298. Wax is added and carved to shape the distal slope of the buccal cusp of the lower second bicuspid. This slope is shaped to the bottom of the mesial incline of the mesial-buccal cusp of the lower first molar.

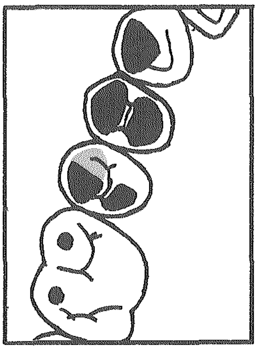


FIG. 299. The mesial inner incline of the buccal cusp of the upper second bicuspid is formed by the distal slope of the buccal cusp of the lower second bicuspid. Working to centric excursion.

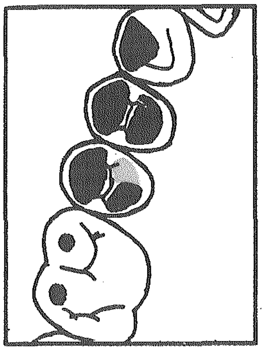


FIG. 300. Wax is added and carved to shape the inner mesial incline of the lingual cusp of the upper second bicuspid.

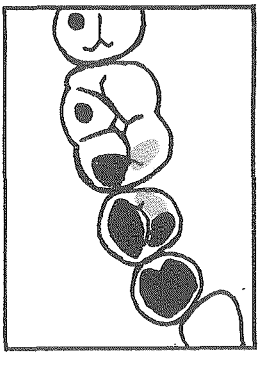
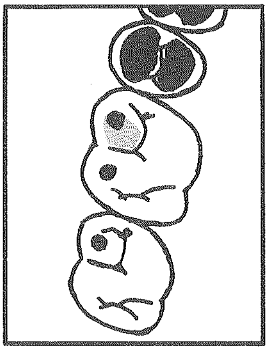


FIG. 301. The distal inner incline of the lingual cusp of the lower second bicuspid is formed by the lingual cusp of the upper second bicuspid. Working to centric excursion.

The mesial inner incline of the mesial-lingual cusp of the lower first molar *also* is formed by the lingual cusp of the upper second bicuspid. Working to centric, lateral-protrusive to centric and protrusive to centric excursions.

FIG. 302. The inner distal incline of the mesial-buccal cusp of the upper first molar is formed by the tip of the distal-buccal cusp of the lower first molar. Protrusive to centric, lateral-protrusive to centric and working to centric excursions.



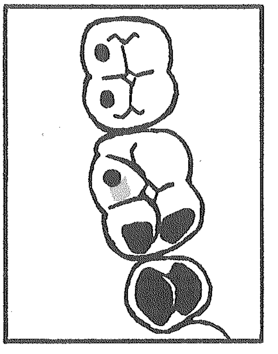


FIG. 303. The mesial incline of the distal-buccal cusp of the lower first molar is formed by the inner distal incline of the mesial-buccal cusp of the upper first molar. Protrusive to centric excursion.

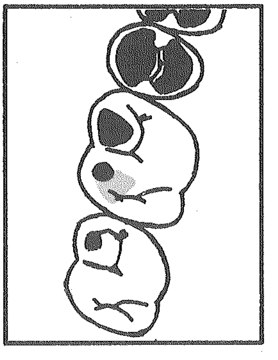


FIG. 304. The distal inner incline of the distal-buccal cusp of the upper first molar is formed by the tip of the mesial-buccal cusp of the lower second molar. Protrusive to centric, lateral-protrusive to centric and working to centric excursions.

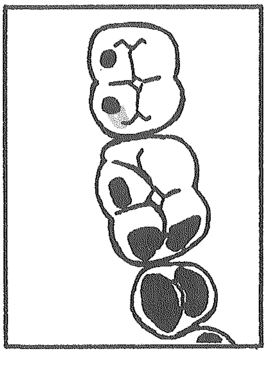


FIG. 305. The mesial incline of the mesial-buccal cusp of the lower second molar is formed by the distal inner incline of the distal-buccal cusp of the upper first molar. Protrusive to centric excursion.

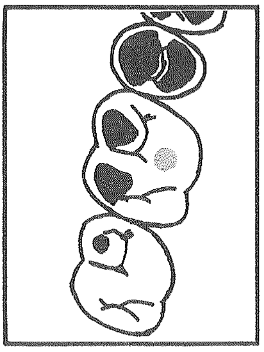


FIG. 306. The tip of the mesial-lingual cusp of the upper first molar is formed in its proper relationship to the buccal cusps. In the balancing relationship, this tip will be at the distal inner aspect of the distal-buccal cusp of the lower first molar and will form the sulcus between the distal-buccal and the distal cusps of the lower first molar.

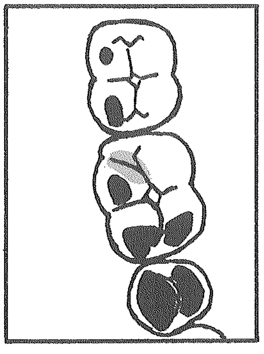


FIG. 307. The sulcus between the distal-buccal and the distal cusps of the lower first molar is formed with the tip of the mesial-lingual cusp of the upper first molar. Balancing to centric excursion.

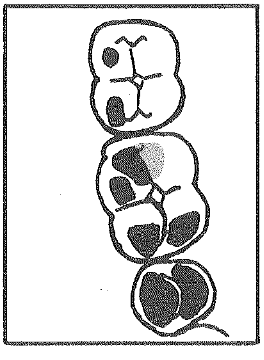


FIG. 308. The crest and the mesial slope of the distal cusp of the lower first molar are formed with the tip of the mesial-lingual cusp of the upper first molar. Protrusive to centric excursion.

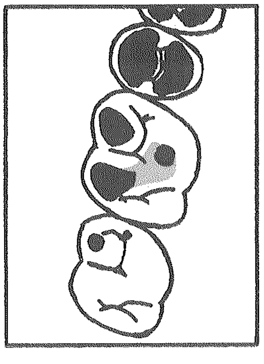


FIG. 309. The transverse ridge and the distal slope of the mesial-lingual cusp of the upper first molar are formed by the mesial slope of the distal cusp of the lower first molar and the sulcus between the distal cusp and the distal-buccal cusp of the lower first molar. Protrusive to centric and balancing to centric excursions.

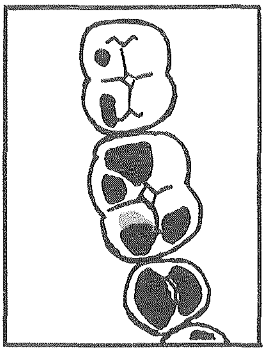


FIG. 310. Wax is added and the distal slope of the mesial-buccal cusp of the lower first molar is carved down to the mesial incline of the distal-buccal cusp.

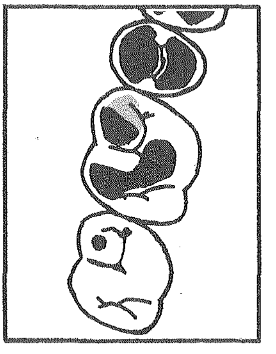


FIG. 311. The mesial incline of the mesial-buccal cusp of the upper first molar is formed by the distal slope of the mesial-buccal cusp of the lower first molar. Working to centric excursion.

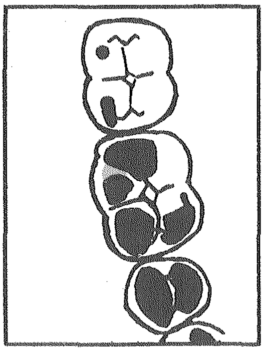


FIG. 312. Wax is added and the distal slope of the distal-buccal cusp of the lower first molar is carved.

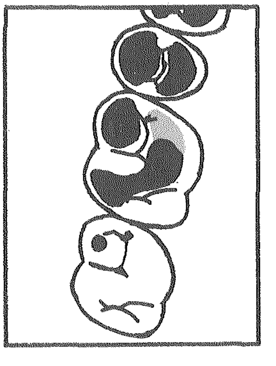


FIG. 313. Wax is added and the mesial slope of the mesial-lingual cusp of the upper first molar is carved.

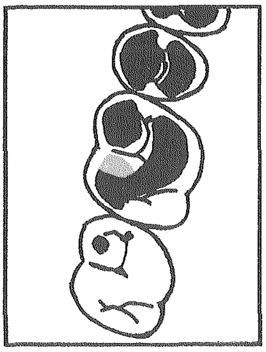


FIG. 314. The mesial incline of the distal-buccal cusp of the upper first molar is formed by the distal slope of the distal-buccal cusp of the lower first molar. Working to centric excursion.

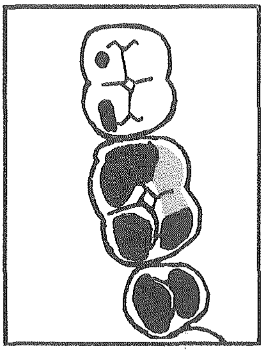


FIG. 315. The distal inner incline of the mesial-lingual cusp of the lower first molar is formed by the mesial-lingual cusp of the upper first molar. Working to centric excursion.

The mesial inner slope of the distal-lingual cusp of the lower first molar is formed by the mesial-lingual cusp of the upper first molar. Working to centric, lateral-protrusive to centric and protrusive to centric excursions.

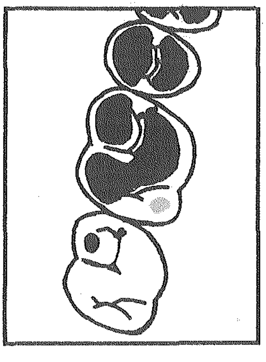


FIG. 316. The tip of the distal-lingual cusp of the upper first molar is located at the inner aspect of the tip of the mesial-buccal cusp of the lower second molar in the balancing relationship.

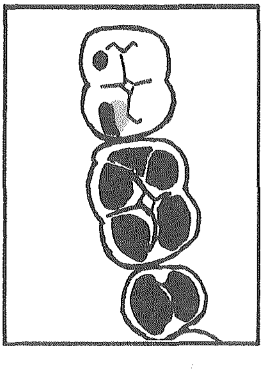


FIG. 317. The mesial inner slope of the mesial-buccal cusp of the lower second molar is formed by the tip of the distal lingual cusp of the upper first molar. Balancing to centric excursion.

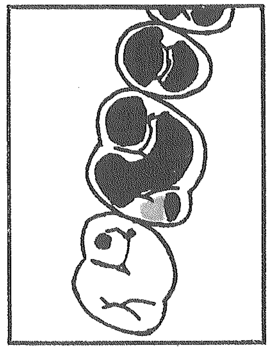


FIG. 318. The inner slope of the distal-lingual cusp of the upper first molar is formed by the inner mesial incline cusp of the lower second molar. Balancing to centric excursion.

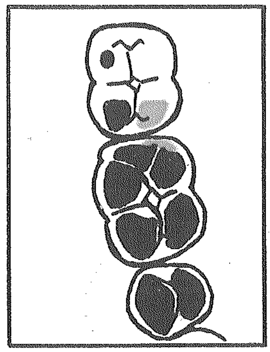


FIG. 319. The distal incline of the distal-lingual cusp of the lower first molar and the mesial incline of the mesial-lingual cusp of the lower second molar are formed with the distal-lingual cusp of the upper first molar. Working to centric, lateral-protrusive to centric and protrusive to centric excursions.

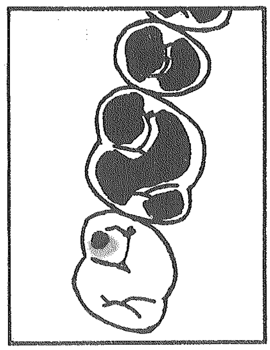


FIG. 320. The distal inner incline of the mesial-buccal cusp of the upper second molar is formed with the tip of the distal-buccal cusp of the lower second molar. Protrusive to centric, lateral-protrusive to centric and working to centric excursions.

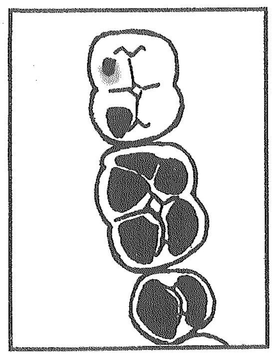


FIG. 321. The mesial incline of the distal-buccal cusp of the lower second molar is formed by the distal inner slope of the mesial-buccal cusp of the upper second molar. Protrusive to centric excursion.

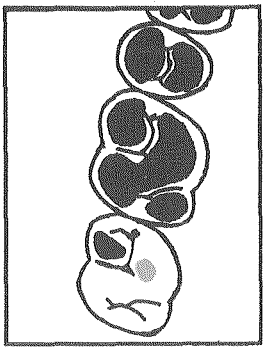


FIG. 322. The tip of the mesial-lingual cusp of the upper second molar is located at the inner aspect of the tip of the distal-buccal cusp of the lower second molar in the balancing relationship.

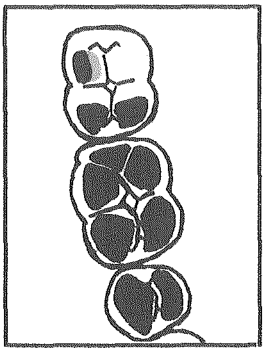


FIG. 323. The inner aspect of the distal-buccal cusp of the lower second molar is formed by the tip of the mesial-lingual cusp of the upper second molar during the balancing to centric excursion.

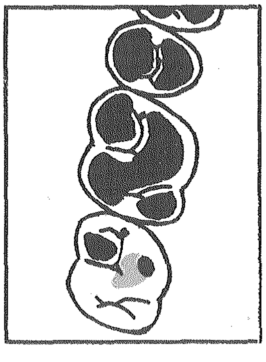


FIG. 324. The inner distal slope of the mesial-lingual cusp of the upper second molar is formed by the inner slope of the distal-buccal cusp of the lower second molar in the balancing to centric excursion.

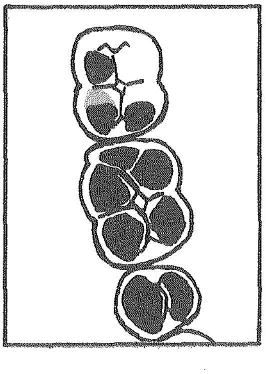


FIG. 325. Wax is added and the distal slope of the mesial-buccal cusp of the lower second molar is carved.

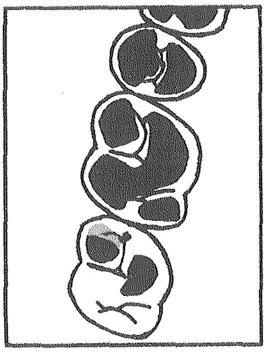


FIG. 326. The inner mesial slope of the mesial-buccal cusp of the upper second molar is formed by the distal slope of the mesial-buccal cusp of the lower second molar during the working to centric excursion.

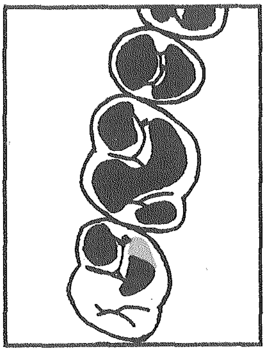


FIG. 327. Wax is added and the mesial slope of the mesial-lingual cusp of the upper second molar is carved.

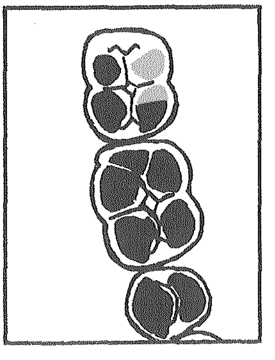


FIG. 328. The distal inner slope of the mesial-lingual cusp and the mesial inner slope of the distal-lingual cusp of the lower second molar are formed by the mesial-lingual cusp of the upper second molar. Working to centric, lateral-protrusive to centric and protrusive to centric excursions.

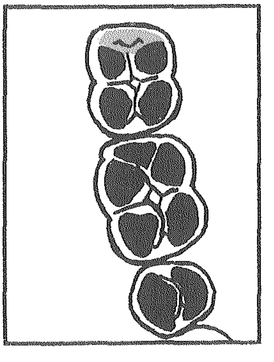


FIG. 329. The distal marginal ridge of the lower second molar is formed by the distal slope of the mesial-lingual cusp of the upper second molar. Protrusive to centric excursion.

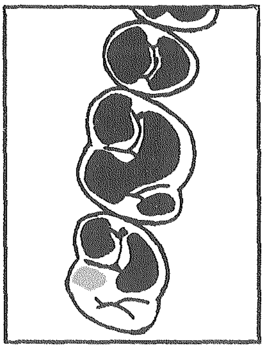


FIG. 330. The mesial inner slope of the distal-buccal cusp of the upper second molar is formed by the distal slope of the distal-buccal cusp of the lower second molar. Working to centric excursion.

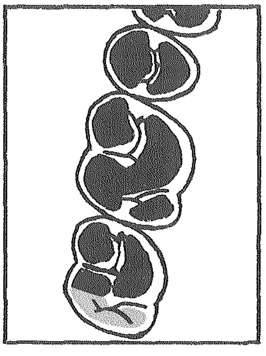


FIG. 331. Wax is added and the distal slope of the distal-buccal cusp and the distal-lingual cusp area of the upper second molar are carved.

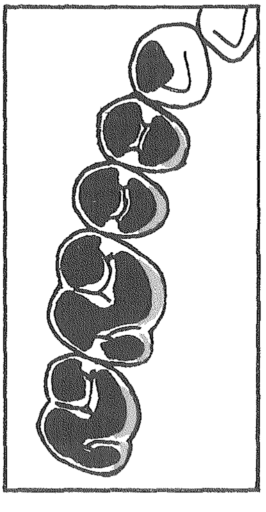


FIG. 332. The outer slopes of the lingual cusps of the upper posterior teeth are waxed and formed against the lower lingual cusps, using the working to centric and the protrusive to centric excursions.

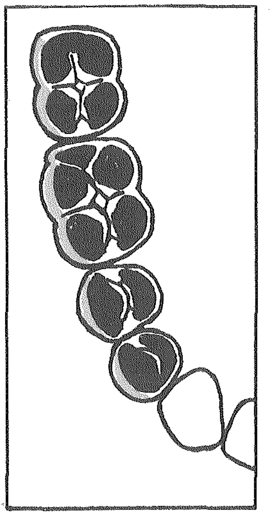


FIG. 333. The outer aspects of the lower buccal cusps are waxed and formed against the upper buccal cusps, using the working to centric and the protrusive to centric excursions.

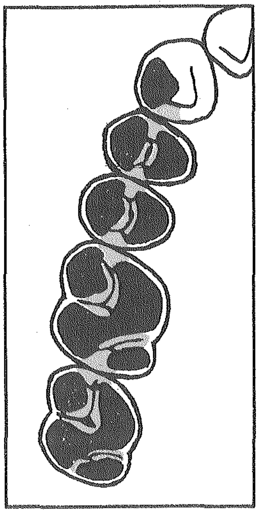


FIG. 334. The fossae and the marginal ridge areas of the upper teeth are waxed and formed with centric closure against the tips of the lower buccal cusps. Move through all excursions to prevent a build-up of excess wax in other areas.

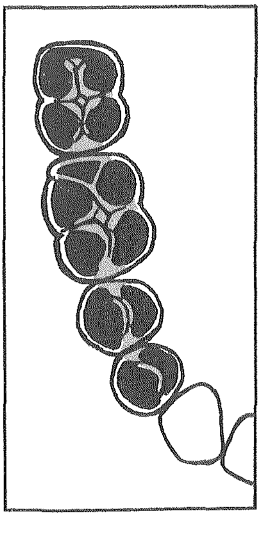


FIG. 335. The fossae and the marginal ridge areas of the lower teeth are waxed and formed by centric closure against the tips of the upper lingual cusps. Move through all excursions to prevent a build-up of excess wax in other areas.

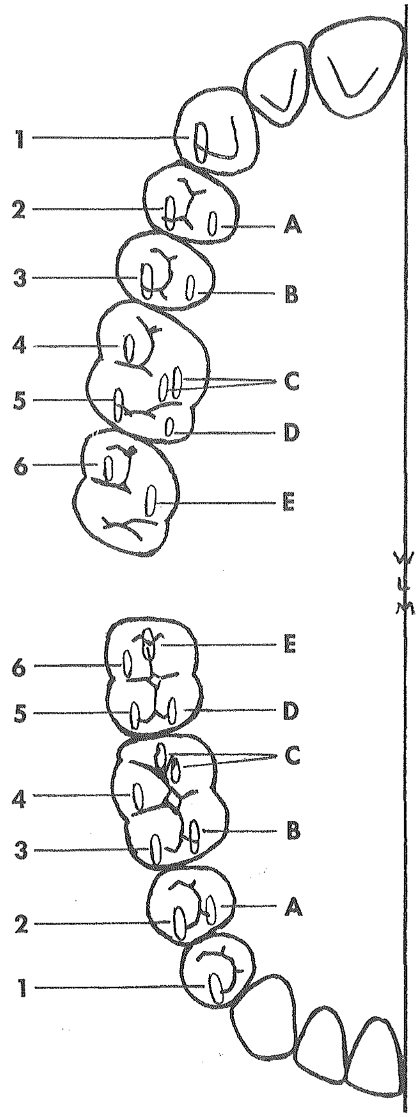



FIG. 336. This shows the paths of the points of contact during the straight protrusive to centric excursion. The path on a cusp of the lower teeth that is indicated by a number or a letter will make contact during the excursion with the corresponding numbered or lettered path on the upper teeth.

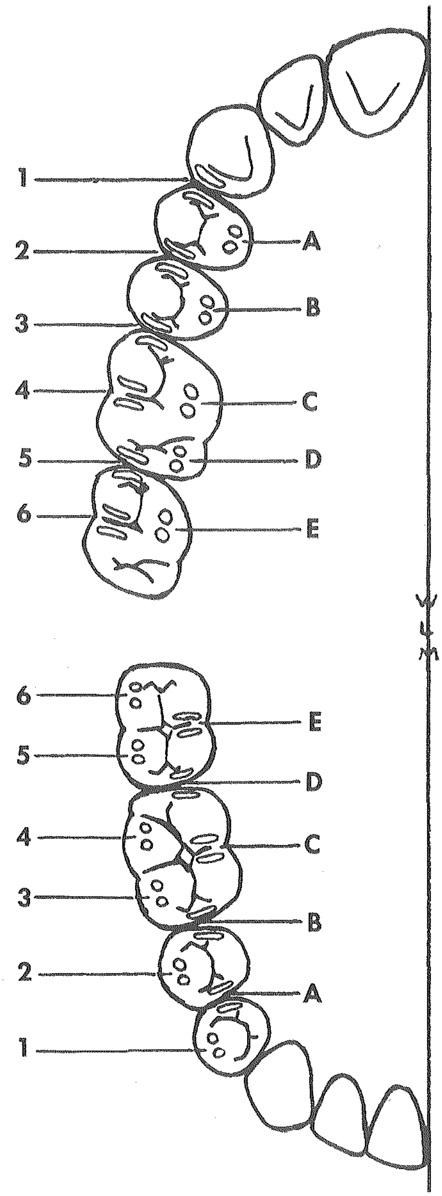



FIG. 337. This shows the path of the points of contact during the lateral excursions on the working side.

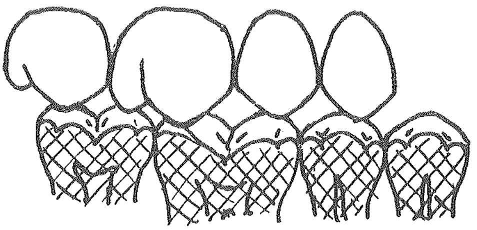


Fig. 338A. This is a view (from the lingual aspect, with the lower lingual cusps removed) of the cusp relationships at the extreme of the balancing contact.

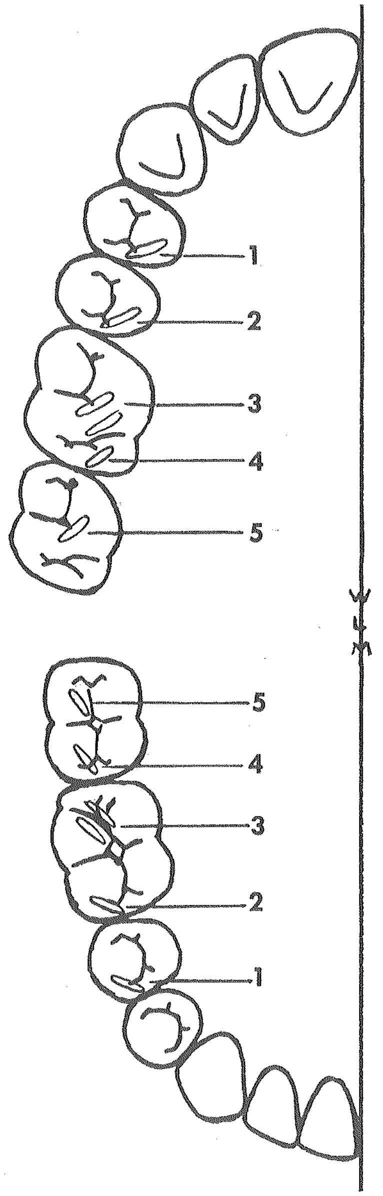



Fig. 338B. This shows the paths of the points of contact during the lateral excursion on the balancing side.

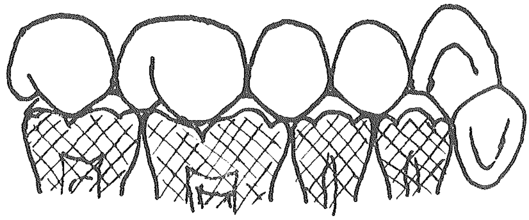


FIG. 339A. This is a view (from the lingual aspect, with the lower lingual cusps removed) of the centric contact between the upper lingual cusps and the opposing marginal ridges and fossae.

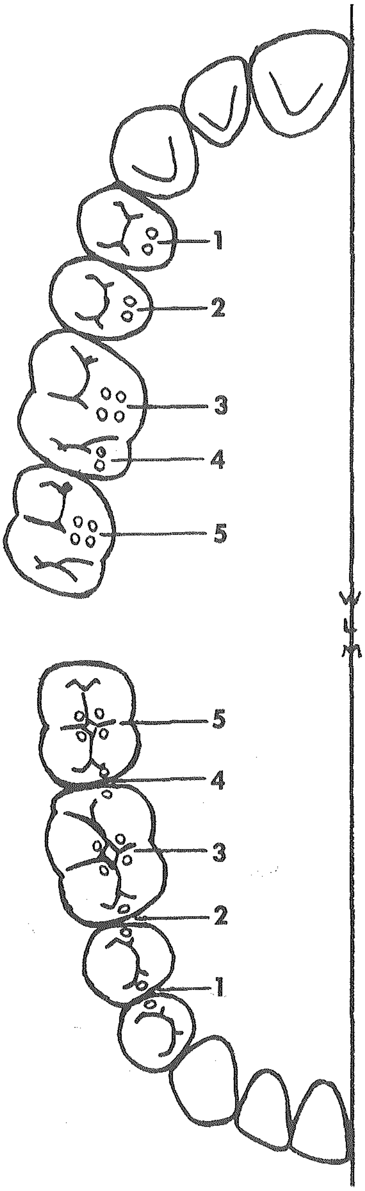



FIG. 339B. This shows the points of contact between the upper lingual cusps and the opposing marginal ridges or fossae in centric occlusion.

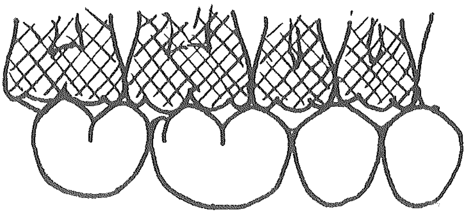


FIG. 340A. This is a view (from the buccal aspect, with the upper buccal cusps removed) of the centric contact between the lower buccal cusps and the opposing marginal ridges and fossae.

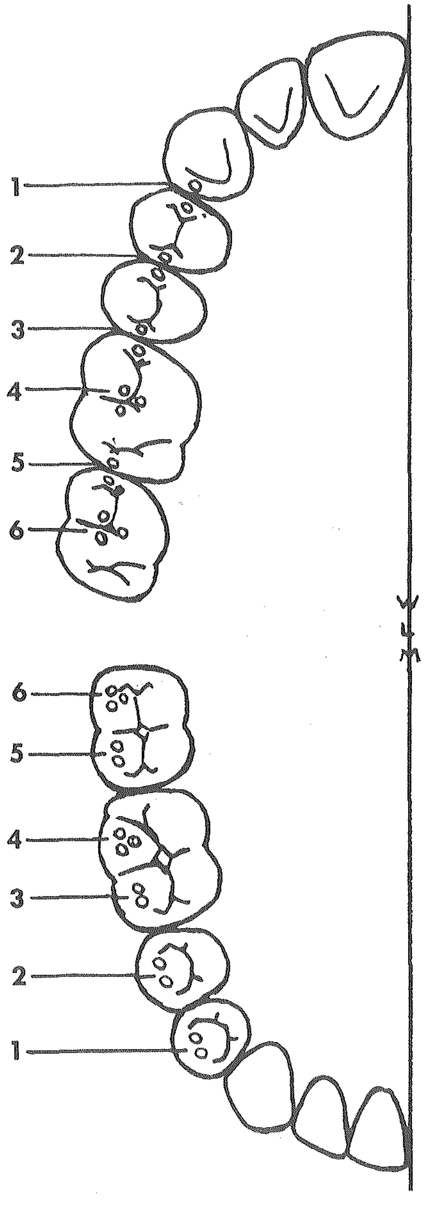



FIG. 340B. This shows the points of contact between the lower buccal cusps and the opposing marginal ridges and fossae in centric occlusion. These contacts and the contacts that are shown in Figure 339B occur at the same time.

*Chapter* 19

# Biometrics: The Measurement of Cusps

Man is an omnivorous animal. With his temporomandibular joints and teeth he can perform the hinge action, the tearing and the shearing of the Carnivora and the gliding and the milling of the Herbivora. Further, he must be able to execute these operations singly or simultaneously without injury to any part of the chewing mechanism. The irregularities of occlusal form which we designate as cusps, sulci and marginal ridges are not there just to make the teeth rough, as glorified rasps. They exist so that man can perform these varied functions which are physiologically necessary to maintain functional equilibrium throughout the entire oral organ: teeth, bones, joints and muscles. Nature designed teeth with cusps. Further, she designed the entire oral organ to utilize teeth with cusps. The movements of the mandible and of the muscles of mastication are all designed for chewing with cusps. The bone in which the teeth are embedded is there for the purpose of receiving the forces from the cusps—that is the biologic reason for its existence. These forces may be physiologic or pathologic. Failure to recognize this has resulted in marked failures in the making of artificial dentures, and so, in desperation, many have turned to pathologic flat teeth with few cusps or none at all. We have not learned to differentiate between the mere balance of teeth themselves and proper articulation as a requisite to functional equilibrium.

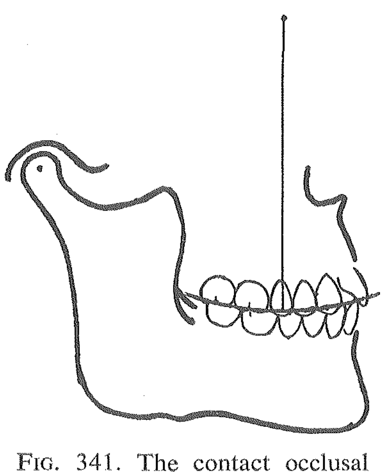


FIG. 341. The contact occlusal sphere.

## CUSP HEIGHT

The physiology of the mouth requires the use of cusps which bear a relation to the bony structures supporting the teeth, and pressure exerted upon abutments by prosthetic appliances must be in harmony with that bone. The basic reason why cusps are necessary is illustrated in Figure 341. In a healthy arrangement of natural teeth the points of contact between the upper and the lower occlusal surfaces lie on the surface of a sphere. This is not the curve of Spee. It is what Maxwell termed the contact occlusal sphere. Since it is formed by the points of contact in centric, this sphere is common to both the upper and the lower teeth. Being a sphere, it has a center, somewhere above and in front of the skull. As the mandible moves down and forward (Fig. 342), the sphere, still in fixed relation to the lower teeth, and, therefore its center, also moves down and forward. Meanwhile, the sphere of the upper teeth remains fixed. These spheres can no longer coincide. There is more space anteriorly than posteriorly. So the only way to maintain contact between these surfaces is to have cusps which rise from the spheres to maintain contact. This, in turn,

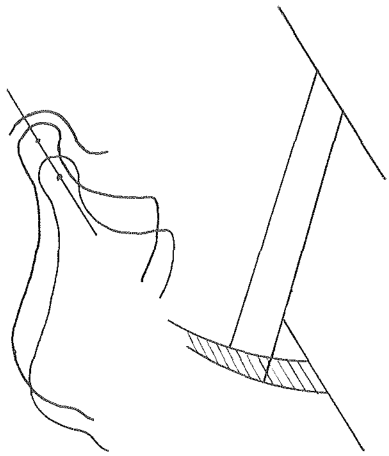


FIG. 342. The center of the mandibular sphere moves with the teeth.

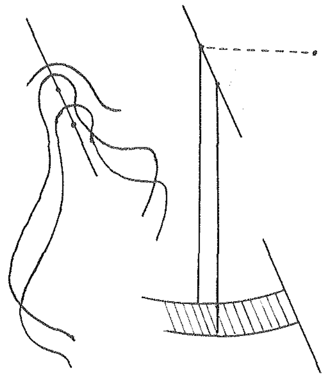


FIG. 343. Changing the center changes the cusps.

creates the anterior guidance of the mandible which determines the overbite and the overjet. It is apparent that changing the center of the sphere (Fig. 343) will change the required cusp height, but not the need for cusps. This change in relationship is discussed with the Plane of Occlusion (p. 195).

Whether the teeth are set on a curve or a plane, cusps would still be required to maintain contact, but, as we shall see, a plane of occlusion would require an abnormal relation and size of cusps. It is obvious that, in order to maintain a state of functional equilibrium upon the supporting structures, these cusps also must bear a definite and important relation to the functional movements of the entire mouth, as controlled by the temporomandibular joint. The movements of the mandible, activated by the muscles of mastication but controlled by the temporomandibular joint's articulating the teeth upon each other, determine the form and the position of the cusps that are required to maintain this state of functional equilibrium throughout the entire oral organ: supporting structures, muscles and joints.

In a properly articulated set of teeth, the cusps do not dictate the movements of the mandible. They follow its movements, as dictated by the temporomandibular joint, to maintain equal distribution of function upon all the supporting structures all the time. The physiology of the mouth demands the use of cusps as nature's only means of maintaining equal simultaneous contact and reducing the functional demands on the supporting structures and the metabolic requirements to maintain health. Properly articulated cusps decrease trauma; so-called cuspless or flat teeth increase trauma.

It is apparent that the cusps which will maintain functional equilibribum in any given mouth are dependent upon a number of factors, some fixed by nature, others capable of being varied to some degree by the operator, viz.: condyle path (slant, curvature and Bennett movement); curve of Spee, orientation and radius; plane of occlusion, which represents the mean average of the influence upon the cusps of the curve of Spee; and anterior guidance, which is the combined overbite and overjet that must result from the posterior cusps to prevent injury to the pure shearing structures during the combined milling and shearing of the posterior teeth in mastication. The path of the condyle is a fixed factor, *but does not determine the cusps per se*. It determines the relation to each other of the curve of Spee, the plane of occlusion and anterior guidance, which in turn determines the cusp height. The other factors, each of which exerts a definite influence, are to some extent under the control of the operator, the degree depending upon the conditions present in a particular

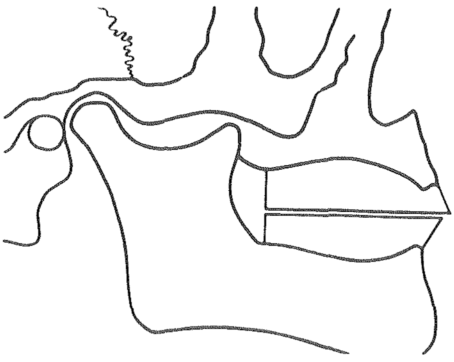


FIG. 344. The "plane" of occlusion.

mouth. They cannot be varied just to make some preconceived cusps work without producing disastrous results.

In recent years, dentists have attempted to utilize all sorts of averages in cusp forms, completely disregarding the fact that they are dealing with a variable biologic entity. One man argues that all cusps should be 20°, another says 33°, another, 45°, and still another, no cusps at all. Obviously, they cannot all be right. Although we could determine a composite average of teeth, it would not represent the mouth of any given individual. In a similar fashion, we could make a composite photograph of a group of people, but it would not be the picture of any single individual. The factors which determine the cusps that are required in a mouth to maintain continuous contact in harmony with the joint are the same in all mouths. But no factor can be used to the detriment of the others. The variability of these biochemical factors determines the need for cusps and the individual cusp forms.

For the sake of brevity we will not consider here the functional relation of the cusps in detail, which is described in Chapters 16 and 17. For the present purpose we need to recall only the cusp relations at the extremes of functional tooth contact in an ideal relationship.

In extreme lateral protrusive relation, the tips of the cusps of the upper and the lower posterior teeth on one side, and the incisal edges of the anterior teeth on that side, are in contact. The posterior cusps on the other side are not in contact. This is a tearing position, not part of a masticatory stroke, and it is the only position in which all of the teeth do not make equal, simultaneous contact.

In straight protrusive relation, the tips of the buccal cusps of the lower teeth and the lingual cusps of the upper teeth rest in contact with the inner aspect of the crest of the parabolic curve of the opposing buccal and lingual cusps, that is, lower buccal tip against upper buccal crest, upper lingual tip against lower lingual crest, except for the lower first bicuspid buccal, which rests on the lingual crest of the upper cuspid. The incisors are in tip-to-tip relation.

In lateral excursion, the cusps of the posterior teeth on the working side pass each other, gliding across the opposing marginal ridges and sulci, exerting almost vertical pressure against each other. On the balancing side, the tips of the lower buccal cusps rest in contact with the tips of the upper lingual cusps, except that the mesiolingual cusps of the upper molars rest in the sulci between the distobuccal and the distal cusps of the lower molars.

Keeping in mind the foregoing positions at the extremes of cusp height relations, let us consider the various factors which can influence the cusp height and form which will articulate in any given mouth. Of course, as the mouth moves, all of these come into action simultaneously. In order to differentiate the part which each one plays in the whole synergy, we will consider each one as a separate entity, and then the combined effect. This discussion is based upon the assumption that the reader has familiarized himself with the functional movements of the temporomandibular joint.

## PLANE OF OCCLUSION

The plane of occlusion (Fig. 344) is defined as the plane formed by two lines drawn from the tips of the lower cuspids to the tips of the distal buccal cusps of the lower second molars. The "plane" of occlusion does not actually exist, since the cusps are not set

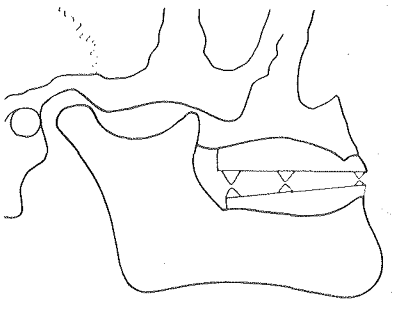


FIG. 345. The cusp height increases from anterior to posterior.

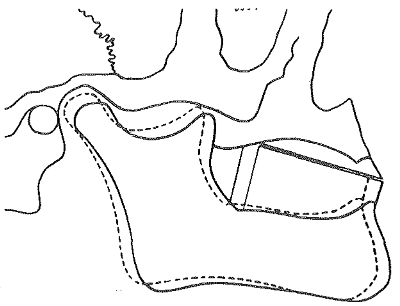


FIG. 346. The closer the plane of occlusion comes to being parallel with the condyle path, the less the separation.

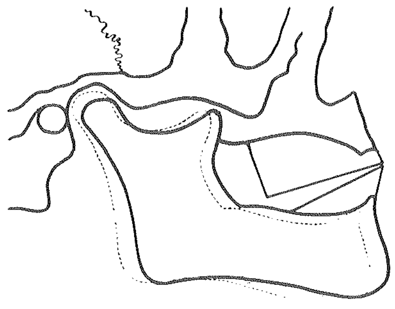


FIG. 347. The closer the plane comes to forming a right angle, the greater the separation.

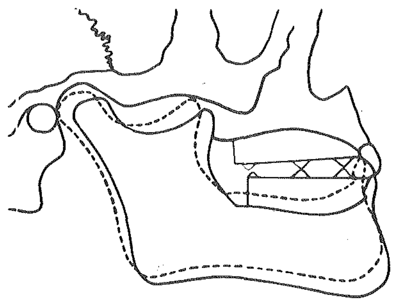


FIG. 348. Anterior guidance requires excessive cusp height.

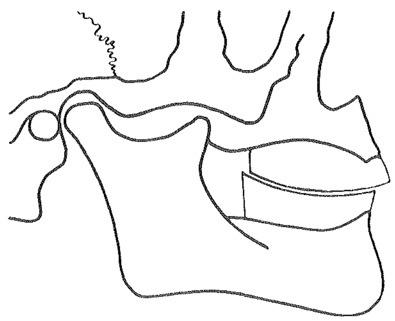


FIG. 349. The curve of Spee.

upon a plane, but it serves a useful purpose in a discussion of cusp height. If we were actually to form the cusps on the plane of occlusion, two things would result. The height of the cusps would decrease from posterior to anterior (Fig. 345), whereas in nature the opposite condition invariably prevails and the supporting structures and muscles are designed accordingly. The plane of occlusion is the position of the curve of Spee with relation to the condyle path. Alterations in the plane of occlusion will alter the height of all the cusps in equal proportion, but not the cusp heights relative to each other. The closer the plane of occlusion comes to being parallel with the condyle path (Fig. 346), the lower the cusp height. The closer the plane of occlusion comes to forming a right angle with the condyle path (Fig. 347), the higher the cusp heights required to maintain contact. If the cusp heights were graduated to give increasing height from posterior to anterior (Fig. 348), that would create an incisal guidance which would make it impossible to set the teeth on the plane. It is self-defeating. Furthermore, the cusps would be a row of "steeples," resembling the carnassials of the dog.

### CURVE OF SPEE

The curve of Spee (Fig. 349) has been defined mistakenly as the curve which contacts the tips of the cusps and passes through the condyle. That is nearly an impossibility.

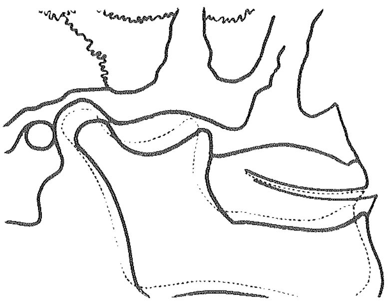


FIG. 350. The curve reduces the cusp height.

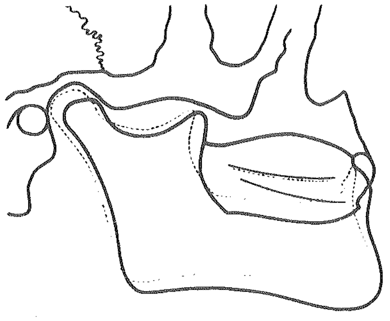


FIG. 351. Anterior guidance can cause excessive cusp height.

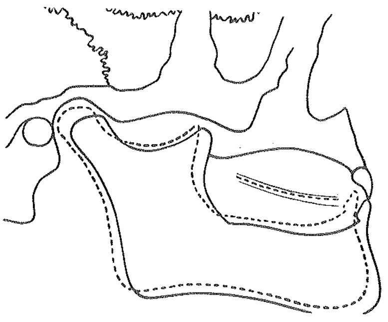


FIG. 352. Decreasing anterior guidance decreases cusp height.

In a natural, ideal dentition, the cusps are parabolic in form and make point contacts with each other. In any position of the mandible, the points of contact between the upper and the lower posterior teeth in both the sagittal and the frontal planes form arcs. As a result, in any position the contacting points fall on the surface of a sphere. That fact has led to the erroneous conclusion that cusps which fit and are set upon a spherical surface will provide continuous contact. While it is true that the points of contact between the upper and the lower teeth do fall on the surface of a sphere, as the mandible moves the points of contact change and the center of the sphere moves, as we saw in Figure 342 (p. 193). So, as the teeth move in function, the points of contact form the surface of a sphere with a constantly changing center. Since the upper teeth are embedded in the maxilla, a spherical surface could not provide continuous contact because its center would be fixed. The two spherical surfaces would have to be concentric in the centric relation of the mandible. As the condyle and the meniscus moved downward and forward on the glenoid fossa, the spherical center of the mandibular curve would have to move also. The points of contact between the upper and the lower teeth would then be at different points on the cusps. They would fall on the surface of a sphere with a different center. Similarly, in every position of the mandible the points of contact between the upper and the lower teeth would fall on the surface of a sphere, but in each position it would have a different center from that in any other position. That is why the contacting surfaces of the cusps are parabolic—since the points of contact are scribed by a moving center. The curve of Spee provides the only way in which the cusps can maintain continuous contact, and thus functional balance, in every contacting position of the mandible.

This functional arrangement of the teeth provides the transition from the pure shearing action of the anteriors to the milling action of the posteriors. Because the cusps are set upon a curve (Fig. 350), the cusp height and width decrease from anterior to posterior. In one sense, the path followed by the lower anteriors is a "cusp form," that is, in a healthy functioning arrangement of teeth, the anterior path (anterior guidance) of the mandible is not created by the movement of the anterior teeth upon each other; it is a result of the harmonious functional relations of all the cusps.

Since, in a normal dentition, the cusp height decreases anteroposteriorly as a result of the curve of Spee, it is apparent that the radius and the orientation (the plane of occlusion) will exert a powerful influence upon the cusps which will function under any particular set of conditions, i.e., the condyle path and the anterior relation of teeth. For example, in a natural dentition with the anterior teeth present, since the temporomandibular joint function is fixed, the curve of Spee that is required will depend upon the relation between the functional requirements of the joint and the anterior teeth.

If the radius of the curve of Spee remains unchanged, changing the position of the plane of occlusion will change the height of all the cusps while maintaining the same anterior guidance. If the plane of occlusion is raised posteriorly, the height of all the cusps will be reduced. If the plane of occlusion is lowered posteriorly, higher cusps on all the teeth will result. In either case, the relation of the cusp heights to each other will remain unchanged. For instance, if, in a given set of circumstances, the distobuccal cusp of the second molar is half as high from the depth of the sulcus as the buccal cusp of the second bicuspid, changing the plane of occlusion will not change the height of the cusps relative to each other. There still would be the same (in this case, perhaps normal) transitions in cusp height anteroposteriorly. But all the cusps would be changed relative to their supporting structures and to the temporomandibular joint.

If the plane of occlusion remains unchanged and the radius of the curve of Spee is altered, then the average cusp height remains the same, but the height of the cusps relative to each other will be different. If the radius is decreased, the molar cusps will be reduced and the posteroanterior cusp height will increase more rapidly. In theory, by varying these two factors simultaneously, an infinite variety of cusp combinations could be formed to operate under a given set of conditions.

In practical restorative problems, the curve of Spee provides us with the means of maintaining continuous contact of the cusps in all the functioning positions of the mandible in order to meet the requirements imposed by the fixed factors of the temporomandibular joint and still be in harmony with the supporting structures of the teeth. The objective is not to impose upon the mouth some preconceived, theoretically ideal, cusp forms. Rather, it is to create occlusal forms which will "follow" the movements of the mandible with minimum vertical guidance. Variations of the curve of Spee make it possible to maintain vertical balance without having the cusps force a lateral component to create excessive stress on the supporting structures or the temporomandibular joint.

To cite a practical example (Fig. 351), suppose that we are called upon to treat a mouth in which the upper and the lower anterior teeth are present in such a relation that an excessive vertical cusp rise on the posterior teeth would be necessary to avoid stress upon the anteriors in mandibular excursion. By "opening the bite" (Fig. 352) on the mandibular axis and reshaping the posterior teeth, we could accomplish two things simultaneously. We would decrease the anterior path and, therefore, the cusp height required to maintain it, and also the cusps, which would still be in harmony with the supporting structures and the temporomandibular joint.

### Anterior Guidance

From the foregoing, it is obvious that the requirements of anterior guidance also will influence the cusp height or the vertical cusp rise in excursion. In a healthy arrangement of teeth, anterior guidance, or, more properly, the anterior path of the mandible, is not created by the anterior teeth—it is a result of the action of the posterior cusps—and the contacting arrangement of the anterior teeth should be such as to follow the path of the mandible as the cusps glide across and upon each other. Thus, the cusp requirement at any particular point of contact in a given excursion of the mandible will be determined by the relation between the position of the condyle on its path and the anterior path of the mandible.

In full denture work, that is a comparatively simple matter of arranging the anterior teeth in such a relation that they will harmonize with the normal increase in postero-anterior cusp rise which creates the anterior path. In natural dentitions with the anterior teeth present, it frequently will be necessary to alter the anterior tooth relationships to make the anterior path conform to the guidance created by the cusps which will work with the other factors present in the mouth that enter into cusp form. If the anteriors present a deep overbite with no overjet, the cusps required to produce such an anterior path of the mandible might be excessive for the posterior teeth for a variety of reasons. In such a case, it probably would be necessary both to open the bite and alter the shape of the anteriors. At the opposite extreme of the worn edge-to-edge relation of the anteriors, the minimum cusps that could work in the mouth in many cases would create an anterior path that still would call for rebuilding the anterior teeth in order to maintain function.

### Condyle Path

Thus far we have considered those factors which, to a limited extent, are under the control of and can be varied by the operator. The condyle path is a fixed factor which determines the variations necessary in these other factors to form the cusps which will fulfill two requirements simultaneously: they must not create stress upon the supporting structure individually; they must conform to the functional movements of the entire mouth in order to maintain functional balance of all the supporting structures collectively.

For convenience, we have divided the path of the condyle into three parts. In the straight protrusive path, both condyles move down and forward on a straight path. The difference between the vertical component of the condyle path and the vertical component of the anterior path of the mandible lies in the anterior guidance of the cusps. Since the condyle path is fixed, the same anterior path can be harmonized with various cusp heights by changing the plane of occlusion. By this means, the cusps can be altered to satisfy the requirements of the condyle path and still not be excessive for the supporting structures.

In lateral excursion, both condyles follow paths which differ from the straight protrusive path. On the working side, as the condyle rotates it also moves laterally in the Bennett movement (the second part of the path of the condyle). On the balancing side, the condyle moves down and forward to the protrusive in a similar movement, but the path is different from the pure protrusive path. Because the condyle on the working side is rotating and moving laterally, the condyle on the balancing side also is moving laterally, and the path that it follows is a combination of the Bennett and the protrusive (or the third part of the path).

This combination path in lateral excursion produces an irregular path of the cusps. Although the points of contact in all these positions are still on the surface of a sphere, it is not the same sphere, and, of course, the center is different. The anterior path is not the same in lateral as in protrusive. It must be different in order to work with the same anterior teeth. As before, the cusps will be a result of the relation between the condyle path and the anterior path. In lateral excursion, the condyle path is different on each side (working and balancing), with the same plane of occlusion constant to the condyle, but in a different position relative to the upper teeth. This also creates the need for parabolic cusps.

We see, then, that there exists a beautifully co-ordinated relation between all the factors which, taken together, create a healthy functioning relation of cusps in every contacting position of the mandible. Each one is related to the others. We cannot consider any one alone without considering how it will bring about changes in the others. We cannot arbi-

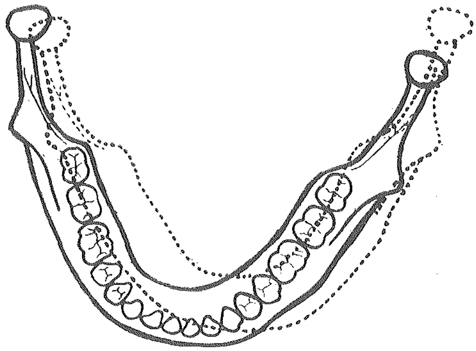


FIG. 353. The Bennett movement.

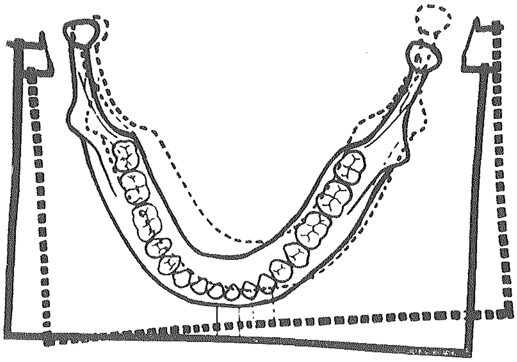


FIG. 354. Tracing the Bennett movement.

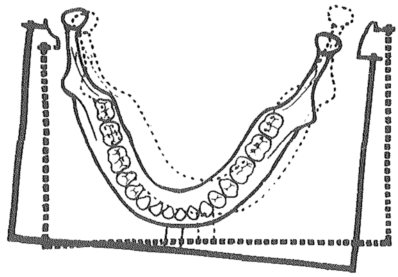


FIG. 355. Timing of the Bennett movement.

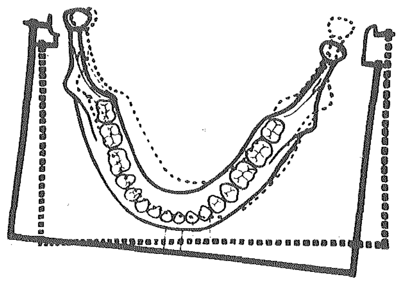


FIG. 356. Different timing changes the path of the cusps.

trarily select some theoretically ideal cusps and expect the mouth to adapt itself to them. The cusps which will work in any particular mouth depend upon all the factors in that mouth. It should be apparent also that in any given set of these factors, viz., condyle path, plane of occlusion, curve of Spee and anterior guidance, there is only one set of cusps which can work. If conditions require a change of any one of these factors, the cusps must be altered to meet that change. Conversely, if conditions call for a change in cusps, then one or more of these factors must be changed to meet the altered conditions. There is no such thing as a universal application of 20°, or 33°, or 45° cusps. They are as individual as the people who are expected to use them.

## CUSP FORM AND POSITION

The factors that we have been considering are concerned largely with cusp height. The form and the position of these cusps, and the marginal ridges and the sulci through which they pass, are determined largely by the timing of the Bennett movement (Fig. 353).

By attaching a pantograph to the mandible (Fig. 354), we can trace the actual path of the Bennett movement. Sometimes, as in Figure 354, it is an equally proportional movement on the working and the balancing sides. As the balancing condyle follows its path, the working condyle is moving laterally at the same rate. As the balancing condyle is gliding forward, the working condyle continues to rotate.

Sometimes, as in Figure 355, the Bennett shift occurs as the balancing condyle moves part way down its path, and then the working condyle continues to rotate without further lateral shift. The balancing condyle describes an inward curve, and then straightens out and continues forward with much less curvature.

Frequently the lateral shift, as in Figure 356, occurs very rapidly as a sudden side

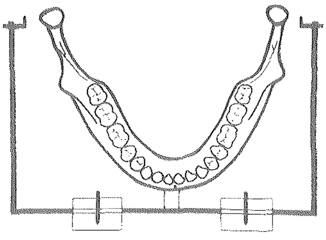


FIG. 357. The Bennett movement is reflected in the Gothic arch tracing.

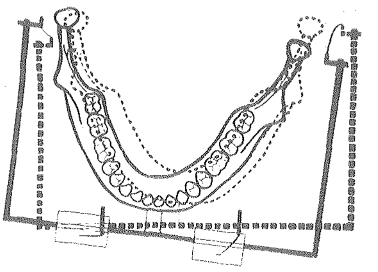


FIG. 358. The apex of the Gothic arch is not always centric.

shift at the very beginning of the forward movement of the balancing condyle. The working condyle continues to rotate without further shift as the balancing condyle completes its path.

There is an infinite number of variations of these three characteristic paths, both in degree of shift and in direction. The important thing is that the timing of these paths determines the form and the position of the sulci.

It is apparent also that the Bennett movement will have an effect on the Gothic arch tracing. By attaching two Gothic arch styli and slides (Fig. 357) to the front of the bows, we can record this result. If the timing of the Bennett movement makes it a sharp lateral movement, the Gothic arch stylus will move laterally (Fig. 358). As the condyle continues to rotate, the stylus will move back in a normal Gothic arch tracing. But the change from lateral shift to rotation of the condyle will create an apex at the end of the Bennett movement. In such a case the apex of the Gothic arch is not centric.

The Bennett movement is never alike on the two sides. Frequently the timing is different. But a similar action does occur, and in such a case the so-called apex of the Gothic arch does not exist. The apex of the Gothic arch tracing, when it does exist, is not a reliable guide to centric relation.

Although there is an inherent pattern of cusps relations in human beings, the actual cusps that are correct for any individual are the result of a synergy of factors. These are true biomechanical factors.

*Chapter* 20

# Remounting

In the practical treatment problems of dentistry there is no such thing as a perfect impression, a perfect model, a perfect bite, a perfect casting or a perfect method of adjusting surfaces to contact. As a result, every dental restoration represents an accumulation of small errors which, in the aggregate, produce a gross error. In a small restoration such as an inlay or a crown, the magnitude of these errors is small enough that they can be compensated by small adjustments in the mouth. But with a full mouth restoration these become a gross error, which cannot be corrected successfully in the mouth. It presents the same problem that attempting to use the mouth as an articulator to carve a full mouth restoration does, and adjustments must be carried out in the same fashion as in carving porcelain teeth.

Therefore, every major restoration must be remounted for adjustment before completion. Remounting consists of taking an impression, a bite and a face-bow mounting of the restoration in the mouth and remounting it on the articulator for final adjustment. This should be done before the margins are finished as, otherwise, they may be damaged in handling. Fixed bridges should be soldered prior to the remount. Acrylic work on veneers and bridge dummies should be left until after remounting. It is routine practice to take two remounts, the first prior to finishing—for adjustment. The second remount—after adjustment—is a check on the first one and is used for the final carving and characterizing of the teeth. The restorations are placed with temporary cement for 3 months or longer. Then a remount study model of the finished restoration is mounted as a final check before cementation.

Remounting is perhaps the most important single procedure of the entire treatment. Perfect records, bites and fitting restorations are of small avail if the occlusal surfaces fail to meet in correct contact. It is the remount which establishes the final perfected contact and relationships of the occlusal surfaces. No attempt should be made to perfect faulty occlusal relationships in the mouth by grinding. It is rarely successful and requires far more time and effort and is much more frustrating than corrections made on the articulator at the laboratory bench. A restoration with known errors should never be placed in the mouth with the hope that in some mysterious fashion the mouth will adapt itself and no adjustment will be required. Furthermore, it is very difficult to detect errors in the mouth which are clearly visible in the laboratory on the articulator. The nonfunctioning mouth can be guided by the occlusion and appear better than it actually is. So, no matter how it may appear in the mouth, no major restoration should be cemented in the mouth without at least one remount.

A special type of impression made with a combination of impression compound and hydrocolloid is used for this purpose. This is an extremely accurate impression but it can be used only when restorations are to be seated back in the impression. The hydrocolloid must be a soft one, such as Kerr Deelastic. Stiff hydrocolloids, which are good for tooth impressions, are not suitable for this purpose. The compound should be a medium fusing one with a softening point of about 125° F. A water-jacketed tray, not a perforated one, must be used.

The restorations are fitted in the mouth, and all soldering and assembly operations are completed. Restorations which might loosen and change position can be retained by dusting with a film of denture adhesive or, in extreme cases, by cementing with zinc oxide impression paste.

The face-bow mounting and the centric bite should be taken first, as many times the restorations will come out in the impression and should not be disturbed. Loose, mobile teeth which might be disturbed by the impression and the bite must be stabilized. This can be accomplished by painting the interproximal space with self-curing acrylic. It should extend over the buccal and the lingual surfaces to immobilize the teeth. It will not adhere to the restorations when they are removed, and it is not to be incorporated in the impression. It is merely to stabilize the teeth in the mouth.

With large partial dentures in which proprioception is not as much of a problem, this first remount bite can be taken with two or more thicknesses of base plate wax. This will assure the seating of the bases on the tissues by the resistance of the wax. The final remount bite should be taken with the Jones Bite Frame and zinc oxide paste. In any case, the manipulation of the patient is the same as for any centric bite.

## THE IMPRESSION

The remount impression is taken by lining the bottom of the tray with a layer of compound in the areas where it is desired to reseat restorations subsequently. The compound must be thick enough to provide a good full-occlusal impression but not to flow over the buccal and the lingual surfaces and become locked in the teeth when it is chilled. In most cases the compound should be about 3 mm. thick. The upper tray must be postdammed with compound. The operator softens the compound and presses the tray into place on the restorations to see that the amount of compound is correct. This is merely a test of the compound, and no attempt should be made to reseat the tray in exactly the same position.

The hydrocolloid is transferred to a tempering bath of 125° F. and left for 5 minutes. With an alcohol torch the compound is heated until it is of a flowing consistency. The hydrocolloid is flowed over the hot compound, filling the tray at the labial flange and barely covering it posteriorly. The filled tray is replaced in the tempering bath of 125° F. for 2 minutes. The cheeks must be well retracted and the impression seated with firm pressure. The postdam is carried into contact, and then the labial flange. The tray is pressed hard against the occlusal surfaces. If the procedure is carried out correctly, the restorations will penetrate the hydrocolloid and seat themselves in the compound. When the impression is removed, a small amount of colloid may be present in the compound in the impression of the sulci, but the cusps should penetrate and leave a clean impression in the compound. This is why the colloid must be a soft, free-flowing material and loose teeth must be immobilized. The pressure required to displace the colloid and seat the compound will displace loose teeth.

The impression is chilled with water at about 70° F. for 5 minutes. It should be removed by a straight pull on the flanges on both sides. No attempt should be made to remove it with the handle of the tray. Usually some of the restorations will be found locked in the compound, and they should not be disturbed except to make sure that they have a good seat and do not rock. The impression is rinsed in cold water. The remaining restorations are removed from the teeth, and replaced carefully in the tray. A careful check should be made to see that each restoration has a definite seat and does not rock.

In most cases there is no occasion to remove the restorations from the model until the adjustment is complete, so the model is poured in a thin, creamy mix of stone. Strength is not necessary in the model, and the vibration required to pour a thick mix could loosen the restorations. The stone is mixed to a pouring consistency. The tray is held in the hand, with the wrist resting on the vibrator so that the impression will be gently vibrated to flow the stone into the restora-

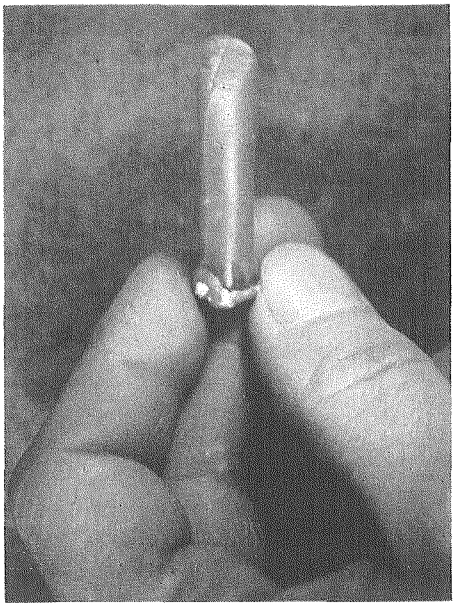


FIG. 359. The wax cone covers the proximal margins.

FIG. 360. Cones ready for investing.

tions. The stone is poured slowly in one end and flowed all the way round into the restorations. When it has thickened somewhat the balance of the impression is filled with the remaining stone by means of a stiff bristle brush.

If the restorations are to be removed and replaced on the model for some reason, they can be filled with Cerrolow 117. This is a low-fusing metal which is poured at 117° F. and will not soften the chilled compound.

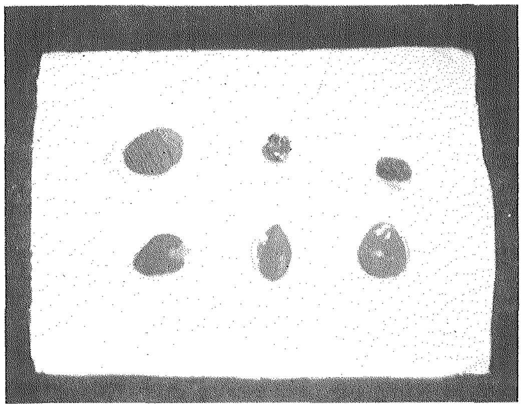


FIG. 361. Restorations in inlay investment.

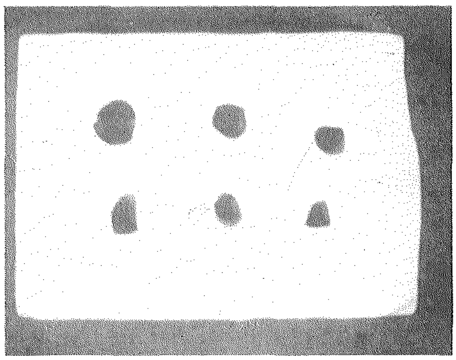


FIG. 362. The wax is boiled out.

The cavo surfaces of the restorations are painted with a thin mix of rouge and alcohol. Cerrolow is softened in a breaker or a ladle containing water at 117° F. It is poured carefully into the restoration from the ladle, still in the warm water. The metal, of course, will flow into the restorations, displacing the water. The rest of the model is poured in stone.

It is not advisable to use Cerrolow for restorations which are to be soldered. They must be boiled in nitric acid before being soldered, which makes assembly difficult. For such cases, it is advisable to make transfer dies of Melotte's metal. To form these dies, a roll of base plate wax about the size of a pencil is made (Fig. 359) and pressed into the restoration. It should extend to the mesial and the distal margins (Fig. 360), but not to the buccal and the lingual. These will be

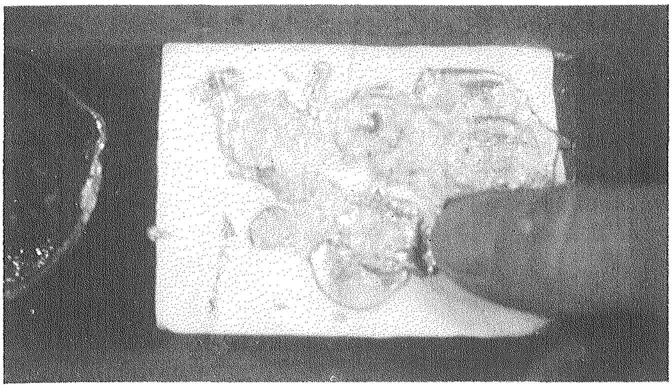


FIG. 363. Melotte's metal is poured into the restorations.

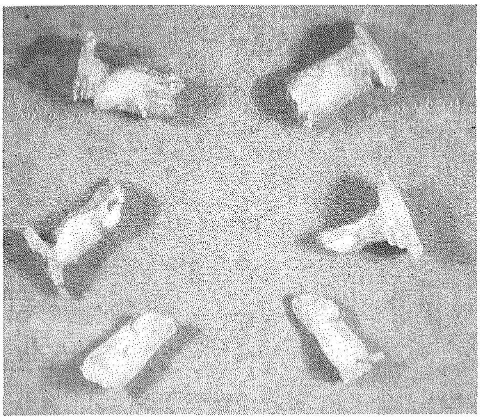


FIG. 364. The dies are separated from the restorations.

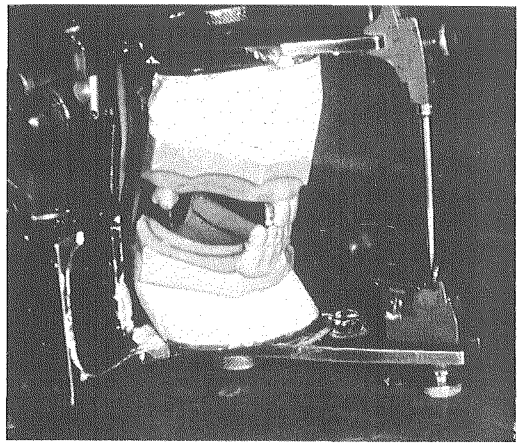


FIG. 365. The working models are mounted.

poured in stone. The restorations are set in some inlay investment in a box (Fig. 361) to make a mold. The wax is boiled out and the investment is allowed to dry (Fig. 362). The metal is poured into the mold (Fig. 363) to fill each restoration. The mold is broken apart to separate the dies. To remove the die (Fig. 364), the operator holds the base with a pair of heavy pliers and hits them sharply; the restoration will fly off. These dies are seated in the restorations before the model is poured.

The remount impression is also useful for making a model with amalgam or copper dies. Transfer copings to fit the dies are cast from scrap gold. The copings are placed on the prepared teeth, and an impression is taken just as though it were a remount. The dies are placed in the copings, and the model is poured in stone. This makes a very accurate and durable model for laboratory handling.

The models are mounted with the mounting frame and the centric bite just as any working models are. Adjustment is carried out in the same fashion as when articulating porcelain teeth. The first gross adjustments should be marked with a hard articulating paper such as Articapak. Soft papers smear and make false markings. The paper should mark only those points which make definite, firm contact.

The final, precise adjustment is made by using a mixture of rouge and alcohol for marking. A thin layer is painted on the occlusals with a sable brush. The point of contact will show through the rouge. As adjustment proceeds, the rouge should be washed off occasionally as it tends to build up in the sulci.

The incisal guide pin should be removed

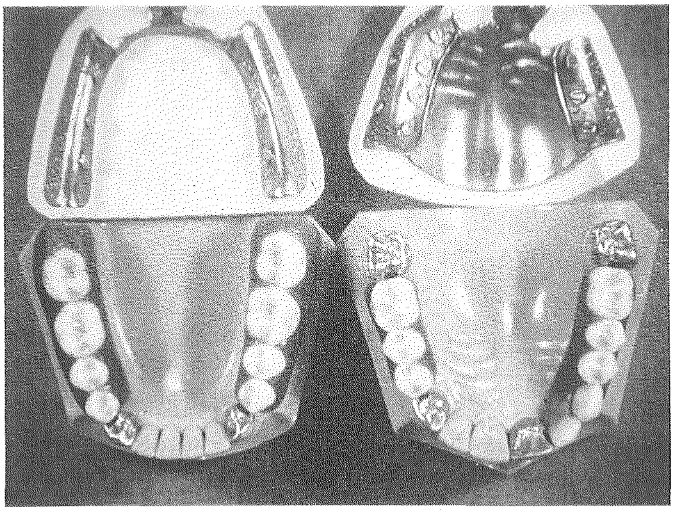


FIG. 366. The restorations and the bases have been cast.

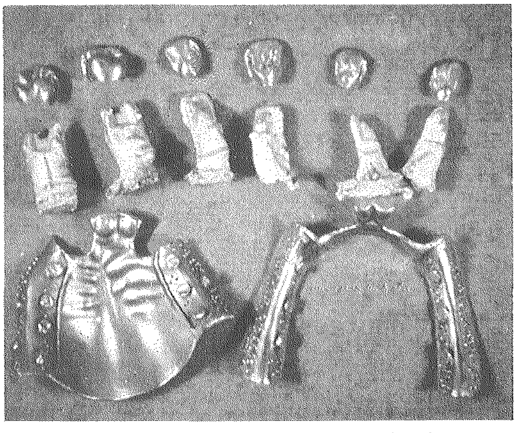


FIG. 367. The abutments and the bases are ready for joining.

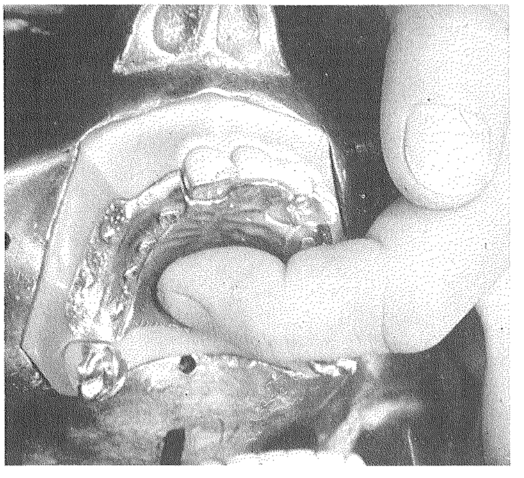


FIG. 368. The base is seated firmly in the mouth.

during these adjustments, as it is used only during the original carving to prevent the wax from being squashed. Final characterizing is carved after all adjustments are completed.

## REMOUNTING TECHNIC

The technic for remounting, involving a complex partial denture problem, is shown in Figures 365 to 394. Working models have been mounted on the pre-set articulator (Fig. 365). The fixed restorations are carved, and the teeth for the removable partials are articulated along with the carving so that they will all function as a unit. The bases are not in position on the models. Mucostatic bases are constructed on separate models of the saddle areas (Fig. 366), as described in Chapter 5. The abutments and any other fixed restorations will have to be removed from the remount model so that the attachments can be soldered. Dies are constructed in them with Melotte's metal (Fig. 367). With the abutments fitted on the teeth, the bases are positioned (Fig. 368) with the index against the unprepared teeth. Small trays (Fig. 369) are formed from flexible tray metal. With the base held tightly seated, the trays filled with plaster are seated over the abutments and the base to join them

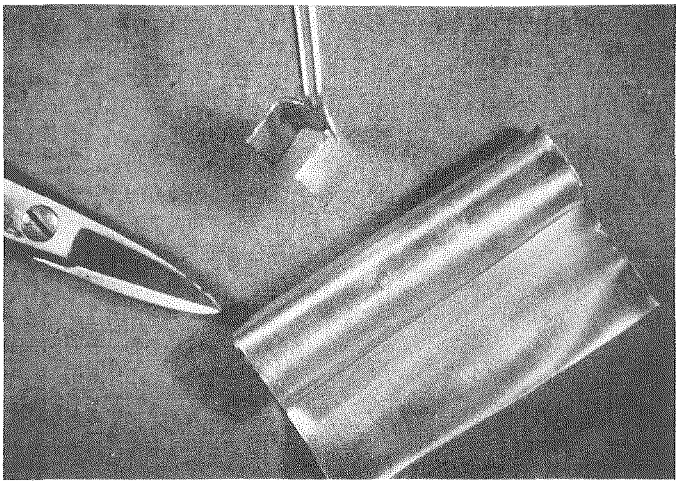


FIG. 369. Trays are cut from Britannia metal.

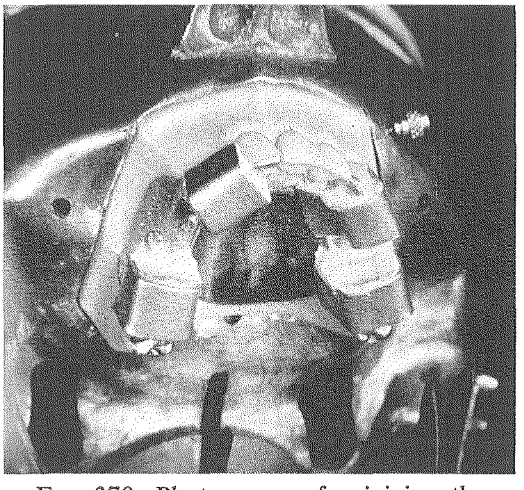


FIG. 370. Plaster cones for joining the base and the abutments.

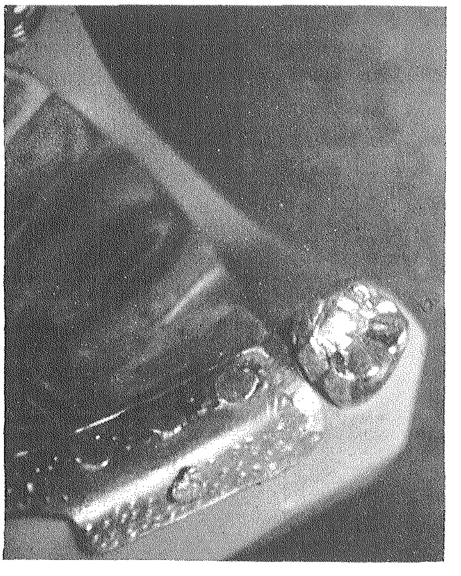


FIG. 371. A model of a base and an abutment.

(Fig. 370). They must all be joined at one time, not successively. An over-all alginate impression is taken for convenience in pouring the model.

The plaster indexes are removed with the base and the abutments. The trays can be peeled off the impressions if it is necessary to split them. Melotte's metal dies are placed in the abutments, and a model is poured for assembly. At the time when the mucostatic base was made, there was no means of knowing where to place the trusses for the attachments. The technic is the same for a clasp and a rest. The female attachments are paralleled and soldered in the abutments, as usual. With the male attachments in place (Fig 371), the base is trimmed so that it does not quite touch the attachment. A wax pattern of the truss is formed to fit around each attachment (Fig. 372) and also to fit the base, using a hard inlay wax. It is removed, invested and cast like an inlay. After it is cast (Fig. 373), it should have a recess which accurately fits the attachment and a surface which accurately positions it on the base. The attachment is covered with a small amount of Cook's paste flux and is seated in the truss.

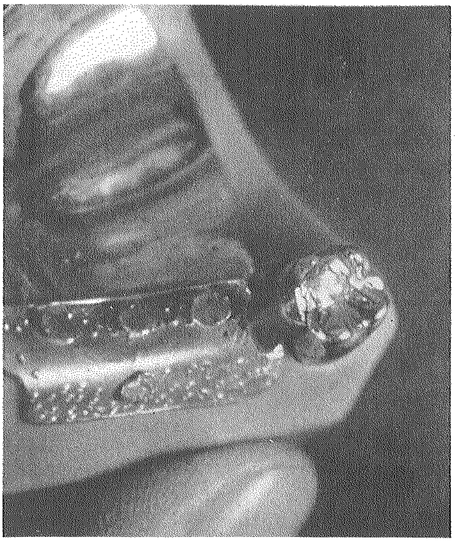
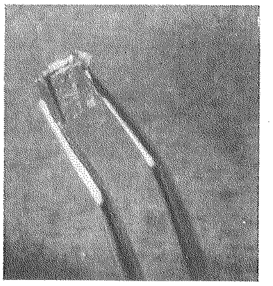


FIG. 372. A wax pattern for the truss.

FIG. 373. Gold casting of the truss.



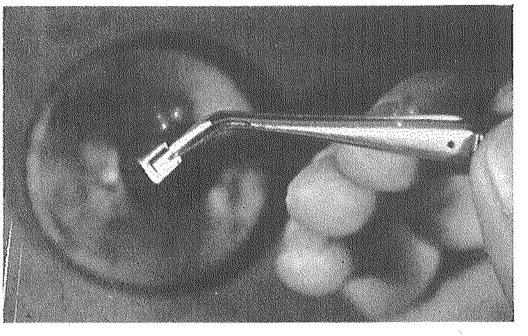
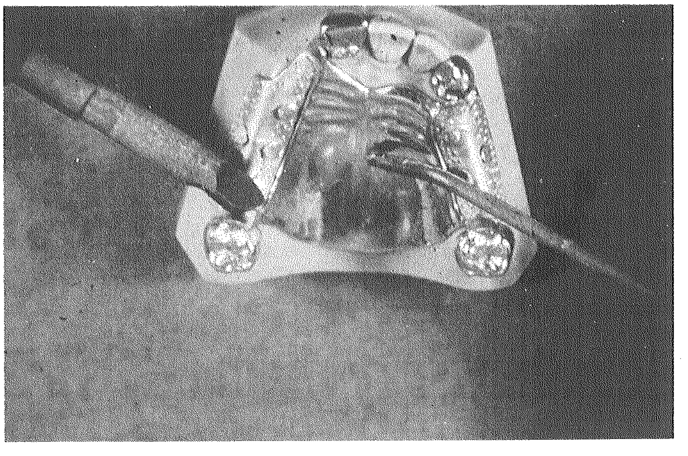


FIG. 374. Soldering the attachment to the truss.

FIG. 375. Soldering the truss to the base.



A very small piece of #800 solder is placed on the top edge of the joint. It is held with solder tweezers (Fig. 374) and soldered in the open flame.

The assembled attachment and truss is placed on the model and welded to the base with an electric soldering machine (Fig. 375). If desired, it can be invested and soldered with a torch just like a conventional attachment. If a stress-breaker is to be used, it is waxed and cast as a separate unit (Fig. 376). This is completely assembled, and then

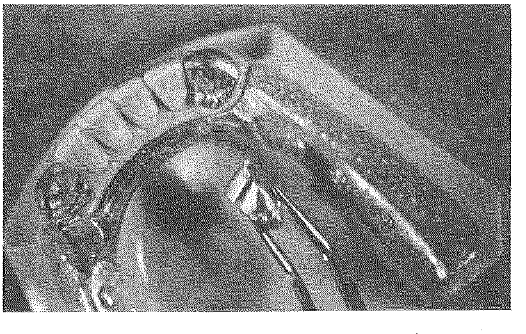
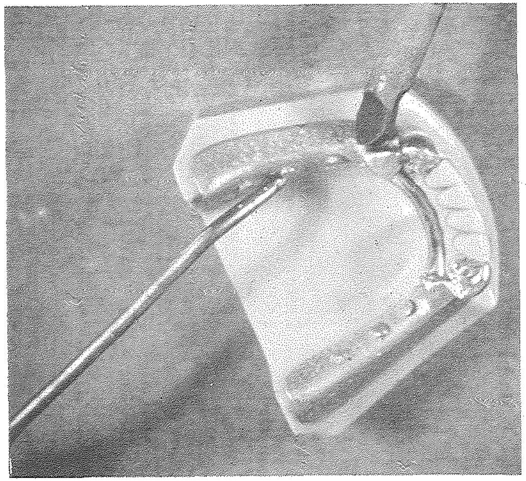


FIG. 376. The stress-breaker unit.



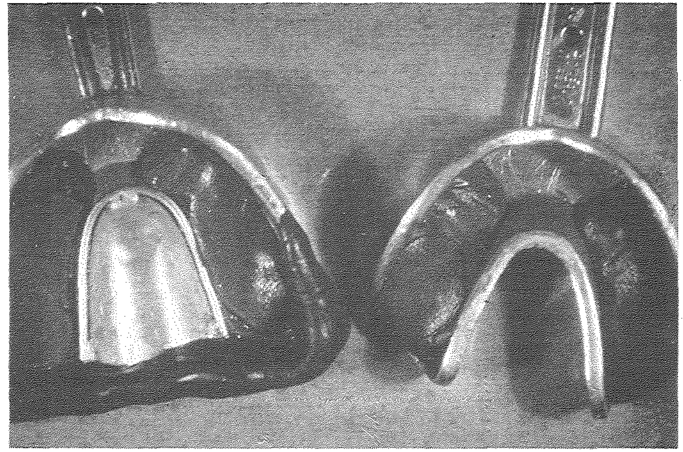
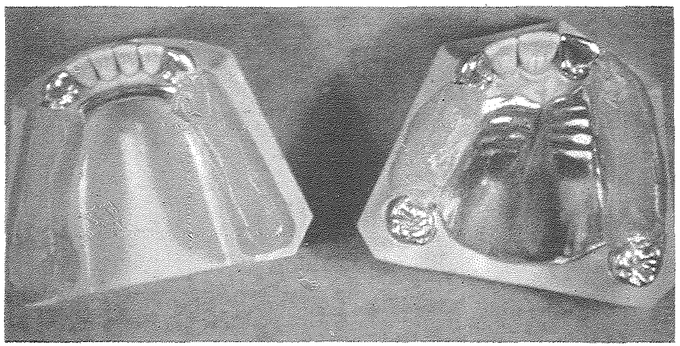


FIG. 377 (*Top, left*). Soldering the stress-breaker to the base.
FIG. 378 (*Bottom, left*). A bite block for mounting.
FIG. 379 (*Top, right*). The compound in the bottoms of the trays.
FIG. 380 (*Bottom, right*). Testing the compound.



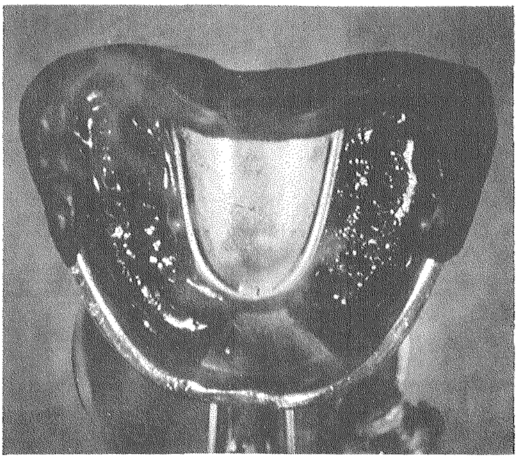


FIG. 381. Softening the compound with dry heat.

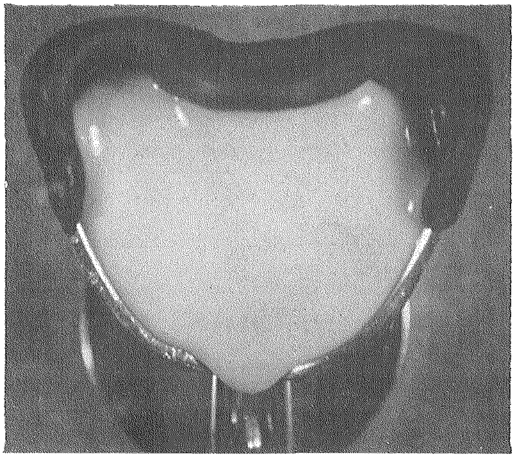


FIG. 382. The tray is filled only in front.

welded to the base (Fig. 377) with the electric soldering machine. If it is invested to solder with a torch, the attachment and the screw must be removed before investing.

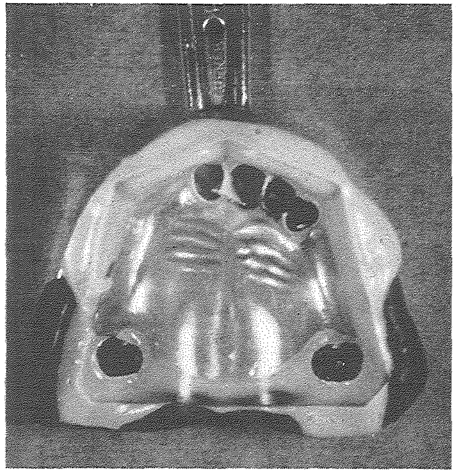
The case is now ready for remounting, along with any restorations on other teeth which may be a part of the whole case. Bite blocks are formed on the bases (Fig. 378), using either Sure Set Wax or self-curing acrylic. Sure Set Wax is hard enough for this purpose and much easier to trim in the mouth. The bite blocks should be adjusted in the mouth so that they do not quite touch. A face-bow mounting and a sheet-wax bite are taken before the impression is made. This is important as some of the restorations, frequently, and the partial usually, will come out with the impression.

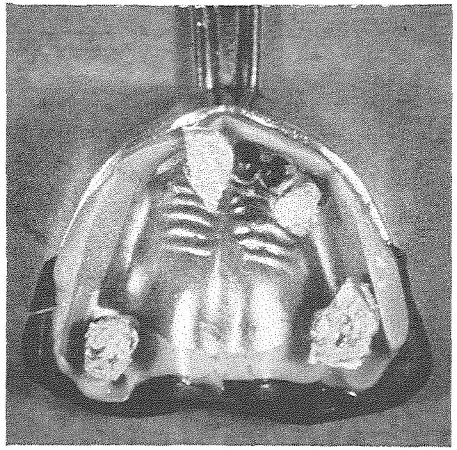
A layer of impression compound sufficient to provide a seat for the restorations is sealed in the bottom of the tray (Fig 379). The upper is postdammed. The tray is immersed in hot water, and the compound is slightly overheated so that it flows freely without being sticky. The type of compound to be used depends upon the hydrocolloid temperature. Kerr's red compound works well with Kerr's De-elastic and will not soften the bite blocks.

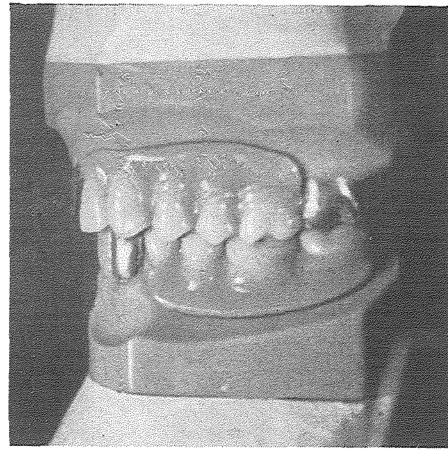
The tray is seated in the mouth (Fig. 380) to check the compound, which should be adequate to provide a good seat and yet not run into undercuts and lock the impression when it is removed. It is removed and the compound is heated with an alcohol torch (Fig. 381) until it flows into the indentations formed when it was tested in the mouth.

While this is being done, the hydrocolloid is transferred to a tempering bath of 125° F., in which it is left for about 5 minutes. Care must be taken not to let it become too stiff. Still of a flowing consistency, the colloid is squeezed from the tube to fill the tray in front and just cover the compound in the posterior region (Fig. 382). The filled tray is placed in the tempering bath of 125° F. for 2 minutes before being carried to the mouth. It is seated posteriorly and then carried up over the teeth. Finally, it is pressed to place with firm, hard pressure until a definite stop is felt. It is chilled with 70° F. water for 5 minutes.

No attempt should be made to remove the tray by grasping the handle and pulling. Instead, the fingers are placed on each side of the rim in the bicuspid region, and the tray is removed with a straight downward pull from the upper, or a straight upward pull from the lower. When it is removed, usually the partial and some of the abutments will







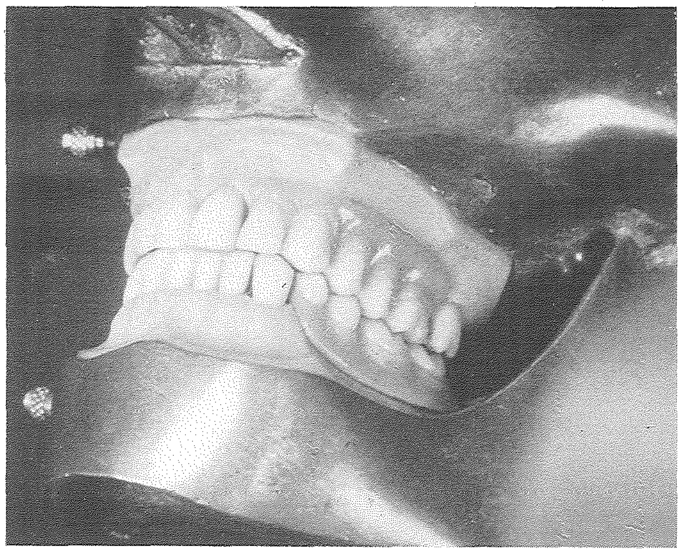


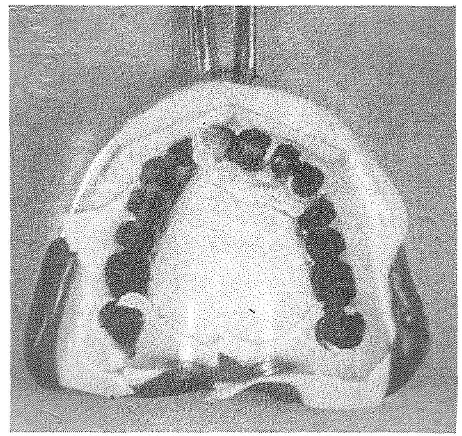
FIG. 383 (*Top, left*). The base remains in the impression.

FIG. 384 (*Top, center*). Restoration and dies seated in the impression.

FIG. 385 (*Top, right*). The completed restoration.

FIG. 386 (*Bottom, left*). The restoration in the mouth.

FIG. 387 (*Bottom, right*). The remount impression with a compound seat.



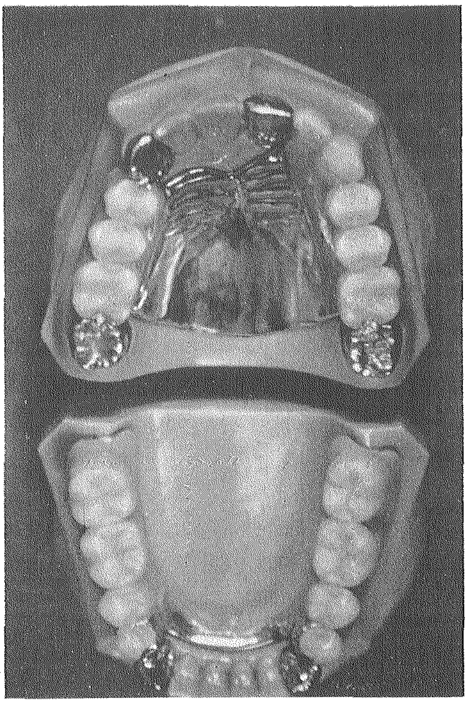


FIG. 388. Remount models.

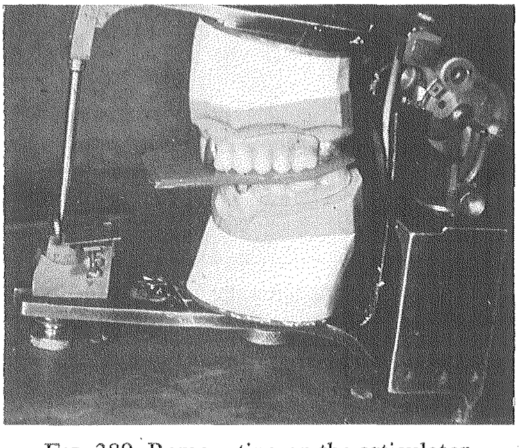


FIG. 389. Remounting on the articulator.

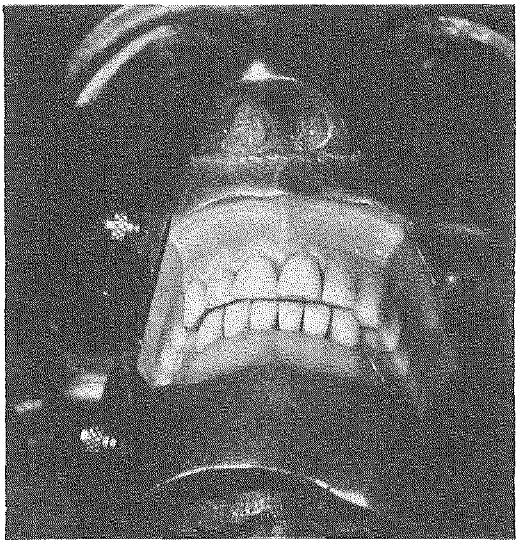


FIG. 390. Checking the restoration for centric.

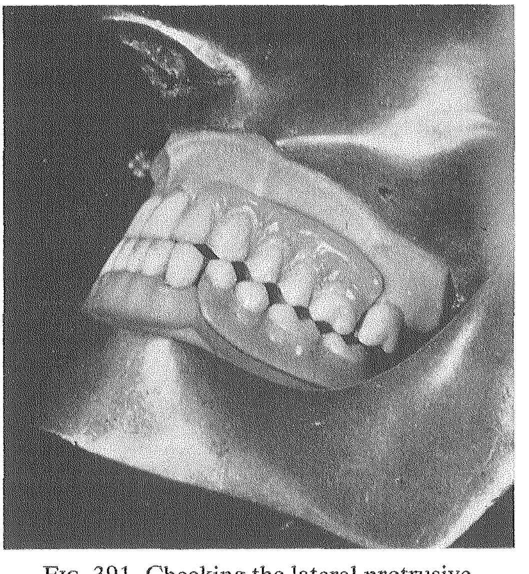
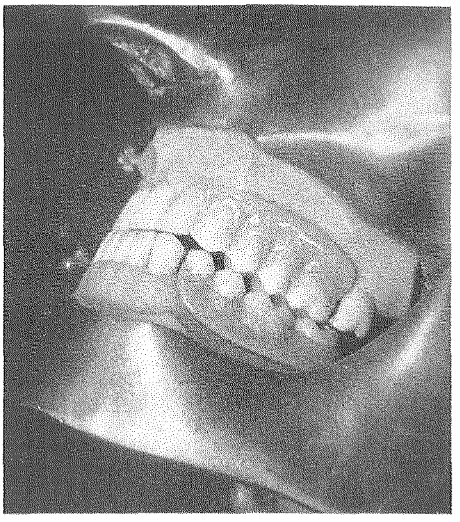


FIG. 391. Checking the lateral protrusive.

be in the impression (Fig. 383), locked in the compound. These are tested to see that they do not rock, and the remainder of the restorations are placed in the impression. The Melotte's metal dies are inserted (Fig. 384), and the model is poured in Vel Mix or a similar stone. The models are mounted (Fig. 385) and the case is completed in the usual manner.

When the restoration is tried in the mouth (Fig. 386), no matter how well it may appear to function, a new remount is taken. To correct any errors or warpage which may have occurred in processing, a new remount impression (Fig. 387) and mounting should be made. The models (Fig. 388) are poured with the dies in case any corrections are required.



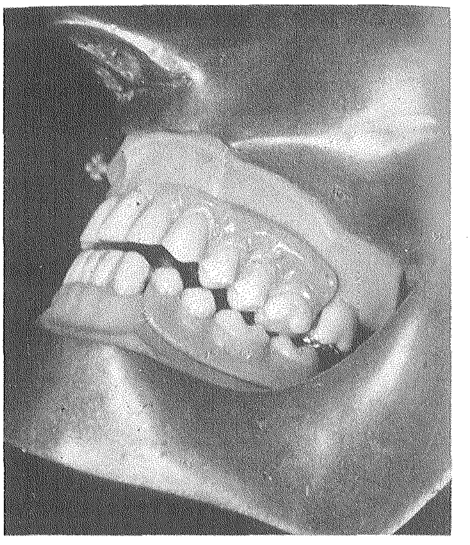


FIG. 392 (*Left*). Checking the protrusive.
FIG. 393 (*Right*). Checking the balance.

The bite may be sheet wax, stone with wax stops, or zinc oxide paste. In any event, the restoration is returned to the articulator (Fig. 389) for final adjustments. No attempt should be made to make these adjustments directly in the mouth. The completed restoration is then tested in the mouth for centric (Fig. 390), lateral protrusive (Fig. 391), straight protrusive (Fig. 392), balance (Fig. 393), and working bite (Fig. 394).

The abutments are cemented for 3 months or longer with a suitable temporary cement and are checked again before final cementation.

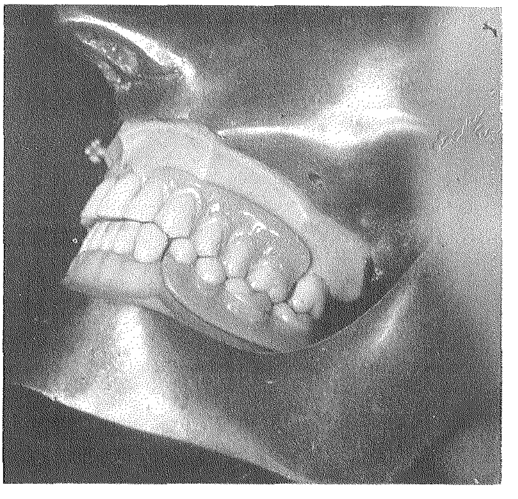


FIG. 394. Checking the working bite.

*Chapter* 21

# Correction of Occlusal Disharmonies

DANIEL ISAACSON, D.D.S.*

Imperfections in the articulation of teeth will arise during the prosthetic laboratory phases of completing cases. Deviations from the normal that are not of a gross nature can be corrected by judicious grinding of the gold or porcelain surfaces. Promiscuous grinding of any surface without a well-developed plan, or the milling in of such mutations by rubbing abrasive material between the teeth, is an incorrect procedure. These methods might weed out some prematurities; however, they would also remove valuable contacts in other excursive movements. The teeth should touch in all positions to maintain a balanced articulation. Therefore, it is vital to develop a procedure which will eliminate prematurities without removing continuous contact during the other excursions. It is imperative for both the dentist and the laboratory technician to know when to deepen a fossa. They must understand when to grind the lower teeth and when an upper tooth can be touched.

Extensive grinding may be necessary to bring surfaces that are out of contact into a normal relationship. The correction of premature contacts on one side of the mouth will bring adjacent teeth as well as teeth on the opposite side of the arch into contact. It is possible the ideal relationship of all cusps and surfaces cannot be reached by grinding alone. Additional material may be required on the occlusal surfaces.

It is necessary for the operator who is grinding in an articulation to have a complete understanding of the ideal relationships of cusp to cusp, arch to arch, and arches to cranial anatomy. These relationships have been described in detail elsewhere in this text. Only with such a mental image of the final goal is the operator equipped to proceed.

The procedures here described cannot be utilized to bring a completely disorganized articulation to a satisfactory relationship. They can be useful only if the articulation has been disrupted by slight, almost imperceptible errors that prevent an exact coming together of the teeth. If the error has been so great that the relationship of cusp to fossa or surface to surface is completely disoriented, the rules are valueless. If, for example, the lower cusps are half a tooth away from their ideal relationship to the maxillary dentition, another solution to the problem must be found. Rearticulating the master models and ultimately recarving the teeth are necessary for the correction of such gross errors.

In the fabrication of a full-denture prosthesis the rules given are useful in many instances when errors creep into the procedures. For example, the position of the mandibular arch in relation to the maxillary arch may have been disturbed from the normal because of a minor discrepancy in the

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centric relation record. Very often the condyles will drop from their most superior position in the glenoid fossa, and a physiologic rest position of the condyle is recorded rather than true centric relation. Even the most careful technician occasionally will allow shifting of a tooth during the processing of the acrylic. Also, dimensional changes of the materials may take place during processing. The aim is to create a denture base which will remain stable. However, after the patient has worn the dentures for a while, the bases may shift. This will create a slight disorganization of the occlusion. Muscle changes which alter the patient's closure pattern may occur after a time. If they are minor, these errors can be corrected by remounting and regrinding the teeth.

In oral rehabilitation, errors of a similar nature will create the need for a grinding technic. Inaccuracy of centric relation records, dimensional changes in materials used and muscle changes are a few of the factors that will create error. Exact positioning of the restorations on the teeth may be slightly different from the counterpart on the master model. Soldering connections may alter the exact positioning of the fixed bridgework. The error created may not produce a marginal defect, yet the articulation may be off a hairbreadth. Defective margins can be corrected only by resoldering inaccurate connections. Before proceeding with any grinding, the margins, the contact areas and all other aspects of the case should be checked. If all check out with the exception of the articulation, then the remount procedure must be utilized to remount the master models. This is done as follows: The castings are cemented in place with a treatment cement—the cementing medium is used to simulate the final cemented position so that the exact conditions are recorded. The face bow and the centric relation records are retaken. An upper and a lower impression are taken, using suitable impression material. The face bow record is used to mount the upper, and the centric relation record is used to mount the lower master model.

In full-denture prosthesis and oral rehabilitation, the first step in the grinding procedure is to test the teeth accurately for occlusal contact in centric relation. As in the setting of porcelain teeth, they are tested in all excursions before any correction is attempted. With the guidance of the descriptions and the illustrations, the proper surfaces are ground so that centric prematurities are eliminated. Then the prematurities in the other excursions are ground away. If the rules outlined are followed the teeth will be reoriented in centric, and they will stay together during the full functional range of mandibular movement without losing valuable contacts.

Many of the sample descriptions in the 9 problems at the end of this chapter show the teeth in normal contact in all but one excursion. This is done to simplify the explanations. Often, especially in the earlier stages of grinding, these contacts may be missing rather than normal. The procedures described are valid for these instances even though contacts may not be present. Grinding is continued until contact is made. If the rules given are used continually after contact has been made, the contiguity will be maintained for further improvement. The prematurities of one side may eventually but erroneously appear to be eliminated. All teeth on that side are in apposition through the various excursive movements. However, contact is negative on the opposite side of the arch. The evenly contacting posterior teeth on one side must be considered premature until a balanced contact has been established throughout the arch. The lateral protrusive position is the only one in which contact on only one side is considered to be normal. Therefore, the process is continued until both sides of the arch have continuous contact throughout the entire functioning range of tooth contact—except, of course, in lateral protrusive.

A point may be reached at which further grinding will endanger the result already

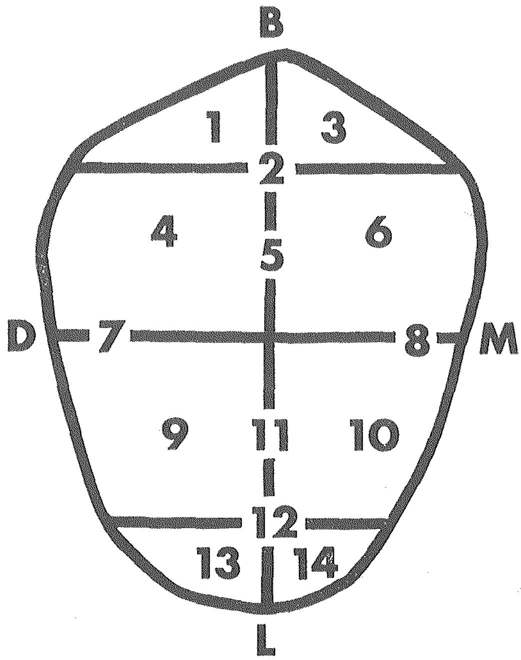



FIG. 395. Ridges and cusp surfaces of a bicuspid.

achieved. In such cases, a procedure that is recommended is the restoration of the lost contact by adding to the deficient area rather than by reducing other areas to bring it into contact. In full dentures, this is done by replacing the tooth in question. In mouth rehabilitation, the procedure is tricky. A good technician will be able to flow solder on the deficient area and grind it into the proper contour.

Figure 395 attempts to determine each surface and area of a tooth exactly, so that the reader may understand the descriptions in the text. Those areas from the crest toward the center are inner surfaces. Those areas from the crest away from the center are outer surfaces. The areas distal to the lingual and the buccal ridges are distal surfaces. Those mesial to those ridges are mesial surfaces. Area 6, for example, is the mesial inner surface of the buccal cusp of the tooth because it is toward the center and mesial to the lingual ridge of the buccal crest.

Buccal Cusp:

1. Distal Outer Surface
2. Crest
3. Mesial Outer Surface
4. Distal Inner Surface
5. Lingual Ridge
6. Mesial Inner Surface

Marginal Ridges:

7. Distal Marginal Ridge
8. Mesial Marginal Ridge

Lingual Cusp:

9. Distal Inner Surface
10. Mesial Inner Surface
11. Buccal Ridge
12. Crest
13. Distal Outer Surface
14. Mesial Outer Surface

B—Buccal

M—Mesial

L—Lingual

D—Distal

## GENERAL RULE

The mesial surfaces of the upper teeth and the distal surfaces of the lower teeth are not stress-bearing surfaces during excursive movements. They may be ground to reduce prematurities if the rules illustrated in the following problems are not violated.

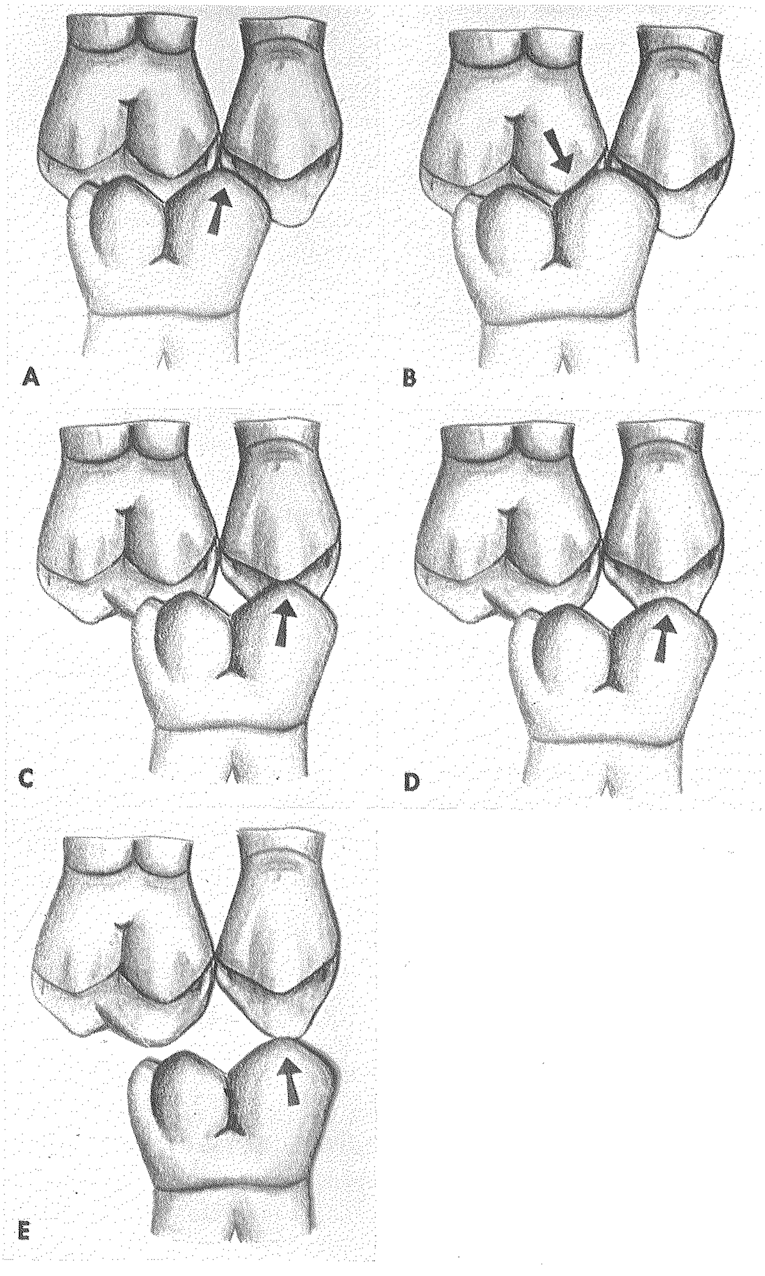



FIG. 396. See Problem 1 on facing page.

## PROBLEMS

### Problem 1
(See Fig. 396)

*Centric Prematurity Plus Prematurities in All Excursions*

(A) The crest of the mesiobuccal cusp of the lower molar is in premature *centric contact* with the mesial inner plane of the mesiobuccal or the mesiolingual cusp of the upper first molar.

(B) In a *lateral excursive* movement on the *working side,* the crest and the outer plane of the mesiobuccal cusp of the lower first molar prematurely contact the mesial inner plane of the mesiobuccal cusp of the upper first molar.

(C) In a lateral protrusive excursion, the mesiobuccal cusp of the lower molar prematurely contacts the buccal crest of the upper second bicuspid.

(D) In protrusive excursion, the mesiobuccal cusp of the lower first molar prematurely contacts the lingual ridge of the buccal cusps of the upper second bicuspid.

(E) In lateral excursion on the balancing side, the mesiobuccal cusp of the lower first molar prematurely contacts the lingual cusp of the upper second bicuspid.

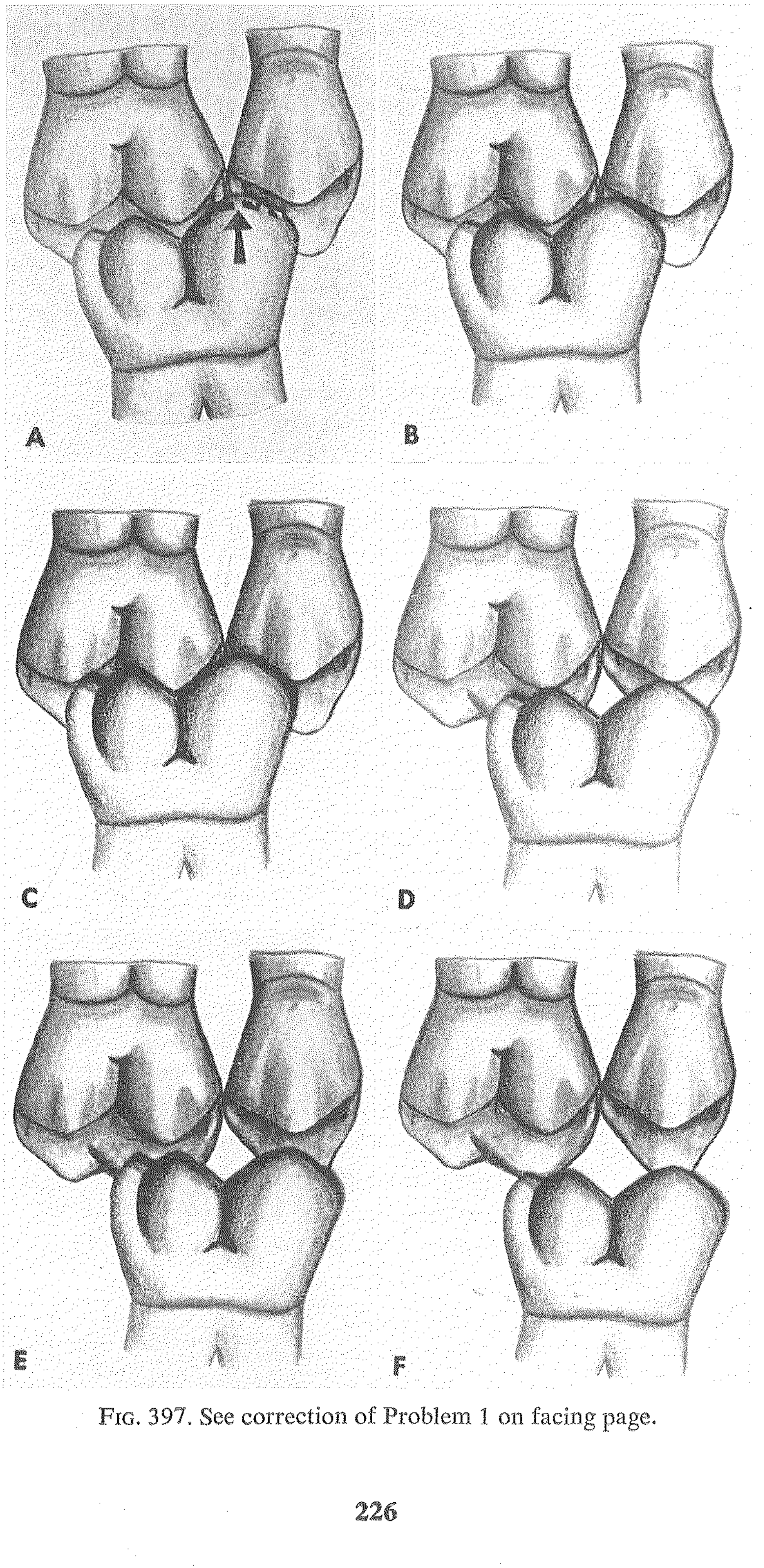



Fig. 397. See correction of Problem 1 on facing page.

## Correction of Problem 1
(See Fig. 397)

### *Centric Prematurity Plus Prematurities in All Excursions*

(A) The crest and the surfaces of the mesiobuccal cusp of the lower first molar are reduced.

(B) The centric contact is corrected.

(C) The working side contact of the lateral excursion is corrected.

(D) The lateral protrusive excursive contact is corrected.

(E) The protrusive excursive contact is normal.

(F) The balancing side contact is normal.

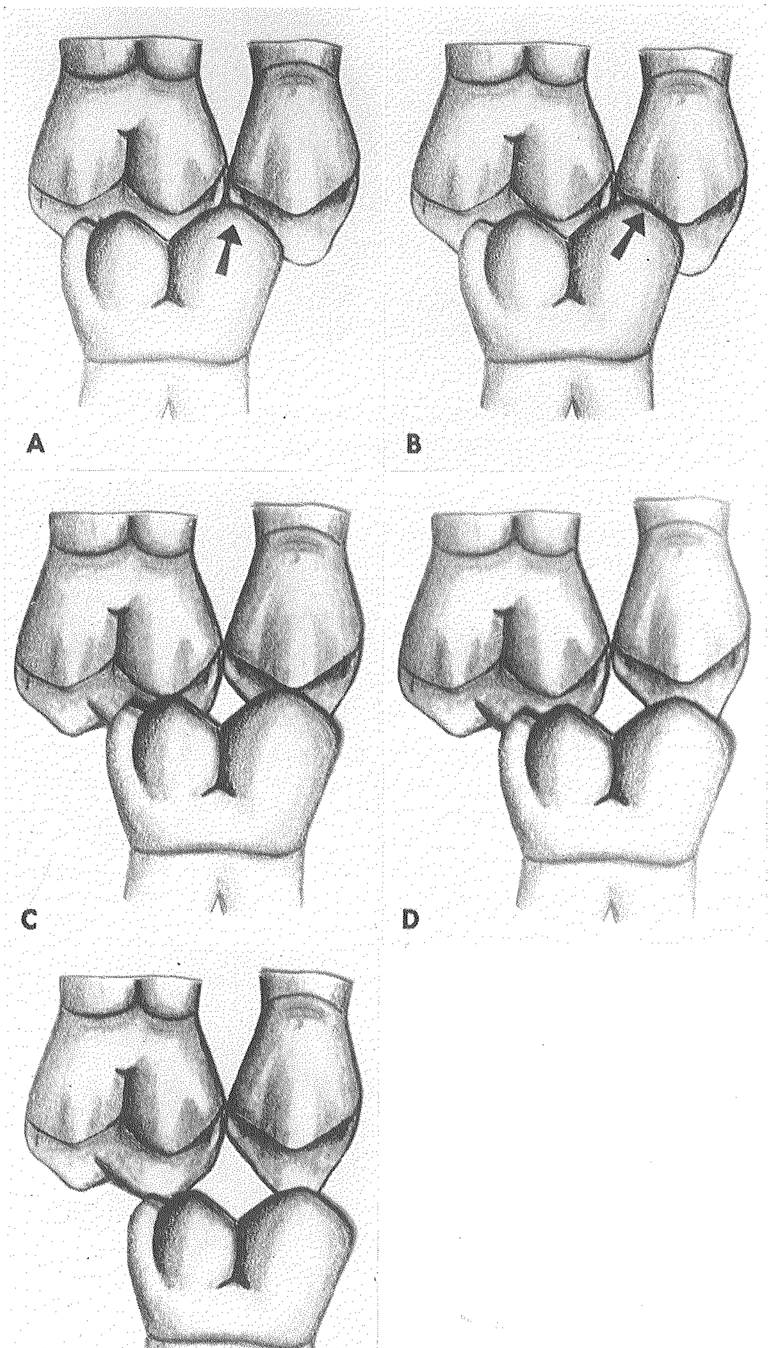



FIG. 398. See Problem 2 on facing page.

## Problem 2
(See Fig. 398)

*Centric Prematurity Plus a Prematurity in One or More But Not in All Excursions*

(A) Prematurity in centric contact. The crest of the mesiobuccal cusp of the lower first molar is in premature contact with one of the marginal ridges of the upper first molar and/or the upper second bicuspid.

(B) Prematurity on the working side of the lateral excursion. The crest of the mesial outer surface of the mesiobuccal cusp is in premature contact with the distal inner plane of the upper second bicuspid as the cusp glides from centric to the extreme lateral excursive position on the working side.

(C) The lateral protrusive excursion contact is normal.

(D) The protrusive excursion contact is normal.

(E) The balancing side of the lateral excursion contact is normal.

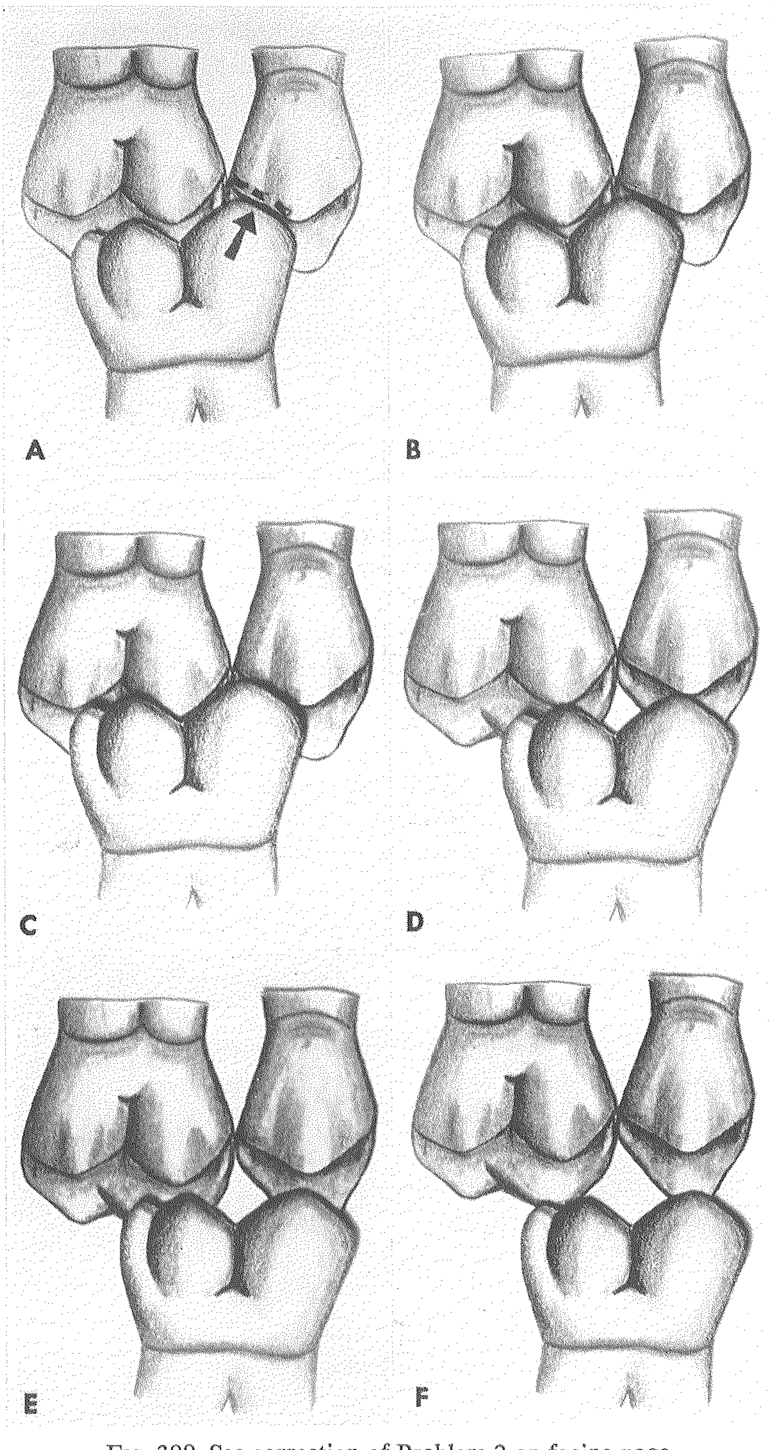



FIG. 399. See correction of Problem 2 on facing page.

Correction of Problem 2
(See Fig. 399)

*Centric Prematurity Plus a Prematurity in One or More But Not in All Excursions*

(A) The marginal ridges and the distal inner plane of the buccal cusp of the upper second bicuspid are ground.

(B) The centric prematurity is eliminated.

(C) The working side prematurity is eliminated.

(D) The lateral protrusive contact remains undisturbed.

(E) The protrusive contact remains undisturbed.

(F) The balancing side contact is undisturbed.

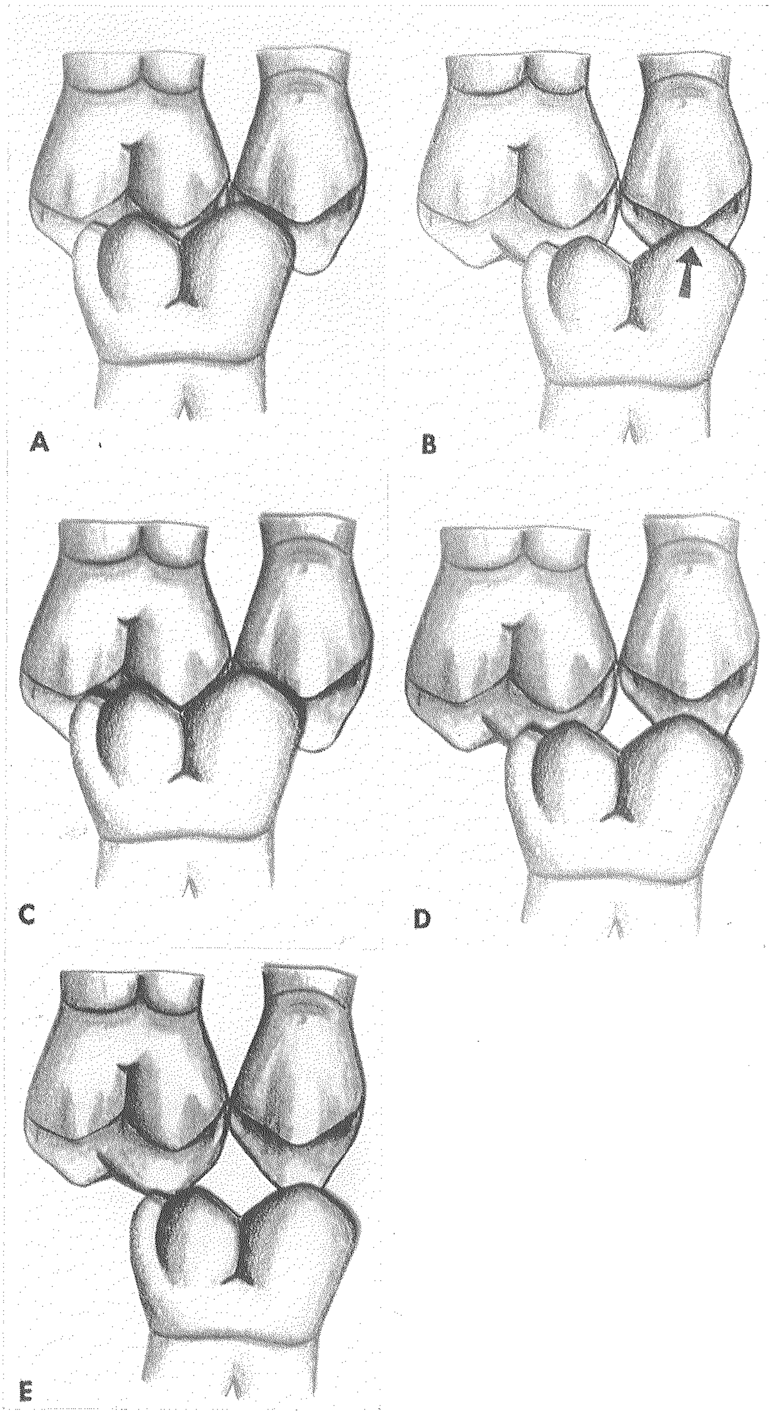


Fig. 400. See Problem 3 on facing page.

Problem 3
(See Fig. 400)

*Centric Contact Normal With Lateral Protrusive Prematurity*

(A) The centric contact is normal.

(B) Prematurity of contact in the lateral protrusive. The crest of the mesiobuccal cusp of the lower first molar prematurely contacts the crest of the buccal cusp of the upper second bicuspid.

(C) The working side contact is normal.

(D) The protrusive contact is normal.

(E) The balancing side contact is normal.

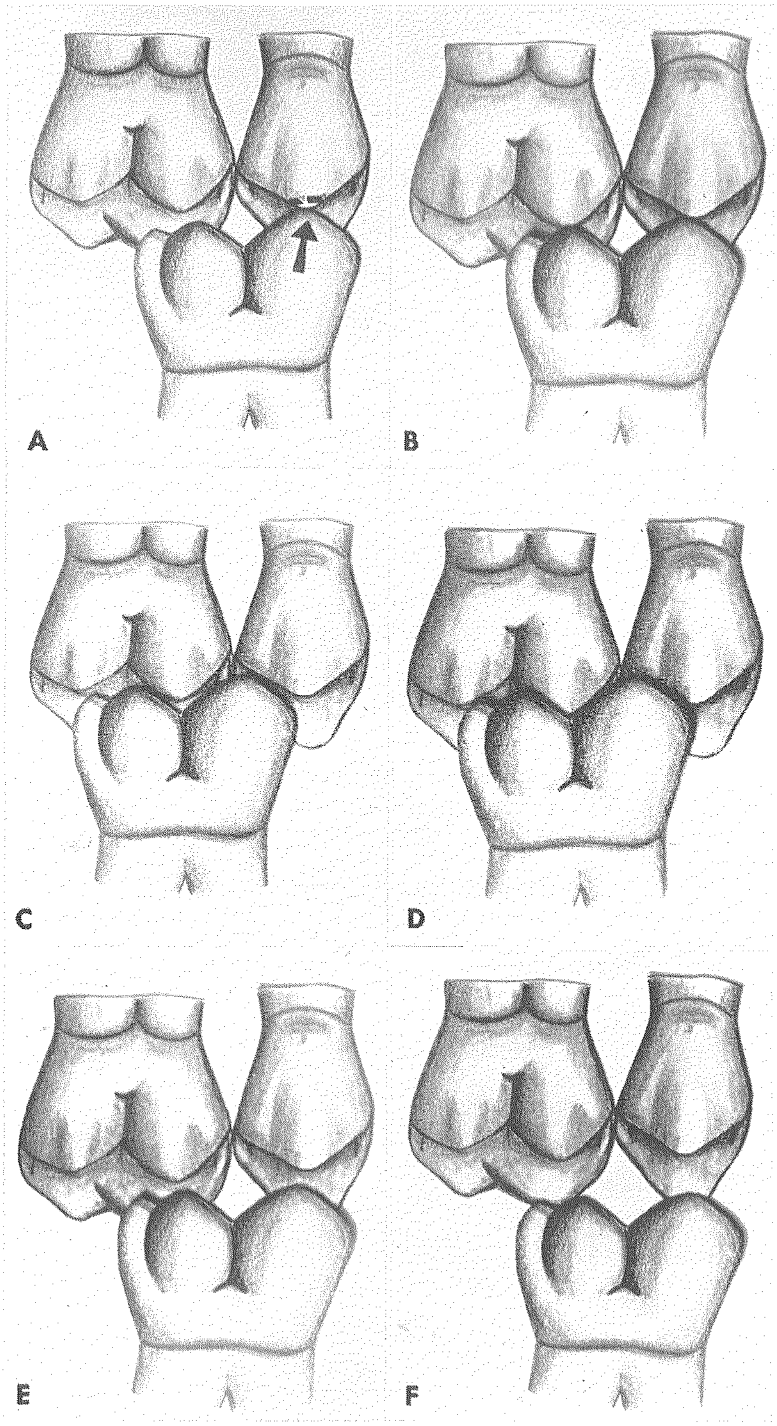


FIG. 401. See correction of Problem 3 on facing page.

Correction of Problem 3
(See Fig. 401)

*Centric Contact Normal With Lateral Protrusive Prematurity*

(A) The crest of the buccal cusp of the second bicuspid is reduced, and any prematurity that is en route to this position is corrected.

(B) The lateral protrusive contact is corrected.

(C) The centric contact is undisturbed.

(D) The working side contact is undisturbed.

(E) The protrusive contact is undisturbed.

(F) The balancing side contact is undisturbed.

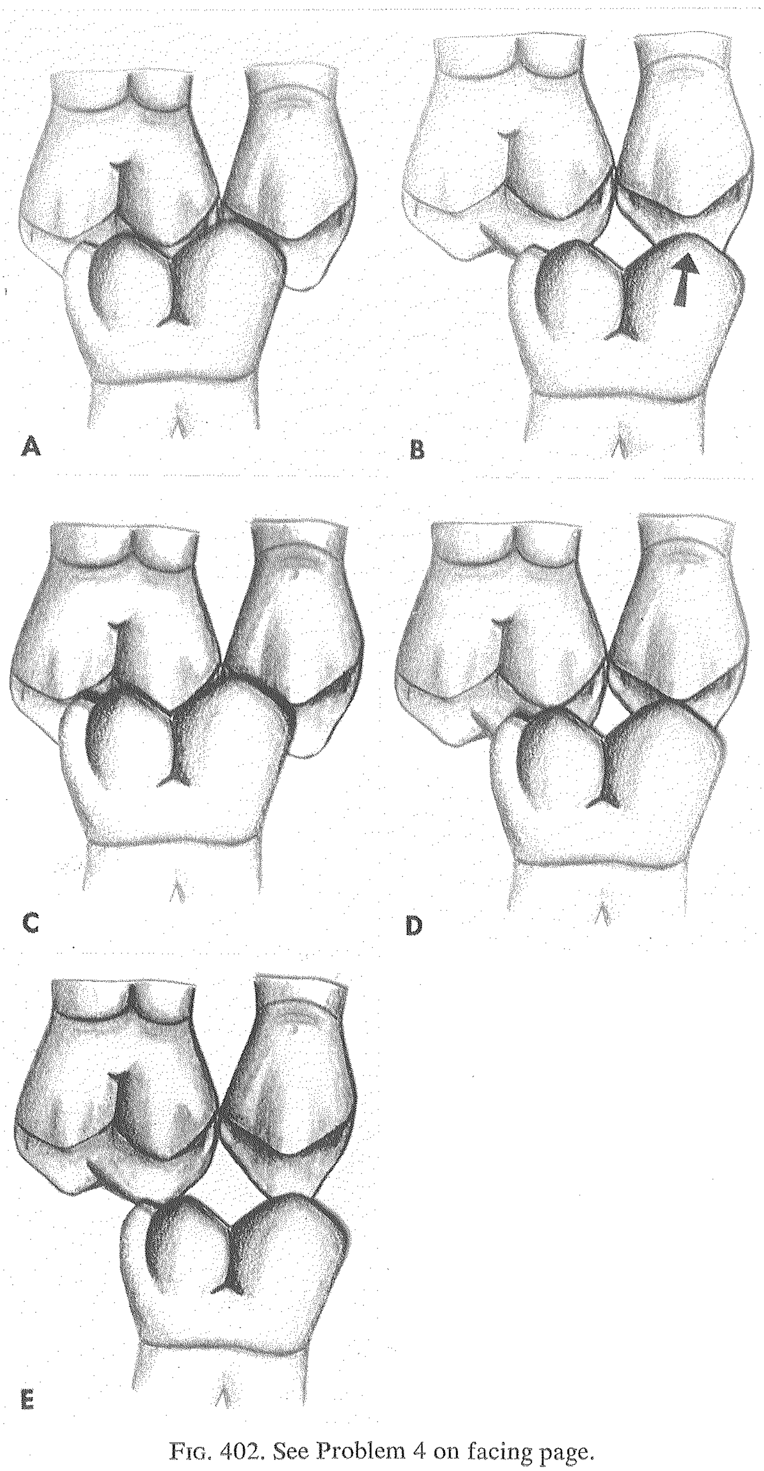




FIG. 402. See Problem 4 on facing page.

## Problem 4
(See Fig. 402)

*Centric Contact Normal With Protrusive Prematurity*

(A) The centric contact is normal.

(B) Prematurity in the protrusive contact. The mesial outer surface and the crest of the mesiobuccal cusp are in premature relation with the lingual ridge of the buccal cusp of the upper second bicuspid.

(C) The working side contact is normal.

(D) The lateral protrusive contact is normal.

(E) The balancing contact is normal.

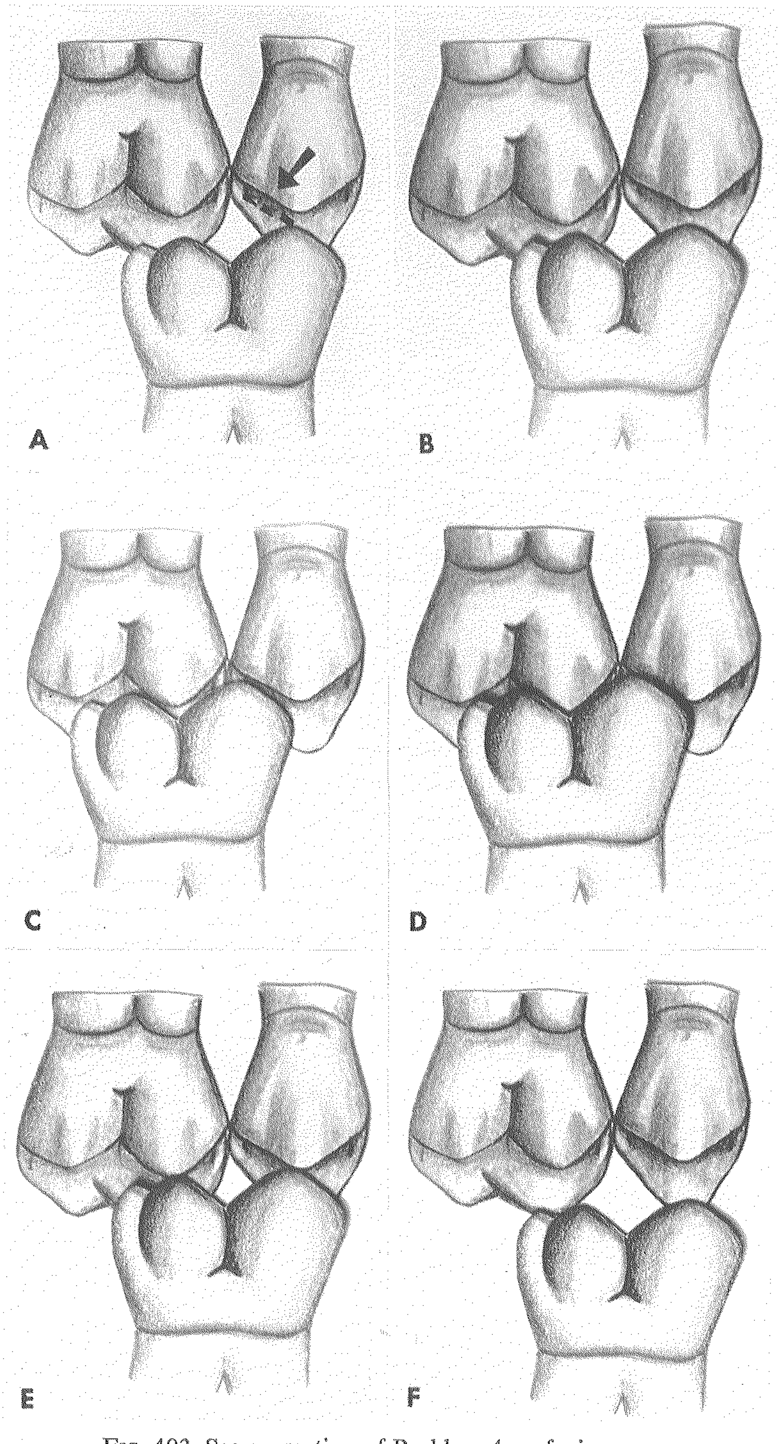



FIG. 403. See correction of Problem 4 on facing page.

Correction of Problem 4
(See Fig. 403)

*Centric Contact Normal With Protrusive Prematurity*

(A) The lingual ridge of the buccal cusp of the upper second bicuspid is reduced from centric to protrusive contact.

(B) The prematurity in the protrusive contact is eliminated.

(C) The centric contact is undisturbed.

(D) The working side contact is undisturbed.

(E) The lateral protrusive contact is undisturbed.

(F) The balancing side contact is undisturbed.

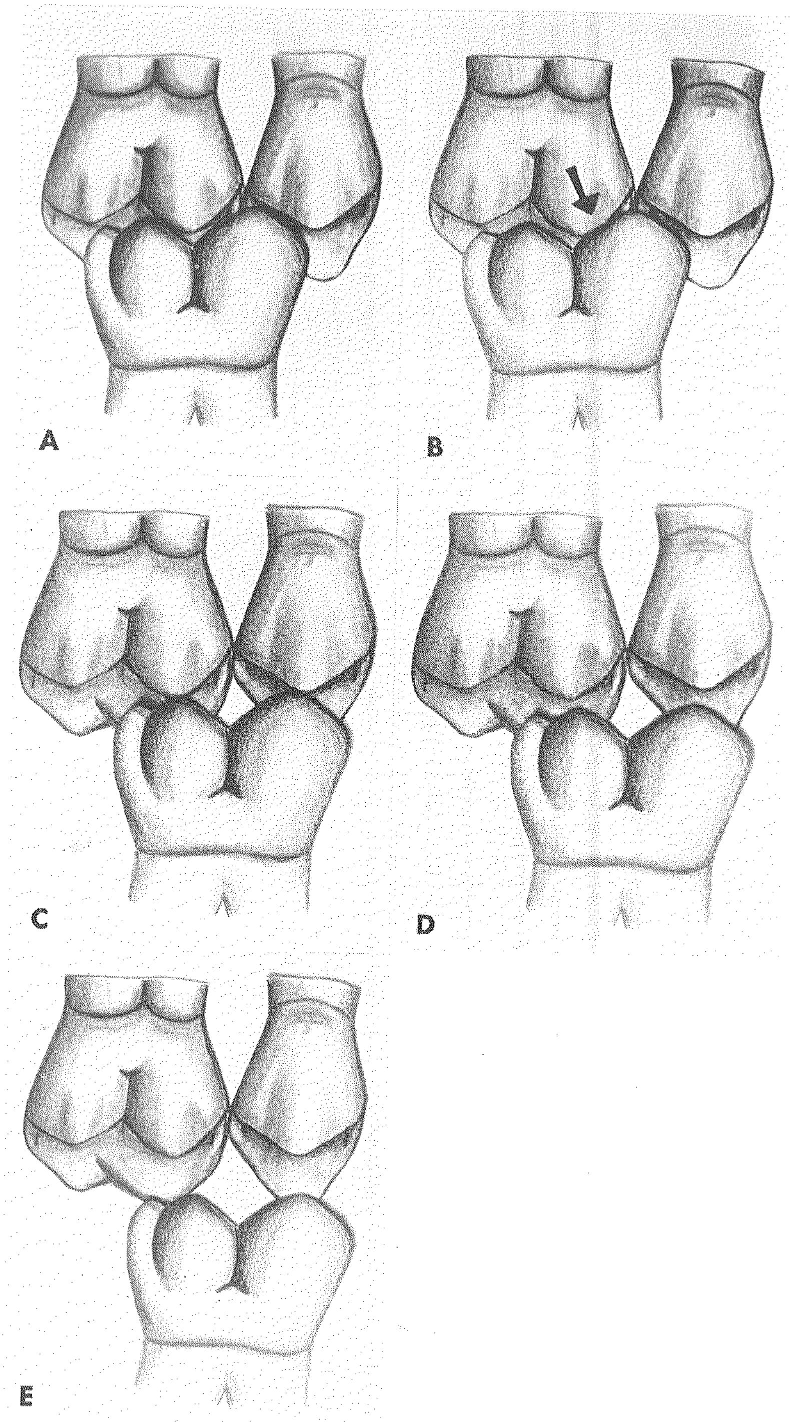



FIG. 404. See Problem 5 on facing page.

## Problem 5
(See Fig. 404)

*Centric Contact Normal With Prematurity in Working Side of Lateral Excursion*

(A) The centric contact is normal.

(B) Prematurity on the working side of the lateral excursion. The distal outer surface and the mesiobuccal cusp of the lower first molar prematurely contact the mesial inner surface of the mesiobuccal cusp of the upper first molar.

(C) The lateral protrusive contact is normal.

(D) The protrusive contact is normal.

(E) The balancing side contact is normal.

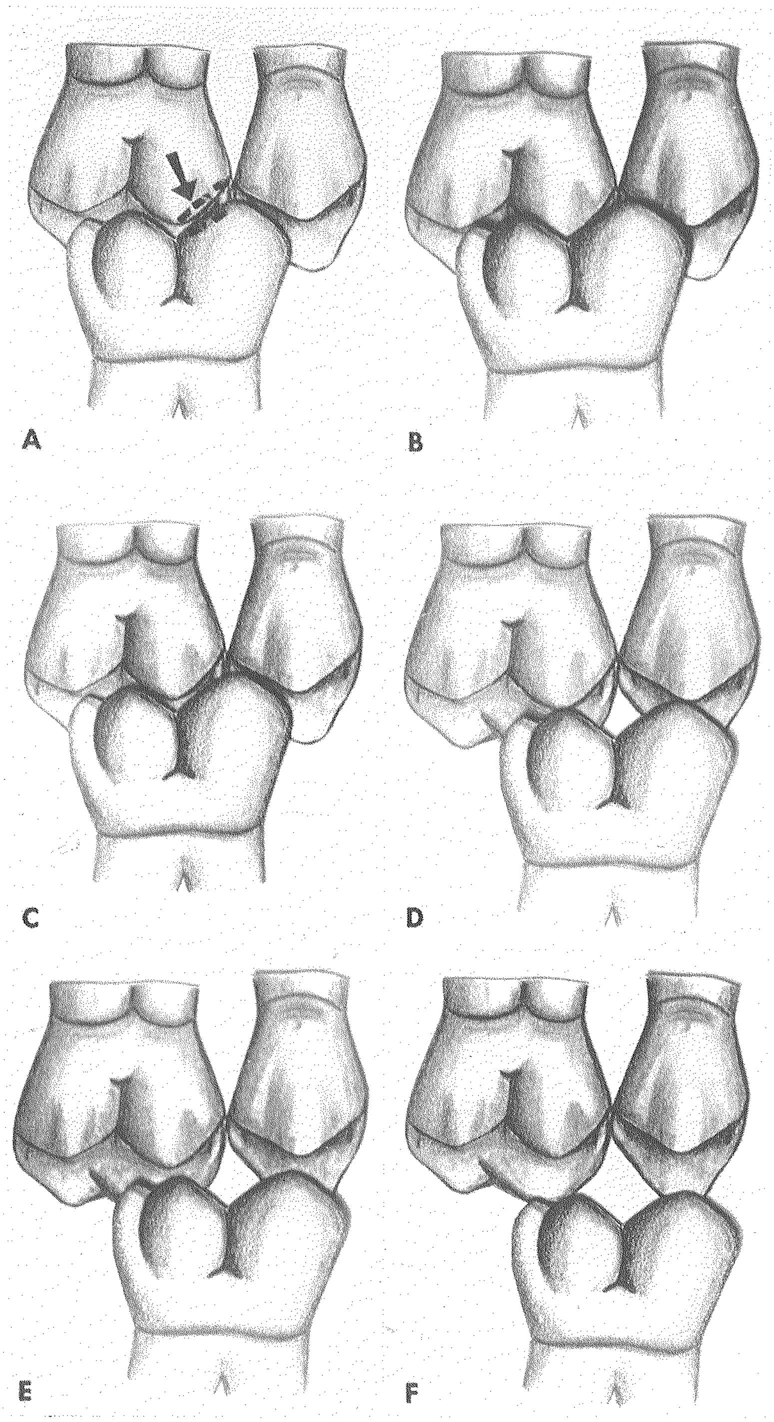



FIG. 405. See correction of Problem 5 on facing page.

## Correction of Problem 5
(See Fig. 405)

*Centric Contact Normal With Prematurity in Working Side of Lateral Excursion*

(A) The mesial inner plane of the upper first molar, or the distal outer plane of the mesiobuccal cusp of the lower first molar, is ground to normal contact during the excursive movement without disturbing centric.

(B) The working side prematurity is corrected.

(C) The centric contact is undisturbed.

(D) The lateral protrusive contact is undisturbed.

(E) The protrusive contact is undisturbed.

(F) The balancing side contact is undisturbed.

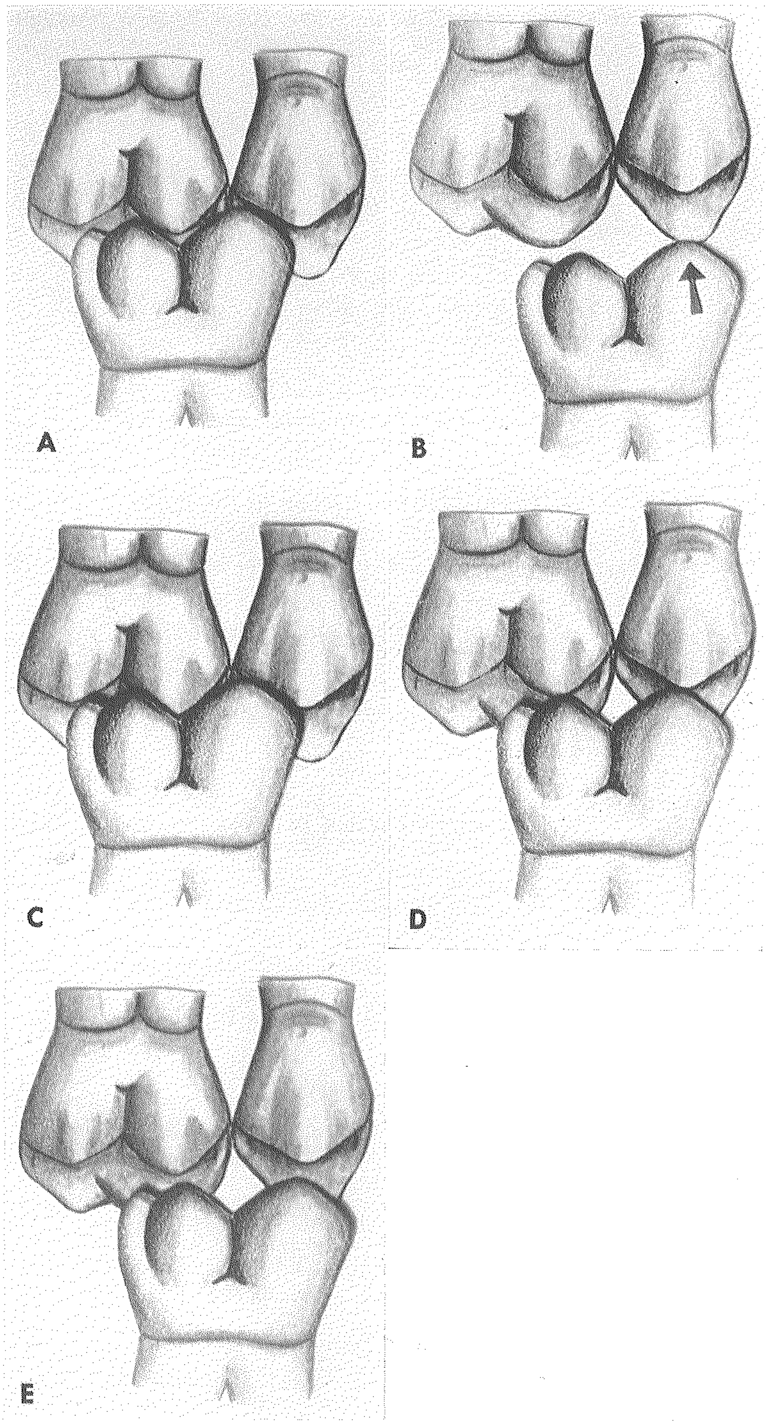


FIG. 406. See Problem 6 on facing page.

## Problem 6
(See Fig. 406)

*Centric Contact Normal With Lingual Cusp Prematurity in Lateral Excursive Position on the Balancing Side*

(A) The centric contact is normal.

(B) During lateral excursion on the balancing side, the lingual cusp of the upper second bicuspid is in premature contact with the mesiobuccal cusp of the lower first molar.

(C) The working side contact is normal.

(D) The lateral protrusive contact is normal.

(E) The protrusive contact is normal.

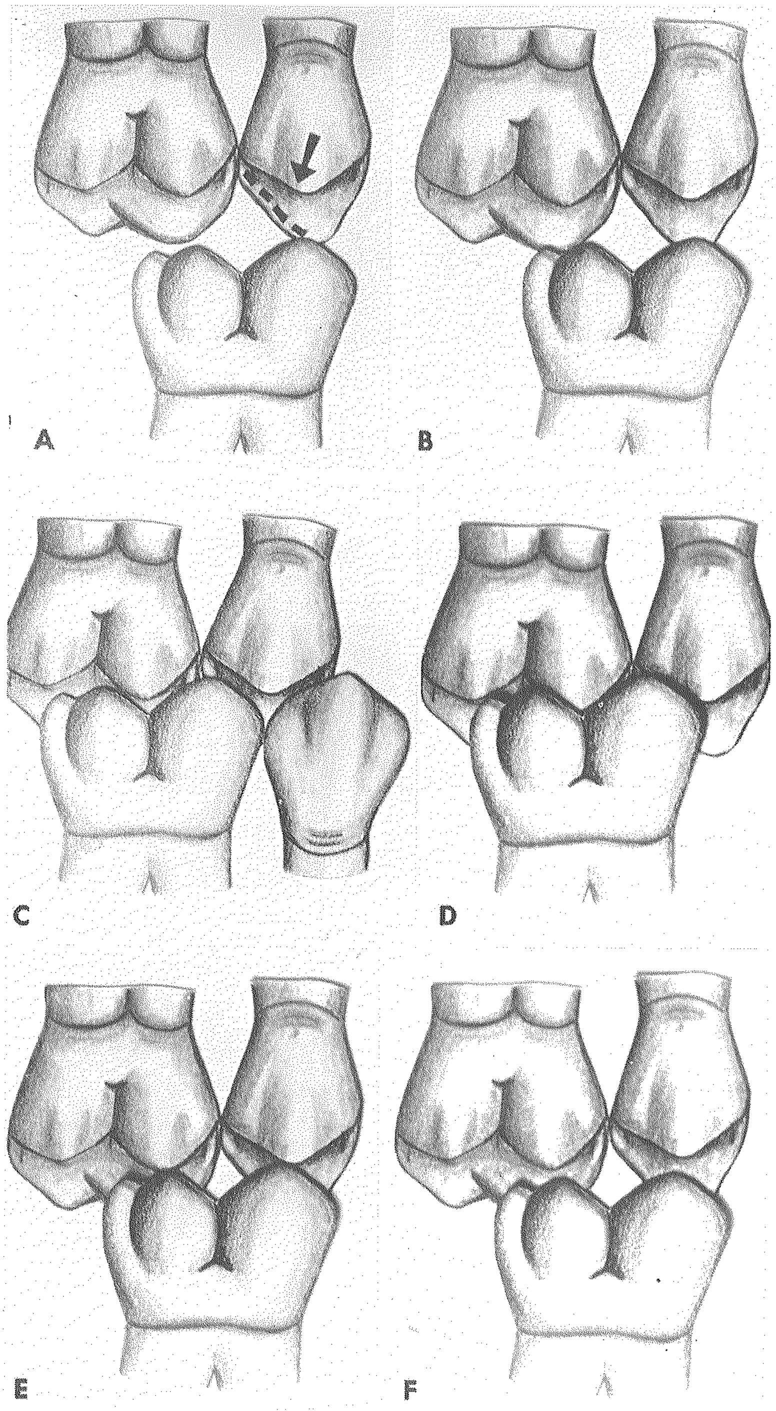




FIG. 407. See correction of Problem 6 on facing page.

## Correction of Problem 6
(See Fig. 407)

*Centric Contact Normal With Lingual Cusp Prematurity in Lateral Excursive Position on the Balancing Side*

(A) The prematurity of the distal inner plane and the crest of the lingual cusp of the upper second bicuspid are reduced.

(B) The balancing side premature contact is eliminated.

(C) The prematurity of the centric contact is eliminated.

(D) The working side contact is undisturbed.

(E) The lateral protrusive contact is undisturbed.

(F) The protrusive contact is undisturbed.

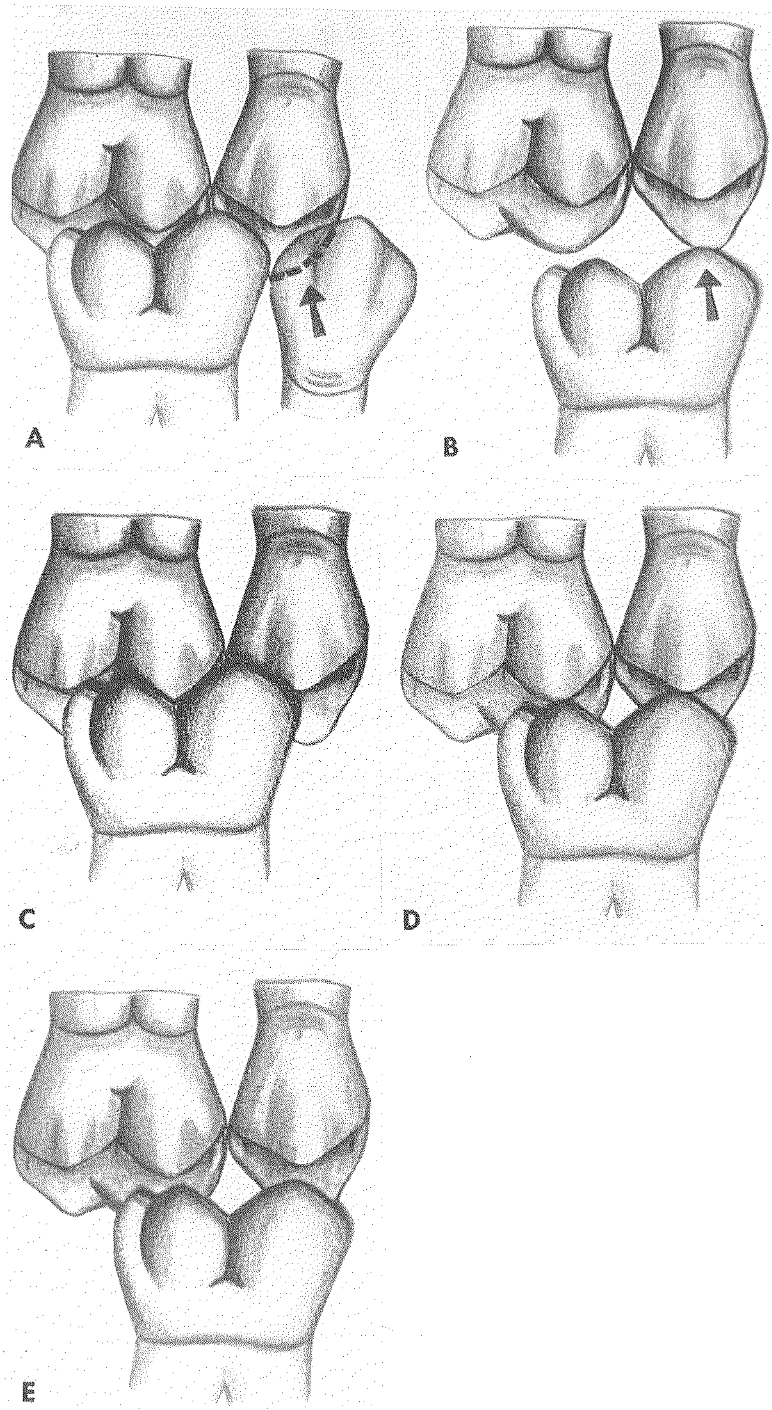



FIG. 408. See Problem 7 on facing page.

## Problem 7
(See Fig. 408)

*Lingual Cusp Prematurity in Centric and Lateral Excursive Positions*

(A) In centric contact, the lingual cusp of the upper second bicuspid is in *premature contact* with the marginal ridges of the lower first molar and the second bicuspid.

(B) During lateral excursion on the balancing side, the mesiobuccal cusp of the lower molar prematurely contacts the lingual cusp of the upper second bicuspid.

(C) The working side contact is normal.

(D) The lateral protrusive contact is normal.

(E) The protrusive contact is normal.

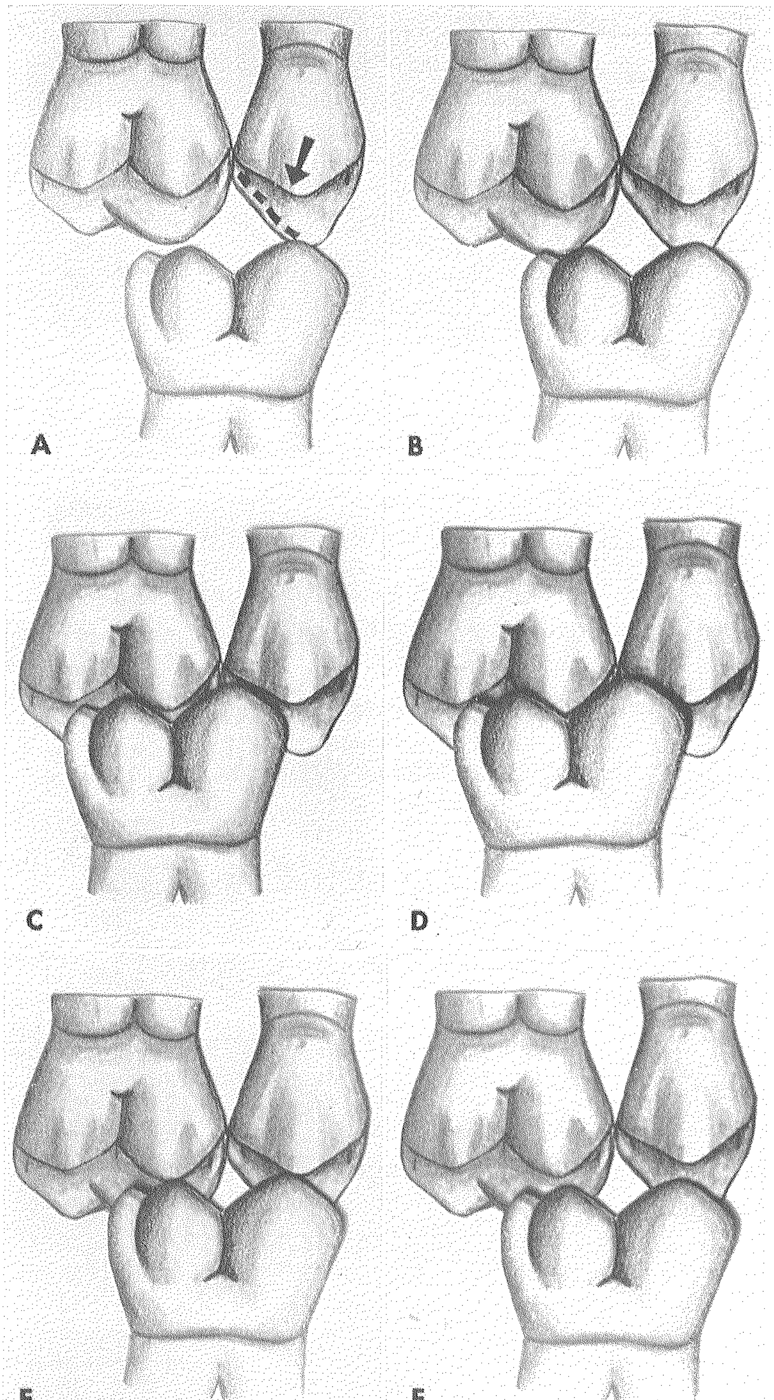



FIG. 409. See correction of Problem 7 on facing page.

Correction of Problem 7
(See Fig. 409)

*Lingual Cusp Prematurity in Centric and Lateral Excursive Positions*

(A) The distal inner plane and the crest of the lingual cusp of the upper second bicuspid are reduced to correct the prematurity in centric and in the excursive movement.

(B) The balancing side premature contact is eliminated.

(C) The prematurity of the centric contact is eliminated.

(D) The working side contact is undisturbed.

(E) The lateral protrusive contact is undisturbed.

(F) The protrusive contact is undisturbed.

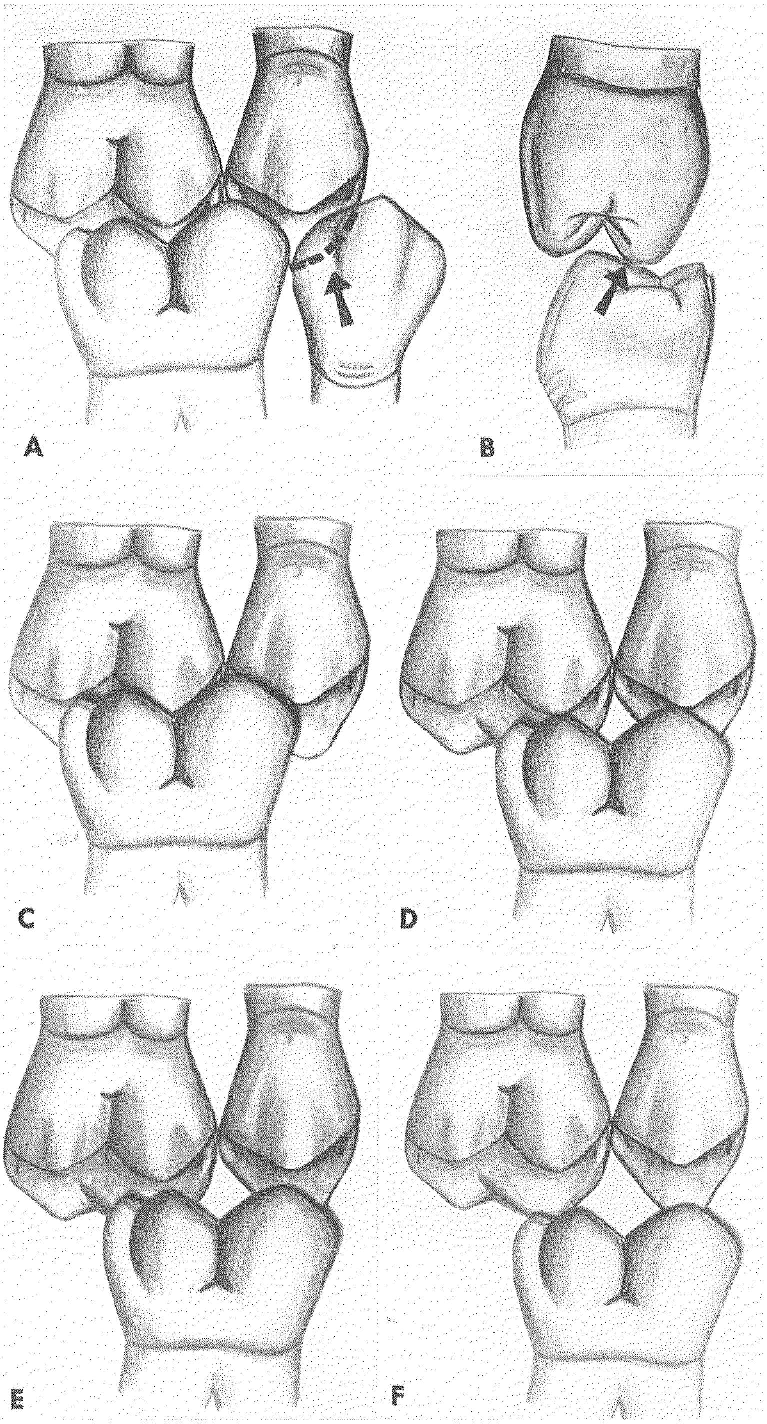


FIG. 410. See Problem 8 on facing page.

Problem 8
(See Fig. 410)

*Lingual Cusp Prematurity in Centric Only*

(A) and (B) In centric contact, the lingual cusp of the upper second bicuspid is in *premature contact* with the marginal ridges of the lower first molar and the second bicuspid.

(C) The working side contact is normal.

(D) The lateral protrusive contact is normal.

(E) The protrusive contact is normal.

(F) The balancing side contact is normal.

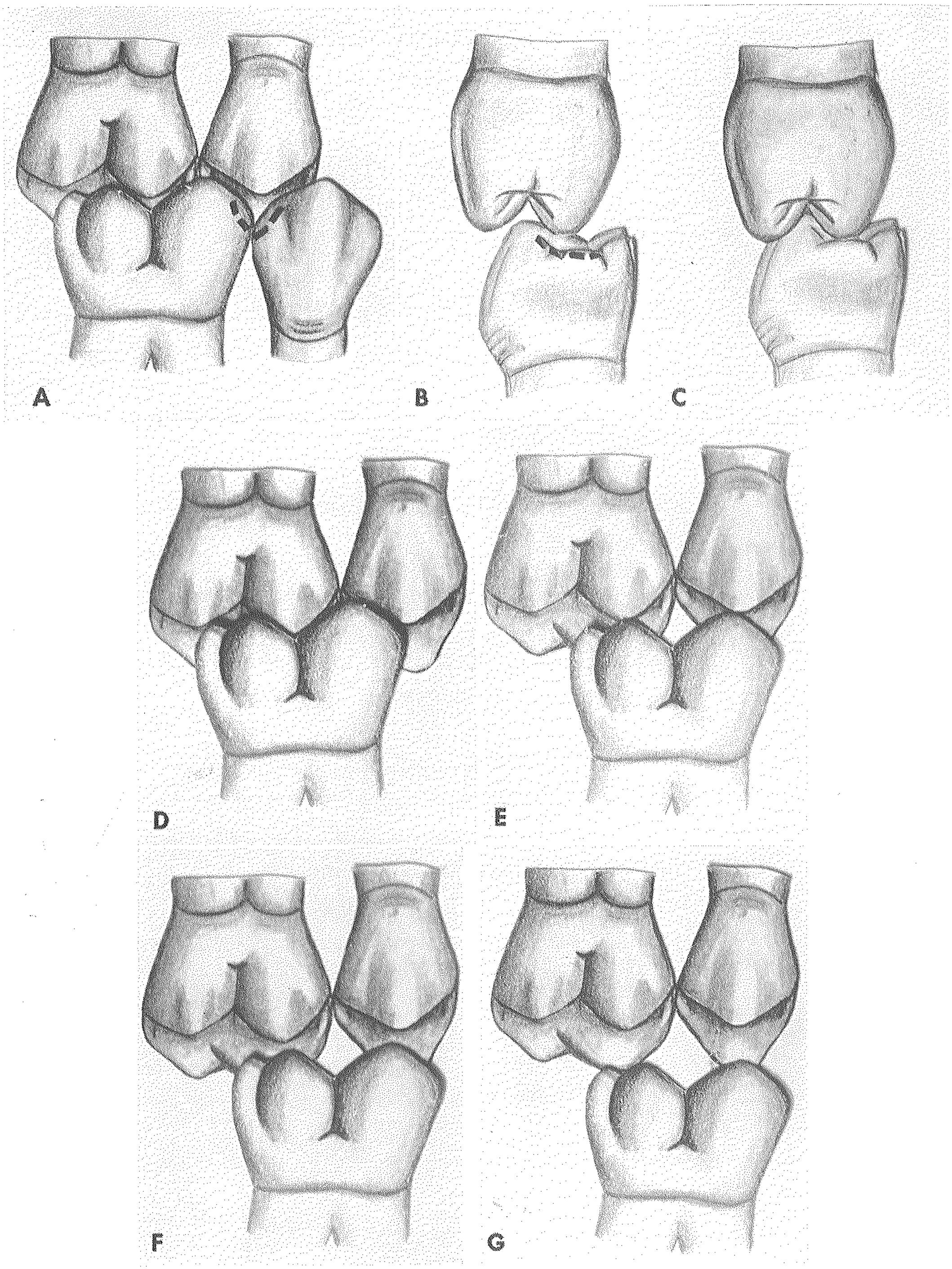



FIG. 411. See correction of Problem 8 on facing page.

## Correction of Problem 8
(See Fig. 411)

*Lingual Cusp Prematurity in Centric Only*

(A) and (B) The distal marginal ridge of the lower second bicuspid and the mesial marginal ridge of the lower first molar are reduced.

(C) The centric contact is corrected.

(D) The working side contact is undisturbed.

(E) The lateral protrusive contact is undisturbed.

(F) The protrusive contact is undisturbed.

(G) The balancing side contact is undisturbed.

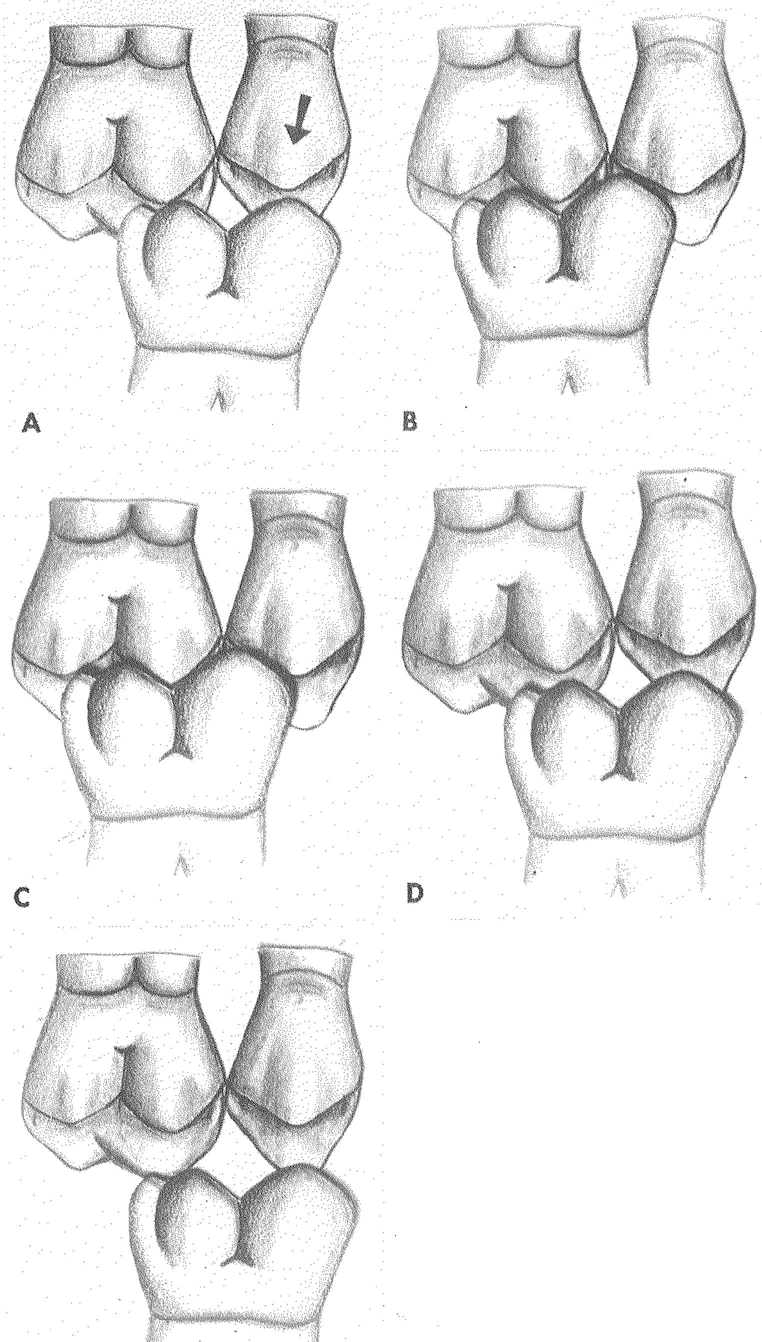



FIG. 412. See Problem 9 on facing page.

Problem 9
(See Fig. 412)

*Loss of Contact; Further Grinding Contraindicated*

(A) The centric contact is normal.

(B) In lateral protrusive, the mesiobuccal cusp of the lower first molar does not contact the buccal cusp of the upper second bicuspid.

(C) The working side contact is normal.

(D) The protrusive contact is normal.

(E) The balancing side contact is normal.

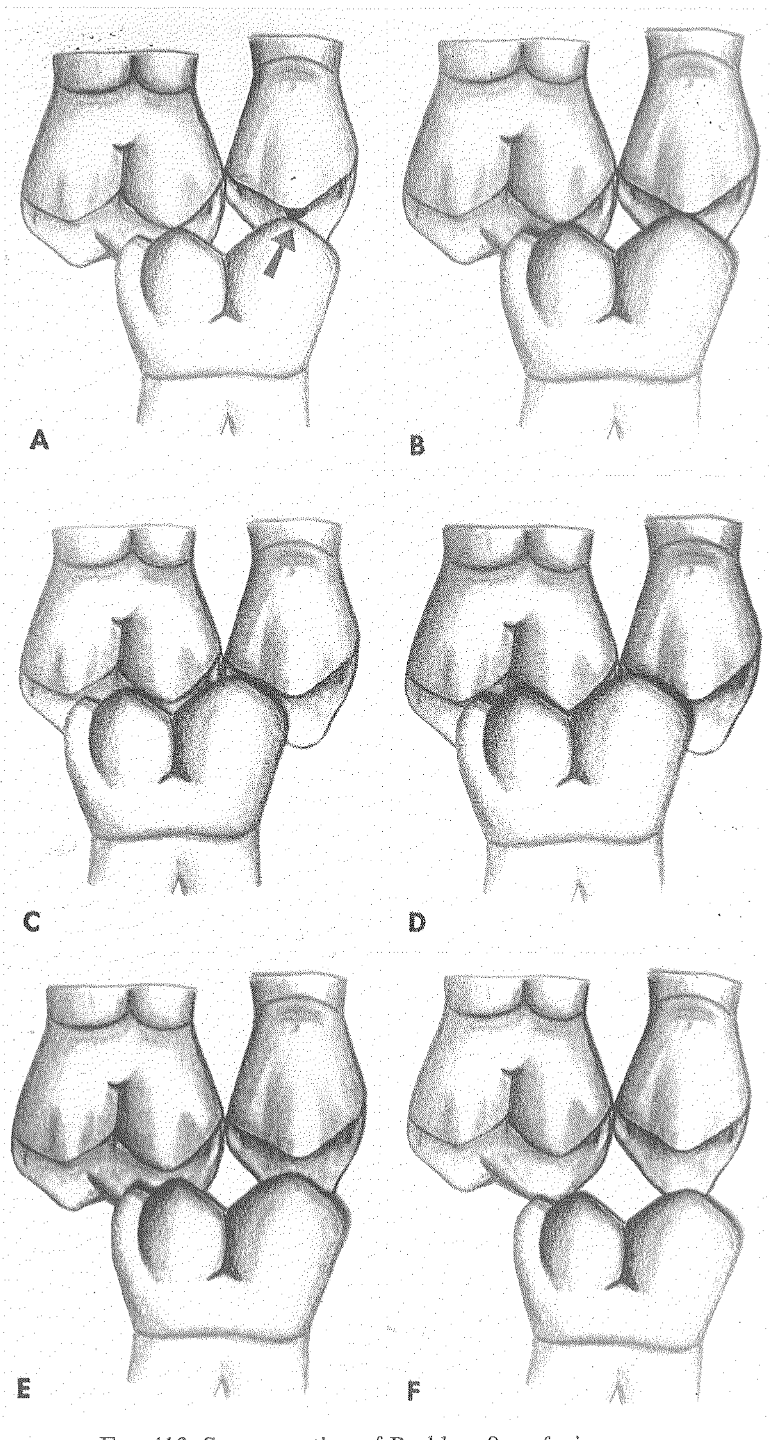



FIG. 413. See correction of Problem 9 on facing page.

## Correction of Problem 9
(See Fig. 413)

### *Loss of Contact; Further Grinding Contraindicated*

(A) The operator adds to the crest of the buccal cusp of the upper second bicuspid.

(B) The lateral protrusive loss of contact is corrected.

(C) The centric contact is undisturbed.

(D) The working side contact is undisturbed.

(E) The protrusive contact is undisturbed.

(F) The balancing side contact is undisturbed.

*Chapter* 22

# Temporary Restorations

One of the most vexing aspects of full mouth treatment lies in the problem of temporary restorations. Good temporaries are an absolute must. Indeed, trouble resulting from inadequate temporary restorations can consume more time and cause more problems than the actual restoration. Good temporary restorations can be time-consuming and often may appear to be wasted effort. Yet attempts to get by without good temporary coverage can be even more wasteful. This is one place where it is difficult to find a good compromise. Not all cases require the same treatment.

The short-term temporary which will be used for a matter of days or at most for a couple of weeks presents few problems. There are many conventional ways of dealing with that. It is the temporary maintenance for a matter of months which constitutes the problem. Temporary crowns, made of acrylic in an alginate impression, are limited in their usefulness to a few weeks at most. The use of aluminum or copper shells inside the acrylic helps somewhat, but this is still not good enough for a long period of treatment.

In almost all cases, gold temporaries are required (Fig. 414). On occasion they can be covered with processed acrylic, as, for example, a 14-tooth temporary upper bridge with acrylic dummies (Fig. 415). However, it usually is better to make the occlusals in gold (Fig. 416) and to use acrylic merely to hide the buccal and the lingual surfaces. This also will give some clue to the esthetics of the finished case and may prevent a lot of wasted work on the permanent restoration.

These temporaries are usually cast from gold, clean, scrap gold. Some coin silver can be added to soften the metal if it contains much partial-denture gold. There is no point in using overly hard golds for this purpose. The temporary restoration should be the approximate equivalent of an ordinary permanent restoration, except that it usually is not as well fitted. If the condition of the teeth permits ideal retentive preparations, it is frequently wise to spoil the fit deliberately by cutting away some of the retentive surfaces from the inside of the restoration, particularly long, parallel, full crowns.

## CONSTRUCTING THE TEMPORARIES

The mouth is usually prepared one quadrant at a time. The gingival crevices are packed with Adrenalin tape to retract the tissues. An impression is taken in a rim-locked tray, using rubber base material. If the tissue retraction is adequate, two models are poured. The first model is set aside to be used later for fitting the permanent restoration and the second model is used for the temporary. An opposing impression is taken in alginate and a wax bite. For full crowns an immediate temporary is made from self-curing acrylic in an alginate impression or in aluminum shells. If more tissue retraction is required to obtain a good impression for the permanent restoration, aluminum shells are preferable. These are overextended into the gingival crevice. They are filled with a very thick mix of Tempak and pressed to place. The gross excess is removed, but some excess is left in the gingival crevice. When the aluminum shells are removed at the next visit so that the gold temporaries may be cemented, a new rubber base impression is taken to be used later for the permanent restorations. If the preparations are inlays or three-quarter crowns, the immediate temporary is made of hard, white base-plate gutta-percha. This is cut in strips ½ inch wide, softened in the flame and rolled into sticks. It is pressed into place with the fingers, as though taking an impression, and the patient bites into it to shape the occlusal. It is removed and trimmed with small, curved crown and bridge shears. It is cemented into the preparations with Tempak. When this has set hard, the gutta-percha is shaped with warm plastic instruments which force it into the gingival crevice. Small preparations can be filled temporarily with Tempak mixed like putty and allowed to set hard before it gets wet.

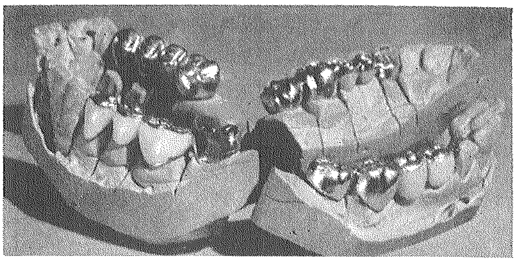


FIG. 414. Quadrant temporaries of gold and acrylic.

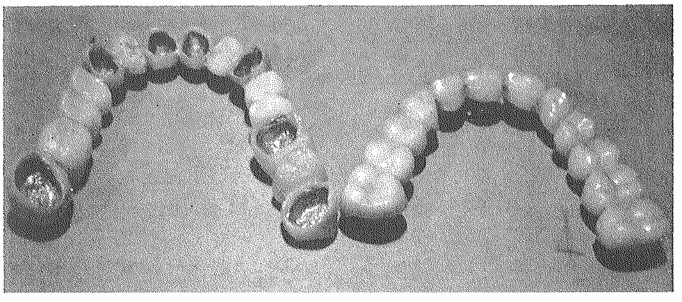


FIG. 415. A 14-tooth temporary gold structure covered with acrylic.

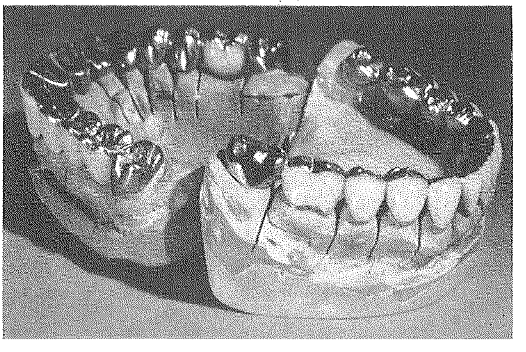


FIG. 416. Fourteen-tooth temporaries with gold occlusals for a tongue-thrust case.

In any case, the models for the temporary are mounted on a simple articulator and constructed like simple permanent restorations. Acrylic veneers are usually brushed in and cured in a pressure pot. When this temporary is being made, gross irregularities on the opposing model, which will have to be removed in those preparations, are carved away and the temporary is made to this relationship.

Each quadrant is made as a complete splint, whether or not the permanent restoration is to be splinted. There are several reasons for this. Since the occlusion on the temporary restorations will be different but not correct if the restorations are individual ones, the teeth may shift and change positions between the time of taking the impression and completing the permanent restoration. Further, they must be removed and replaced several times during construction. This is a matter of minutes if they are splinted, but a more difficult and tedious procedure for both patient and operator if they are removed and replaced singly. In addition, they do not have to be cemented as tightly as individual restorations do. The primary purpose of splinting is to prevent changes in relationship. Cements will be discussed later (p. 264).

At the next visit, if it is needed, a new impression is taken upon the removal of the immediate temporary. The new temporary is cemented and the opposing quadrant is prepared. Instead of correcting the occlusion on the temporary, the operator prepares the opposing teeth as indicated by the temporary.

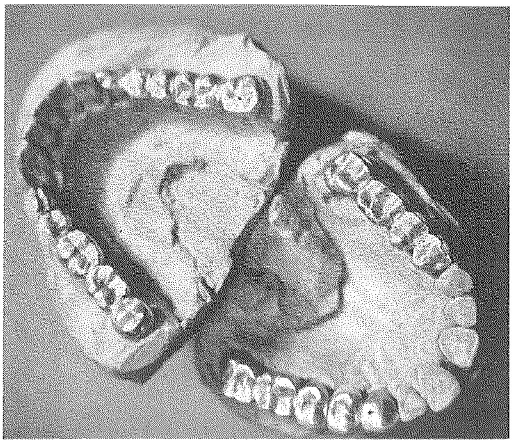


FIG. 417. A treatment temporary for a temporomandibular joint case.

Impressions and bites are taken as before, except that this time the patient is guided back into a centric bite as this second temporary will be made in centric. But it cannot be cemented until the other side is ground to permit centric closure or a quadrant on the other side is prepared to eliminate prematurities. However, it should be constructed with a centric bite and, at the next visit, a quadrant on the other side should be prepared to permit the first two temporaries to function in centric. In taking the bite for this second temporary, it may be necessary to correct gross prematurities on the unprepared side to take the centric bite. Since the average temporary is made on a simple articulator without a hinge axis mounting, the bite should be taken at the desired vertical dimension.

At the third visit the second temporary is cemented. A quadrant on the opposing side is now prepared until all the prematurities are removed and there is sufficient room for the permanent restorations. Then the temporaries on the first side are adjusted for gross interferences in lateral excursions. After that, impresisons are taken for the next temporary and, again, a centric bite. This temporary can be formed in centric and cemented at the next visit. Finally, the last quadrant is prepared and finished in centric. Then all the temporaries are equilibrated for lateral excursions directly in the mouth.

## TREATMENT TEMPORARIES

The temporaries just described are adequate for the average case. In mouths with bad periodontal involvement, temporomandibular joint problems, or muscle spasm, the temporaries must be constructed on the articulator with occlusion which approximates that of the permanent restorations. They are carved (Fig. 417), remounted and adjusted exactly as though they were the permanent restorations. However, the final case should never be carried right through without these intermediate temporaries. It is nearly impossible to secure a perfectly correct centric bite in these cases until the temporaries have been in the mouth for a considerable length of time. They are remounted and adjusted at intervals of several weeks until no further change is discernible. The fact that change always takes place is the best reason for not completing the permanent case until the joint has become stable. As these repeated adjustments are made, frequently it will be found necessary to change the preparation to accommodate the required carvings. For this reason, neither the working models nor the centric bite can be made until the mouth is ready for the permanent work. These temporaries are very definitely treatment splints.

The temporomandibular joint case is remounted and adjusted at close intervals until the symptoms have subsided. These changes take place because, while the centric bite is not perfect at first, it is less in error than it was before treatment. This allows some healing to take place and produces a better relation on the next remount. So there is progressive improvement until finally a stable relation is achieved. A centric bite cannot be forced on a patient with a periodontal or temporomandibular joint problem.

When a fully articulated temporary is being made, speed in preparation is necessary. A patient cannot be maintained long on immediate temporaries. Only for the unusual patient is it necessary to make two sets of temporaries. For the average patient the mouth is prepared in one sitting, or sometimes in two sittings close together. The operator should not attempt to finalize the preparations at this time. With the use of high speed and copious amounts of water, the preparations are roughed out to the approximate final form. There is no point in doing the final finishing at this time, as some re-preparing after remounting is almost sure to be necessary. Immediate temporaries are made with acrylic in alginate impressions. Full-mouth impressions are taken in hydrocolloid and the usual centric bite and face-bow mounting. The models are mounted on the set articulator and are carved as a permanent restoration.

Since the temporaries will be splinted in any case, each quadrant is waxed and cast as one piece. However, the casting sometimes will not go to place as a one-piece casting. Any rock in the temporary is fatal, since it will not only leak and become sensitive, but never seat twice alike upon re-cementation. If it exhibits any rock after casting, it should be cut apart with a gold saw and soldered together.

In periodontal cases (Fig. 418), scaling and routine prophylaxis are carried out first. After the temporaries are completed and cemented, each quadrant is treated thoroughly, with the temporary removed. This permits easier access to every surface of every root.

When the upper anteriors are to be porcelain jacket crowns, they are usually prepared separately after the other temporaries have been completed. They are made up as individual acrylic jackets and cemented on the thoroughly varnished teeth with a thin mix of Shade One Kryptex. When the permanent restorations are constructed, a second set of acrylic temporaries is carved to the corrected occlusion. They are cemented with the permanent case, and the porcelain jackets are constructed after the rest of the case is completed. The acrylic temporaries are used as a model for the carving of the permanent jackets and are given to the patient as a set of spares in case a porcelain jacket is broken.

Pin-ledge preparations can be most uncomfortable to the patient and, whenever possible, are left until after the completion of the remainder of the restorations. If this is done, the minimum amount of tooth structure can be removed and still be adequate. Since the purpose of pin ledges usually is to build up the teeth to contact, all that is necessary is to prepare the pinholes and the margins for the restorations. It is seldom necessary to remove any of the lingual surface, as these teeth frequently have been worn quite thin. If they are prepared before the other work is completed, there is no room for a temporary except in the pinholes. These are difficult to maintain on temporary stopping and can become very sensitive.

A temporary for this purpose can be formed by placing wire posts in the pinholes, roughened to grip, and painting self-curing acrylic directly on the teeth. Such a temporary and a model of the mouth are shown in Figure 419. The temporary is tapped out

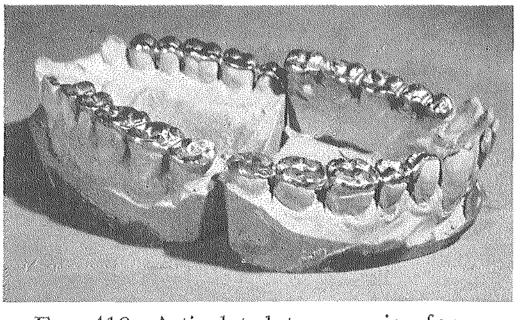


FIG. 418. Articulated temporaries for a periodontal problem case.

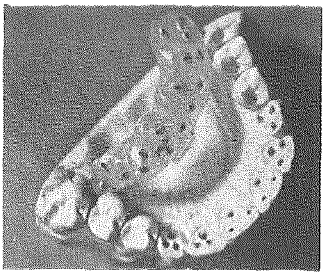


FIG. 419. An acrylic temporary for pin-ledge preparations.

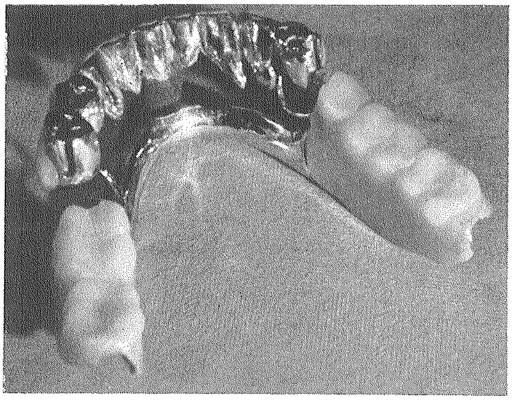


FIG. 420. A temporary partial and fixed bridge.

after the acrylic has set, trimmed to the bite, and cemented with temporary cement.

This temporary also makes an excellent tray for a rubber base impression. When it is separated, adhesive is painted on it. Heavy-bodied rubber base is spread over it, and the temporary is pressed to place. When the rubber has set, an alginate impression is taken over it. When the alginate impression is removed, the rubber base impression usually will remain in the teeth. This is removed and replaced in the alginate impression. The model shown in Figure 419 was secured in this fashion.

After the model has been separated, the tray is used as a temporary. This kind of temporary is good for only a few weeks without re-cementing, as it will spring and leak unless it is unusually thick. A small, round bur dipped in benzene and turned in the fingers will remove the cement from the pinholes with a minimum of discomfort.

Temporary partial dentures usually are made with mucostatic bases and Neurohr attachments. A lingual arm (Fig. 420) is recessed into the lingual surface of the temporary abutment. In the case illustrated, the abutment is a temporary lower anterior splint.

## TEMPORARY CEMENTS

There are a number of materials that are suitable as temporary cements under various circumstances. The cement should hold without leakage for a reasonable time and yet not require too much hammering to remove. Multiple splinted temporaries usually are removed with a back-action hammer. Single units on isolated teeth can be removed best with the I. F. Miller towel clip remover. This is a towel clip, with two buttons on the tips, which is useful for removing band impressions and temporary restorations. It is used with an orangewood stick as a fulcrum.

The holding power of the temporary cement depends not only upon the cement but also upon how thick the mixture is and the degree of dryness of the teeth. Usually, particularly with sensitive teeth, the zinc oxide and eugenol base materials are very satisfactory. Plain zinc oxide and eugenol should never be used, as it makes removal most difficult. Eugenol should not be used repeatedly on fully dried teeth, as it is a pulp irritant and repeated applications on dry teeth can cause pulp involvement in deep preparations. To increase retention, the teeth may be dried superficially with cotton pellets and one quick blast of air to blow away the free saliva. But the operator should be careful not to dehydrate the teeth so that they soak up the eugenol like a sponge.

Pulprotex and Moyco are both good general-purpose materials. Pulprotex is obtainable in a slow-setting mix. Both allow ample working time on the slab, set fast in the mouth, and chip away clean from the teeth. After the removal of the temporary, they also clean easily from sensitive teeth. They are both excellent for soothing sensitive teeth, and this can be a great advantage. When a large number of teeth are prepared at one time, and a large area of freshly prepared surfaces is exposed, there can be quite a problem in mouth comfort. The consistency of the mix and the drying of the teeth are matters for the operator's judgment, depending upon the retention. Sometimes, when more than one type of preparation is used on one temporary splint, a thin mix is placed in some of the restorations, and more powder is added to make a heavier mix for the remaining restorations. Occasionally an unusual temporary is cemented by using two different cements in different restorations on the same splint.

Ackerman's Impression Cement and Zorite both set harder and are tougher and more difficult to remove than the materials just mentioned. With full crowns having long parallel walls and maximum retention, the temporary cement is a space filler to keep out saliva rather than a retentive agent. In such cases, a very thin mix of these materials works well, as it never sets hard but remains sticky and gummy. It is difficult to clean from the teeth. A little benzene is helpful if the teeth are not too sensitive.

Ward's Wonderpak is excellent on very sensitive teeth for a short time. Because of the asbestos fibers, it should not be used over a long period of time, as they become foul and can cause decay. Ward's Tempak is strong and hard, being particularly good when there is a lot of space to fill. For example, when teeth have been re-prepared extensively and the temporary has been cemented, a heavy mix of Tempak works well. It should be used with caution on tightly fitted restorations.

In cases when it is known that temporaries on badly broken-down teeth with minimum retention will have to remain for a long time, Caulk's Pro Tem Cement is useful. It should be used with great caution because it is almost as strong as oxyphosphate crown and bridge cement. Indeed, at times, a thin mix of crown and bridge cement placed on wet teeth can be useful. After cementation it should be covered with Dryfoil, so that the saliva will not wash it out before it has set.

For the cementation of temporary acrylic anterior jacket crowns, a thin mix of Shade 1 Kryptex will help esthetically. It should be used only over well-varnished preparations. At least two coats of varnish should be applied.

Some non-eugenol temporary cements have recently appeared which are excellent, particularly with acrylic. They set hard but are brittle enough to break for easy removal. The only objection to them is that they are not very helpful in relieving sensitivity. Two such materials are Opotow and Coe non-eugenol zinc oxide temporary cement.

Many operators customarily mix some petroleum jelly with the cement to keep it from setting too hard. Based upon my own experience, I prefer to use a thinner and weaker cement without petroleum jelly, but the matter is really one of individual preference. At times it is useful to leave small buttons on the lingual surfaces of crowns to hold the back-action mallet for easier removal. However, since these are usually splinted, a hook on the mallet, inserted through the interproximal spaces, serves the same purpose and is less annoying to the patient.

The strongest of all the so-called temporary cements is Temrex. In fact, it sets so hard that it is rarely used for temporary cementation. It is a zinc oxide and eugenol material, very kind to sensitive teeth, and considerably slower-setting than the others. It is more useful as a permanent cement with good mechanical retention, because it is actually less soluble than crown and bridge cement. I have had complete restorations cemented with it for years with excellent results. It is not quite as strong as oxyphosphate cement for abutments—hence the need for better mechanical retention. It is very difficult to clean from the teeth when it has been set for a long time.

Temporaries that are too well cemented can present real problems, and occasionally they have to be cut for removal. It is better to err on the side of too little than too much cementation and explain why to the patient. Leakage is annoying to both patient and dentist, but it is the lesser of two evils.

Chapter 23

# Occlusion in Temporomandibular Joint Pain

The relation of occlusion to temporomandibular joint pain, as we are dealing with it here, implies a relation of the mechanics of tooth contact which may be a contributing factor in producing joint symptoms. Since it is the dynamics of tooth contact rather than a static position, it is likewise the dynamics of joint relations to tooth relations which constitutes the problem. We might visualize the relations of joint, teeth and muscle as a circle—one which could be physiologic and actually contribute to the health of all these structures. It can also be a vicious circle which, if allowed to continue unchanged, can and does lead to the breakdown of any or all these structures.

In this circle relation, the teeth play a passive role. They follow the movements of the joints, in harmonious synergy, as the musculature provides the power. To understand and diagnose inharmonious relations which may be symptomatic requires an intimate knowledge of the mechanics of joint relations and an even more precise concept of tooth relations in normal function. Anatomically and surgically the temporomandibular joint is a complex structure. From the dynamic standpoint of joint and tooth relations, it is important to remember that when the condyle is moving it is maintained in precise relation to the meniscus as they glide together.

With this almost infinite variety of possible combinations of motion, the joint can adjust itself to bring about the great variety of changing tooth contacts as the mandible moves, but it cannot adapt itself permanently to tooth relations which are not harmonious with these two actions, without injury to some part of the mechanism. That is why the teeth play a passive role. They cannot, by malarticulations, compel the joint to deviate from these normal relations without injury. Thus we have the circle which can be beneficial or vicious, depending upon these relationships.

In voluntary movements of the joint, the condyle and the meniscus are maintained in precise relation by the action of the external pterygoid muscle. Simultaneous contraction of the two heads moves the condyle and the meniscus as a unit. The nerve and blood supply is located around the periphery of the meniscus in areas in which, in normal relation, the condyle does not make forceful contact when the mandible is being elevated by the closing muscles against resistance between the teeth. In protrusion of one joint in lateral excursion of the mandible, or both joints in lateral protrusive or pure protrusive (which rarely occurs), the condyle and the meniscus are moved simultaneously by the external pterygoid, which maintains the position of the condyle on the avascular portion of the meniscus. However, if the mandible is closing in lateral excursion, the condyle is rotating on the working side while returning from protrusion on the balancing side. The closing muscles are seating the meniscus tightly against the fossa, through the pressure exerted against it by the condyle as it braces itself on the meniscus to provide a fulcrum for the closing muscles, in order to overcome resistance against the mandible.

As was pointed out previously, rotation of the condyle on the meniscus is always accompanied by translation of the meniscus: these two actions never occur independently. In the closing action just described, the condyles are making pure rotary motions on the meniscus while the menisci are translating on the fossae. But, in the working side, this translation is not protrusive: it is a path across the fossa. (This is called the Bennett movement after its discoverer. Its path on the fossa we have referred to as the centrodynamic path.) The protrusive paths on the fossa are usually referred to as the condyle paths, but technically, in the Bennett movement, the centrodynamic path is simply a different direction of the condyle path. In both cases the type of action is the same: the condyle rotates while the meniscus translates. However, from the standpoint of joint problems it is very convenient to consider these as separate actions, even though they are similar, since they are totally different in their relation to tooth occlusions. Most joint pains of occlusal origin occur in traveling across the centrodynamic path during the Bennett movement.

## FUNCTIONAL DISHARMONY

When, for some reason, the condyle makes a forceful translatory movement on the meniscus instead of pure rotary motion, symptoms of joint disturbance may occur. This can be brought about by a variety of causes other than tooth relations, such as muscle spasm, and other factors always enter into the total picture, but for the moment we are concerned with the occlusal facet of this problem.

When the teeth are brought into forceful contact as the condyle is rotating on the meniscus, and the occlusal relation of the teeth compels the mandible to deviate in a translatory path that is not initiated by the external pterygoid, the condyle may move independently of the meniscus and impinge on a surface of the meniscus which is not normally a pressure-bearing area. Occlusion of the teeth can create such a situation in a variety of ways. To diagnose this condition it is necessary to understand not only the minutiae of tooth relations per se in all contacting positions, but also the harmony of those relations to normal joint movements. Normal tooth relations are the result of normal joint relations. Changing tooth contacts, through the range of mandibular movements, follow the dictates of the joints; the teeth are passive partners in a joint enterprise. It is the necessities of these harmonious relationships which determine the occlusal forms required in any given mouth to maintain the integrity of this beneficial circle. Disharmonies between the joints and the occlusal forms can change this to a vicious circle. If the occlusal relation of the teeth attempts to force the mandible into a position that is not acceptable to the joint, the conflict created by the muscles, which are attempting to maintain a harmonious relation in the joint and at the same time to actuate a disharmonious occlusion, may lead to the breakdown of one or the other. Usually the joint wins the battle, resulting in a breakdown of the supporting structures of the teeth, whether they are natural or artificial. Occasionally the teeth win the battle, resulting in injury to the joint, and sometimes they succeed in injuring each other.

## FUNCTIONAL HARMONY

Man is an omnivorous animal. He chews his meat, potatoes and vegetables all at the same time. To perform this minor miracle, he is endowed with the hinge action of the Carnivora and the gliding action of the Herbivora, through the medium of his gliding ball-and-socket joints. It is also necessary for him to have teeth with cusps, which are no accident of nature. They exist as nature's only means of maintaining the harmony of these two simultaneous chewing actions without injury to the joints or the supporting structures. If we were given the privilege of redesigning the joint to suit the requirements of such a diet, we would be compelled to create teeth with cusps. The thing which is the most difficult for dentists really to understand is that cusps exist as nature's only means of avoiding stress on the supporting structures while maintaining the integrity of the joints. Grinding away disharmonious cusps and replacing them by flat tooth forms has the attractive appeal of an easy way out, but it ignores the real objective of treatment: restoration of a harmonious relation of the teeth to the functional relations of the joints. Flat teeth, which cannot satisfy joint requirements, create greater stress than properly articulated cusp teeth. Irregularities in mandibular movements which are activated by the muscles but controlled by the joints require cusps on the teeth in order to maintain a state of equilibrium. In normal relation, cusps do not bump into each other. On the working side, they pass each other by gliding over the opposing marginal ridges and sulci. On the balancing side, they pass around each other in a circular path. These paths of motion are not in a plane. They are curved paths which require cusps to maintain equal, simultaneous contact of all the teeth, with the forces directed in the long axis of the supporting bone.

Cusps should not be condemned because, in malocclusion, they do bump into each other and create lateral stress; nor does this justify creating flat teeth without regard to the joint. It does highlight the necessity for creating cusp forms and relations which will maintain harmonious relations.

Although the need for natural cusp forms to maintain equilibrium in the joint results from functional masticating movements of the joint, it is apparent to anyone who has had occasion to deal with many of these cases that the original problem was not created by the mastication of food. During mastication there may be very little tooth contact; certainly there is not enough to be productive of symptoms from malocclusion. Yet the patient will complain that the symptoms are worse during mastication. Joint movements are the same whether the teeth are in contact or not. It is the stress created by nonfunctional malocclusion which produces the derangement of condyle and disk. This, in turn, creates the symptoms when heavy force is applied in mastication, with or without tooth contact.

A basic qualitative diagnosis of this condition is a relatively simple matter, rarely requiring more than a minute or two after a little training in the procedures. Since these symptoms result from derangement of the ball-and-socket relations of the condyle on the meniscus, the method consists in obtaining pure rotational movement of the condyle, unaccompanied by translatory movement of the meniscus, while the teeth are brought into contact. This is not a natural action for the patient to use unaided. As was pointed out previously, rotary motion and translatory movement always occur simulataneously. But it is not an abnormal action, since all normal movements of the joint are a resultant of these two actions. In order to diagnose this condition, it is necessary to break it down into its component parts.

With the operator's thumb placed against the chin, the patient is guided into the most posterior position of the joint, while opening and closing with pure rotary motion. By maintaining steady pressure on the chin, the operator prevents the patient from making translatory motions. A certain amount of skill and judgment is required, or the procedure may defeat itself. The object of the thumb against the chin is not to shove the mandible back as far as the strength of the operator will permit. Doing so, particularly in joint cases in which the relation of the condyle to the meniscus has been disturbed, may itself cause a translatory movement of the condyle on the meniscus and a completely erroneous diagnosis. The objective is to aid the patient to avoid translatory movement by a guiding hand, not brute force. The patient's neuromuscular pattern will attempt instinctively to guide the mandible into a position of maximum tooth conduct. This must be overcome by careful guidance, and at times it can be a very troublesome factor.

Last, but by no means least, is the problem of the physiologic rest position. Physiologic rest is not a functioning position. As its name implies, it is a position of rest into which the mandible drops when function has ceased. This is particularly apparent in joint cases, in which the relation has been disturbed. The closure from rest position to occlusal contact always is accompanied by some degree of translatory motion. The condyle is lifted bodily to seat the meniscus tightly on the fossa. Therefore, it is necessary to determine that the patient is not closing from physiologic rest, since this is not a functional movement. The patient with a joint problem is the one who is most prone to drop into physiologic rest as soon as function ceases. But, to secure a correct functional relation of the teeth, the condyle must be held upon the meniscus in its rotating position when force is applied. To obtain this position, as the patient is closing with rotary motion, a soft rubber block can be introduced between the upper and the lower anterior teeth. The muscular force exerted to bite into it will force the condyles up into functioning position, while the thumb on the chin prevents translatory movement. If, from the point of initial contact to occlusion, there is translatory movement of the mandible, there is a disharmonious relation of the teeth to the joint.

## PSYCHOLOGICAL PROBLEMS

Thus far we have been considering the mechanism by means of which disharmonious relations of the teeth to the joint can produce symptoms. That may show us how these symptoms occur, but it does not tell us why. There are untold millions of people with similar malrelations who continue happily on through life, completely unaware of any disturbance. This brings us to the final and, by all odds, most difficult phase of this problem. In all cases of joint symptoms of dental origin we are dealing with psychogenic factors, which are sometimes very difficult to handle. That does not imply by any means that we can dismiss the patients as neurotics. There is a strong tendency today, when an operator is faced with a problem that he cannot understand, to turn it aside with the excuse that the patient is just a neurotic. But there is always present a psychogenic factor which must be understood in its proper perspective as it affects treatment results.

The mechanical relation of the teeth to the joint provides the mechanism which enables the patient to produce the injury. I have never seen a temporomandibular joint case of dental origin in which this relation did not exist. Indeed, if it did not exist, I would not regard it as a case of dental origin. But the answer to the question of whether or not the patient uses this mechanism to create stress in the joint lies in the psychological make-up of the individual. On the other hand, I have treated many malocclusions in patients of a similar psychological make-up, who, lacking the mechanism for joint injury, are free of joint symptoms.

From the standpoint of prognosis, this is a very difficult factor to evaluate, even with the aid of a good psychoanalyst. I am not now referring to those who are frank psychiatric problems, although, at times, the dividing line is a tenuous thread and I have never been able to find just where it lies. I have in mind the so-called mentally normal individual who, in the stress of modern living, reacts to the "slings and arrows of outrageous fortune" by placing abnormal stresses on the temporomandibular joint through the medium of his teeth. Since the beginning of time, the mouth has been closely linked with the emotional state, even in the animal world. We have given tacit recognition to this for many years in such expressions as "gritted his teeth in anger," "snarled at his adversary," "set his teeth on edge." The tensions of modern life are reflected in the mouth. Relieving the mechanical relationships which made the injury possible does not change the psychogenic problems. If the injury is severe and of long standing, recovery may be a slow and tedious process, unless it is accompanied by psychological aid. On the other hand, once an injury has occurred, complete relief by psychological means alone is rare.

There is another group of cases in the same category in which the malocclusion itself has created the psychological problem responsible for the stress in the joint. Unfortunately, most of these cases are created by bad dentistry. Sometimes even oral surgeons are responsible because they have extracted a tooth which has been in premature contact with a developed neuromuscular pattern. The removal of the prematurity creates the immediate need for a new neuromuscular pattern, without adequate time to develop it, and the resulting chaos creates a joint problem. All too frequently, an identical situation occurs in haphaazrd extensive tooth grinding and inadequate rehabilitation.

## TREATMENT

Although the clinical appearance is quite similar from an occlusal standpoint, it is important in the treatment to differentiate between pain in the joint and muscle spasm caused by malocclusion. A case of true temporomandibular joint pain can be relieved quickly by constructing a splint in physiologic rest, to prevent pressure in the joint. This is strictly a temporary first-aid measure, but is frequently a method of giving the patient relief. In some cases, the prolonged pain has created a really sick patient who needs relief before more rational treatment can be undertaken. The splint cannot be used while eating, but otherwise should be worn day and night. The restoration should never be constructed in this rest position as the patient will be unable to eat.

A muscle spasm case should not be treated by such a splint. The splint cannot be made without some bite opening, and this mitigates against rapid relief. Muscle spasm cases should be treated, as outlined in Chapter 22 on Temporary Restorations, by the rapid preparation for and the construction of a fully articulated temporary.

## SUMMARY

To summarize, the temporomandibular joint, within the range of tooth contact, functions as a moving ball-and-socket joint. Occlusal disharmonies which, by their relation to the joint, cause a derangement of the condyle-to-disk relation, may produce characteristic joint symptoms. Factors other than the occlusal relation may produce similar manifestations but, in those cases which are of dental origin, this disturbed relation always is present. In those cases the psychogenic factor always is present also, and sometimes it can be a serious problem in treatment. In many cases, correction of the occlusal problem is adequate to bring the symptoms under control, but it is difficult to evaluate its role in the prognosis. Clinical qualitative diagnosis is relatively simple, but exact diagnosis and treatment require a precise mounting on a suitable instrument that is capable of accurate reproduction of joint-to-tooth relationships. Tooth-grinding and removable splints sometimes will bring temporary relief but offer no permanent solution.

## Chapter 24

# Treating the Patient

The most difficult thing to express in tangible terms is the application of technics to treatment of the patient. All too often the technics themselves are confused with treatment. To apply to every patient a standardized, routine treatment is not practicing dentistry—it is merely being a glorified technician. The problem, to quote Gilbert and Sullivan, is "to make the punishment fit the crime."

Not every patient requires rehabilitation. Not all patients who require rehabilitation require the same treatment. It is not either black or white—there are all shades of gray between the extremes. There is a time and a place for equilibration, if its limitations are understood and it is used intelligently. It does not take the place of rehabilitation. It can be used as an adjunct, to a limited degree. Occasionally it may be adequate as treatment. More often it can be applied to supplement rehabilitation, as a more conservative approach. Sometimes it can be used to improve a restoration, or its functioning opponents, in a local area where complete rehabilitation is not indicated. Strictly speaking, every restoration on a tooth is partial rehabilitation. It is a matter of degree.

So-called preventive grinding is rarely indicated. Altering the function in a mouth merely because it does not look right, with the idea that it will prevent some kind of future trouble, will itself frequently lead to trouble. There are many people who go through life healthy and happy in spite of what looks to us like a malocclusion. Treatment of any kind should not be undertaken unless a proper diagnosis clearly indicates the need for treatment. Need for treatment would be based upon the existence of some disease which could be eradicated. Indication for treatment would be based on a clinical manifestation of disease, a functional mounting which would indicate a relationship between teeth and breakdown, and roentgenologic evidence that such a relationship does in fact exist. All three of these are of equal importance. Here again arises the question of precisely what and how much treatment is indicated. It does not fall into a set pattern.

There is one exception to the foregoing. Occasionally a patient will present, needing major restorations in all the posterior teeth, without any further evidence of disease which would normally indicate rehabilitation. Frequently, this will be a relatively young patient with a badly neglected mouth, or an older patient with a large number of old restorations in bad condition. In such a case, most, if not all, of the occlusal surfaces must be restored as a part of the treatment of the teeth themselves. Under these circumstances, proper restoration of the occlusal surfaces is a preventive treatment, since it prevents the same neuromuscular problem that a full-mouth restoration does. In this instance, occlusal restoration as a functional problem is indicated, even though it is not per se the reason for treating the patient. This is not the same as altering the occlusion in an otherwise healthy mouth merely for the sake of altering it, either by grinding or restoration. Unless evidences exist that the occlusion presents problems which the patient cannot sustain, or which cannot be treated by less drastic means, or which require restoration of occlusion for other reasons, complete rehabilitation is not indicated.

Such a case is shown in the study models (Fig. 421). This patient was in her late

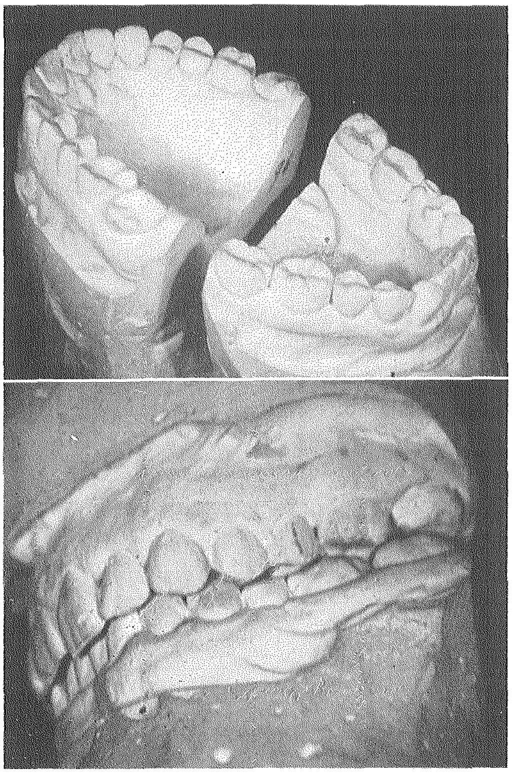


FIG. 421. A young patient who needed extensive restorations.

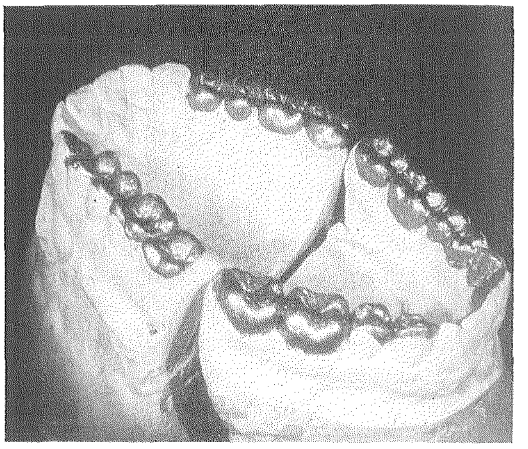


FIG. 423. Restoration of the case shown in Figure 421.

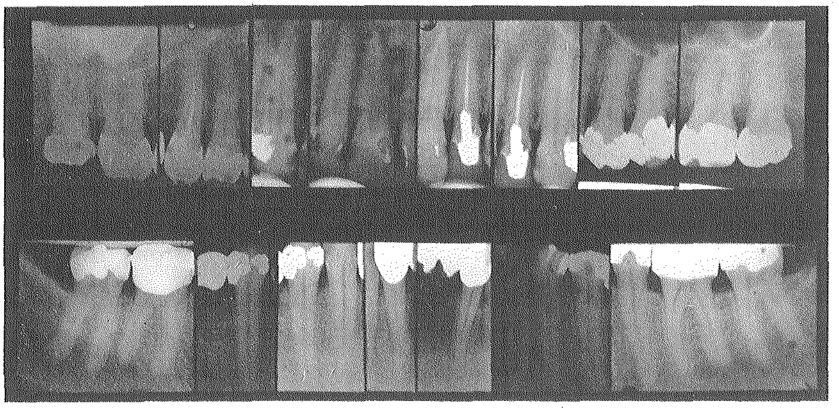


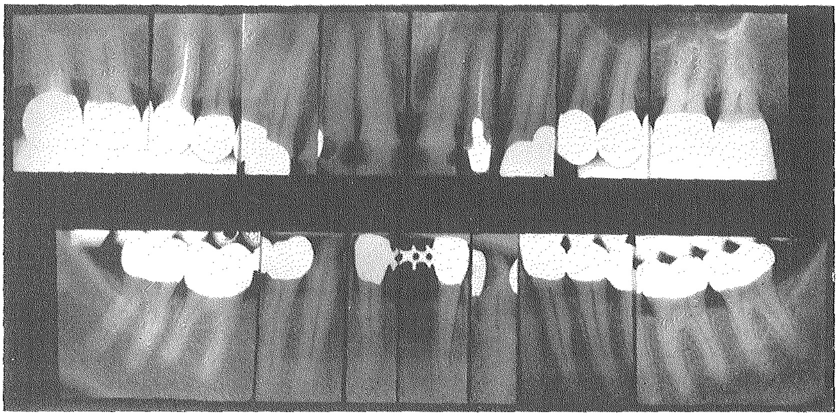
FIG. 422. Roentgenograms of the patient in Figure 421 taken before treatment.

twenties. Clinically the mouth presented a poor condition. Chronic gingivitis, swollen, hypertrophied tissue, and chronic bleeding caused her much discomfort. Most of the teeth held restorations which needed replacement. The roentgenograms showed a good prognosis (Fig. 422), and the pockets were relatively shallow, with a good bone level. The case was treated by a variety of restorations (Fig. 423), depending upon the condition of the individual teeth. The case responded well, as shown by the roentgenograms (Fig. 424) and the tissue condition (Fig. 425) 15 years after treatment.

## TOOTH PREPARATION

There is no one type of tooth preparation which is indicated for all teeth in all mouths. Here again, this should be decided on the basis of the conditions presented by each tooth; there should not be an arbitrary standardized routine. A full crown is indicated when the breakdown of the tooth structure requires it, or when the relation of the tooth in occlusion requires extreme warping of the occlusals, or there is a decided change in the contour of the tooth. It is likewise indicated

FIG. 424. Roentgenograms of the case in Figure 421 taken 15 years after treatment.



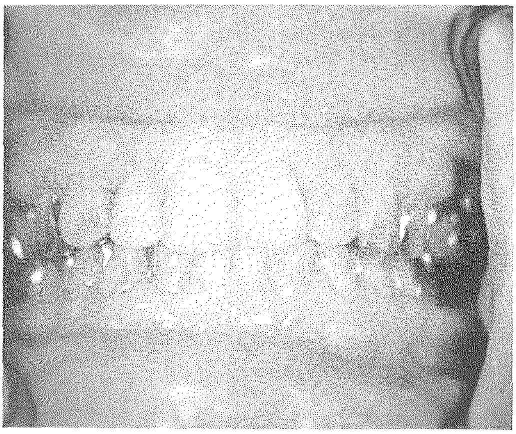


FIG. 425. The mouth of the case in Figure 421 fifteen years after treatment.

when needed for retention, as a large bridge abutment or as a veneer crown to conceal excessive gold from the buccal aspect. Anteriorly, the choice between a jacket crown and a pin-ledge preparation frequently is decided on the basis of the changes required in anterior guidance. At times it is necessary to change not only the lingual contour but also the incisal edges to secure proper co-ordination of the anterior guidance with the posterior cusp form. However, there are many cases which call for only small changes in lingual contour, which can be accomplished by a simple pin-ledge preparation with a minimum of tooth preparation. Pin-ledges are rarely used as bridge abutments. Usually a minimum of a three-quarter crown is indicated.

It is not uncommon to be presented with a caries-free mouth, with little or no restorations present, which requires occlusal restoration for some reason. If it is a case of unworn teeth, which requires rehabilitation primarily as a part of the periodontal therapy, a minimum of preparation is indicated. This usually would be in the form of M.O.D. inlays with full occlusal coverage. Frequently, to conceal gold, the first bicuspids can be treated with D.O. inlays and some equilibration of the remaining tooth. Occasionally, the occlusal preparation of upper M.O.D.'s may stop just short of the buccal edge. However, if it is a case of extreme abrasion, it usually will require full crowns even though the other conditions are equal.

Many operators have come to the conclusion that the gingival crevice is the poorest place to end a margin. From the standpoint of recurrent decay, it is the worst area. It is very inaccessible for cleaning. The theory that the contour of the restoration would deflect food and thus aid in periodontal health has not been found to be valid clinically. Except for the labial gingival contour of the anterior teeth, the action of the tongue and the cheek is more effective in preventing food from slipping over the buccal and the lingual surfaces to impinge on the tissues. In constructing full crowns, a slight overcontouring of anteriors at the gingival, analogous to the form of the enamel where it meets the root, does appear to aid in preventing recession of the gingiva.

For splinting in large fixed bridges or multiple splinting of natural teeth, a minimum of a three-quarter crown is required. This would be limited by the condition of the teeth. It should be used only where long parallel grooves can be prepared and there are enough parallel walls without much taper. Sometimes this can be achieved by using a lingual shoulder, which is limited by the taper of the tooth. If it is very tapered, the amount of the tooth structure that is removed to form a shoulder without undercuts may endanger the pulp.

Tooth preparation also must take into account the amount of room needed in the occlusal part of the preparation to receive the opposing cusps and still leave a substantial covering for the prepared surface. If it is too thin, the cement may be destroyed by the pounding of the opposing cusps. Cavity preparation is not only a matter of cavity form but also of tooth preparation for function. If the operator is conservative in the preparation, in order to avoid cutting away excessive tooth structure, it frequently will be found that in carving the case there are some areas where the remaining tooth structure interferes with the proper cusp form. In such cases it usually is necessary to go back and re-prepare some teeth. This can sometimes alter the original decision and indicate an entirely different kind of restoration. It is not wise for the operator to commit himself to any type of restoration until the case is carved. Also, remount adjustments may develop holes and thin spots which will require alterations in the preparation.

The entire restoration should be planned before any work is started in the mouth. Only emergency first-aid procedures should precede treatment planning. It is imperative to make registrations and mountings prior to undertaking any work. Changes in tooth contours, warping of cusps, and the necessary allowance in the preparation for the room needed for the cusps can be determined from the mounted models. Cusps calls for changes in cavity preparation. If necessary, a rough carving can be carried out on the study models to aid in determining tooth preparation.

Some dentists make it a practice to equilibrate the mouth prior to preparation, since these areas would have to be prepared in any case to allow room for the proper cusps. There is nothing wrong with this procedure, but it is usually an unnecessary step. Equilibration does not necessarily mean that there will be adequate preparation. If the case is properly studied from the mounted models, the equilibration is usually an automatic part of the tooth preparation. Tooth preparation is more than just cavity preparation.

Frequently there is doubt concerning the preparation of the cuspids, and sometimes of all six anterior teeth. Since the purpose here is to avoid the display of gold, these preparations frequently are left until the rest of the case has been completed. The cuspids must always be included, and usually the incisors. The exception would be an edge-to-edge bite for the case which can be treated without any increase in vertical. If it is known that these teeth must be included, it is usually good practice to leave them as temporaries until the posteriors have been completed.

In cases of deep overbite and no overjet, the incisors must be kept in proper function on the finished restoration. While it is not necessary that they make contact in centric occlusion, they must make functional contact in lateral excursion. Frequently this requires no more than a small pin ledge on the lingual. On the other hand, the patient with a long overjet, who has never made a functional contact, does not need to be restored to make such a contact. It is not necessary to have protrusive balance in the sense that the incisors are edge to edge at the cusp height of the posteriors. This is rarely possible. Protrusive balance with a normal overjet must exist to the extent that the anteriors make passive contact during the excursion from centric to cusp height. Usually the patient will have to move further than this to incise, and the posteriors will be out of contact.

## ORTHODONTIC AIDS

Sometimes a relatively simple orthodontic movement can improve the relation of teeth

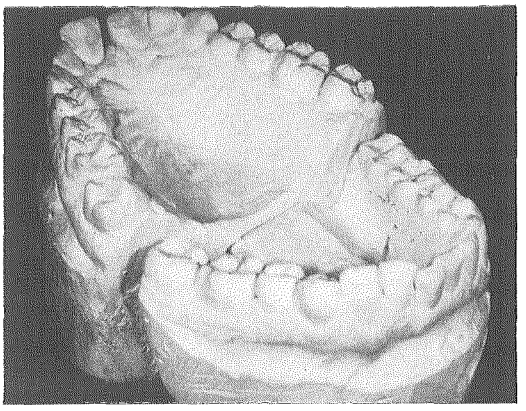
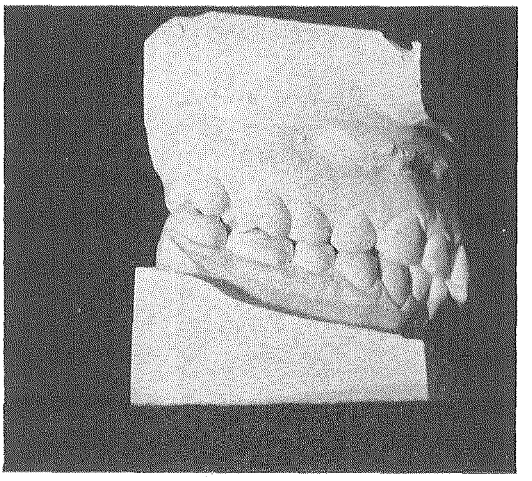


FIG. 426. A young patient who needed orthodontic and periodontal treatment.



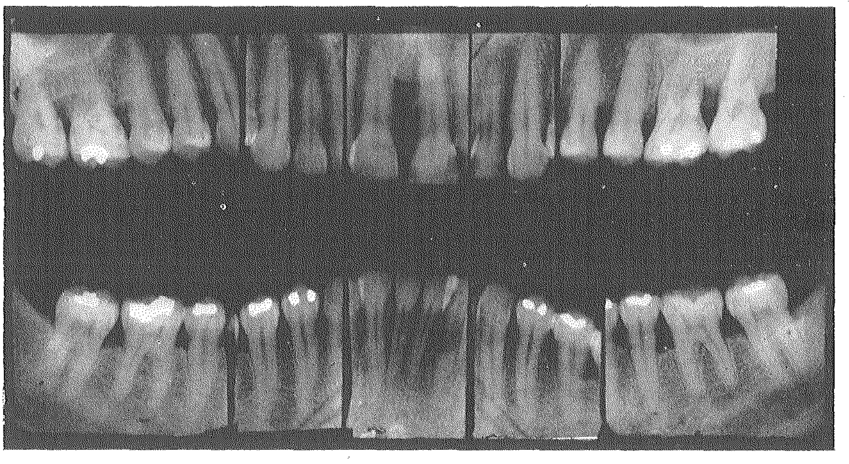


FIG. 427. Roentgenograms taken before treatment of the case shown in Figure 426.

for subsequent rehabilitation when orthodontics alone could not solve the problem. This usually can be accomplished with ligatures, finger springs soldered to temporary restorations, temporary partials with finger springs, or a Hawley retainer. It usually is not necessary to band the teeth for this purpose. If the orthodontic movement required is more extensive than that, it usually should be handled by the orthodontist prior to treatment. There are many cases in which all that is required is simple retraction of anterior teeth which have drifted labially. Such a case is shown in Figure 426 of study models of a relatively young patient. There was considerable bone loss, as shown by the roentgenograms (Fig. 427). The mounted models (Fig. 428) showed that there had been considerable forward drift of

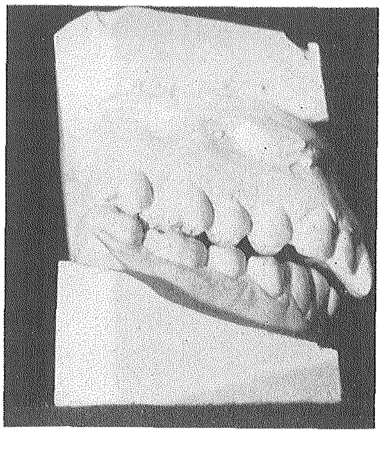
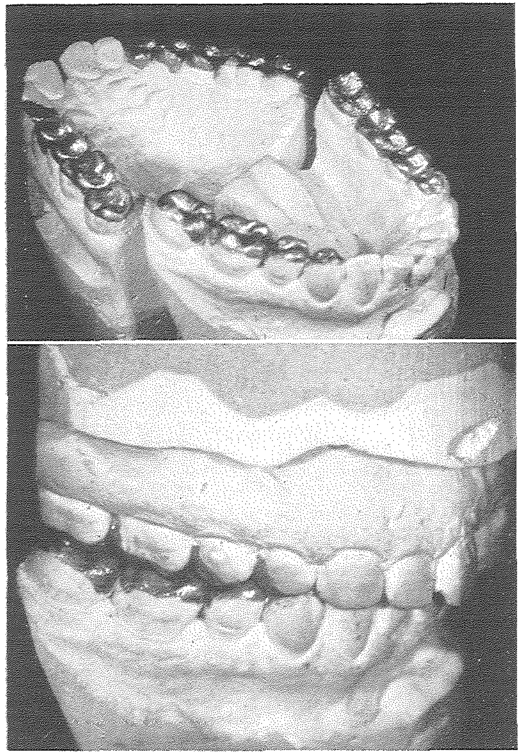
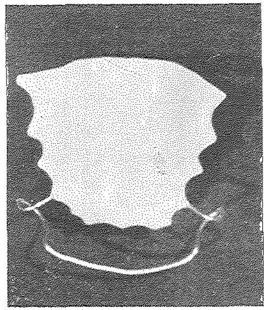
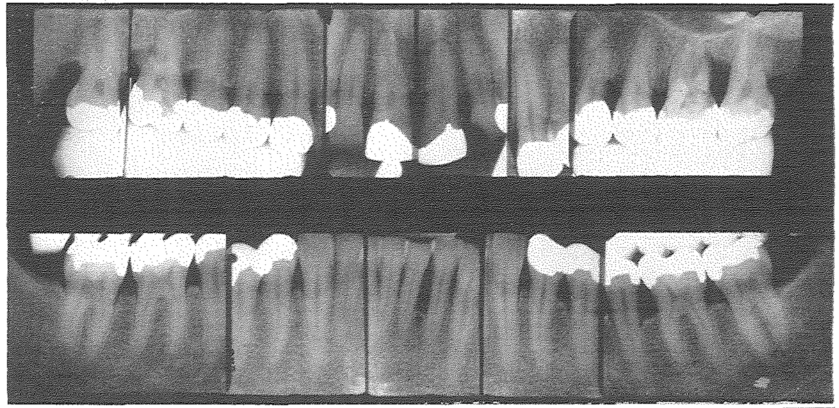


FIG. 428. The incisors have been pushed labially.







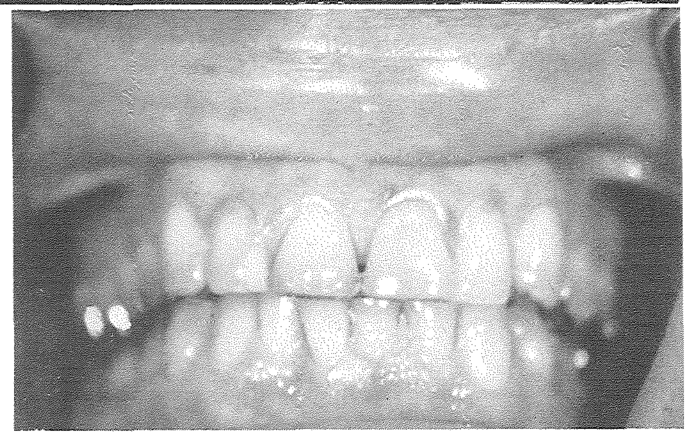


FIG. 429 (*Left*). Restoration of the posterior teeth.

FIG. 430 (*Top, center*). A Hawley retainer used to retract the anterior teeth.

FIG. 431 (*Top, right*). Roentgenograms of the case in Figure 426 taken 10 years after treatment.

FIG. 432 (*Bottom, right*). The clinical appearance 10 years after treatment.

the mandible, since the lower incisors in centric occlusion were in contact with the lingual of the upper incisors and yet the upper had been pushed labially by the contact. There were relatively few restorations, with large pulps in young teeth. It was not possible to close the bite enough to maintain any function on the anterior teeth. The restoration shown in lateral excursion in Figure 429 prevented functional contact of the anterior teeth. Even after the anteriors were retracted with the appliance shown in Figure 430, it was necessary to place pin-ledge restorations on the lingual of the upper anteriors. The roentgenograms (Fig. 431) taken 10 years after treatment give the impression that new bone has grown around the incisors, but this is an illusion. The teeth have merely been moved back to a higher level of bone. The clinical condition of the tissues is shown in Figure 432, also taken 10 years after treatment. The stippling of the tissues should be noted.

A similar orthodontic problem in a young woman is shown in Figure 433. The patient had already had several years of orthodontic treatment, and the case had collapsed, as shown. This was not a case which could be treated either by orthodontics or rehabilitation alone. It required both. There was no periodontal problem, as seen in the roentgenograms (Fig. 434). This case was treated by rehabilitation of the posteriors and realignment of the anteriors with the appliance shown in Figure 435. The lower anteriors

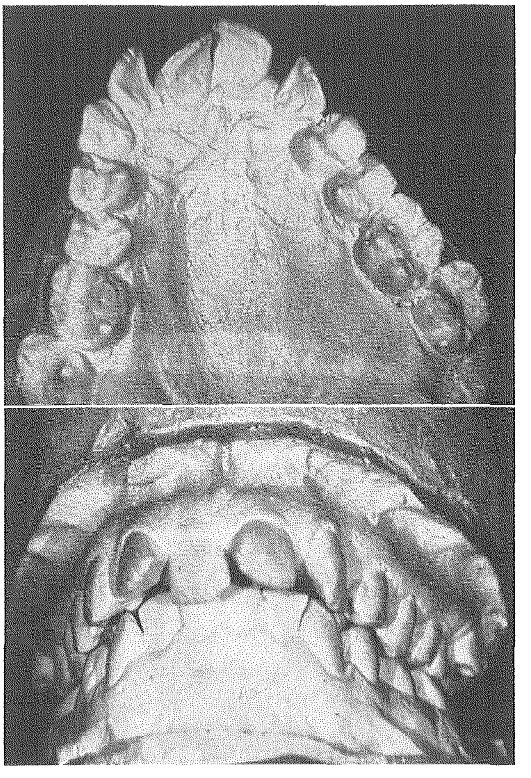


FIG. 433. A case after the collapse of the anteriors.

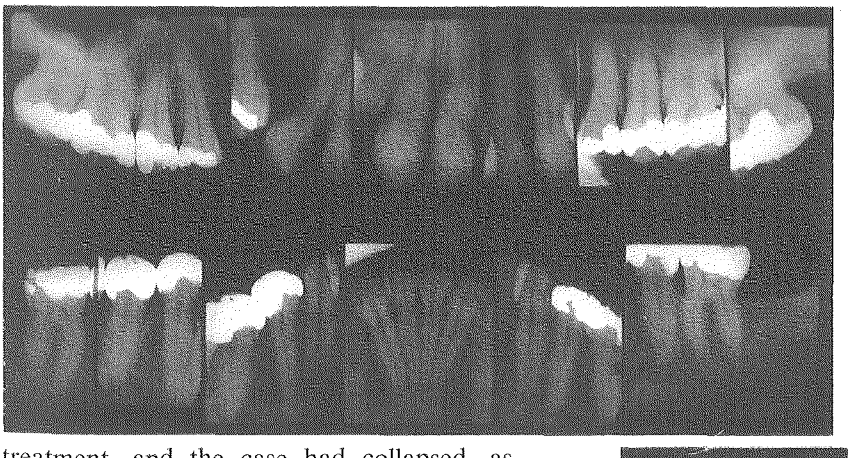


FIG. 434 (*Left*). Roentgenograms show good bone conditions.

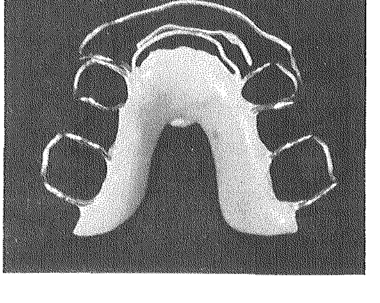


FIG. 435 (*Below*). An appliance that is used to realign the anteriors.

were shortened slightly by grinding, and pin ledges were built on the lingual of the upper anteriors. At the time that treatment was begun, it was assumed that the upper anteriors would be jacket crowns, but the patient was satisfied with the result (Fig. 436) and preferred not to have the teeth cut down for jacket crowns.

A much more extensive orthodontic problem is shown in Figure 437. This case was also that of a young patient in whom loss of teeth had collapsed the lower arch. The upper left central incisor was a bridge. In this case, the lack of basal bone prohibited bodily movement of the teeth. It could not be treated orthodontically, but some tooth tipping could be used to produce a better relationship for rehabilitation. The upper left first bicuspid was missing. It was decided to extract the upper right first bicuspid. The upper arch was expanded slightly and the anteriors were retracted. The lower anteriors were tipped labially to restore the space lost by extraction of the lower first bicuspids. The molars were uprighted. Immediately after the

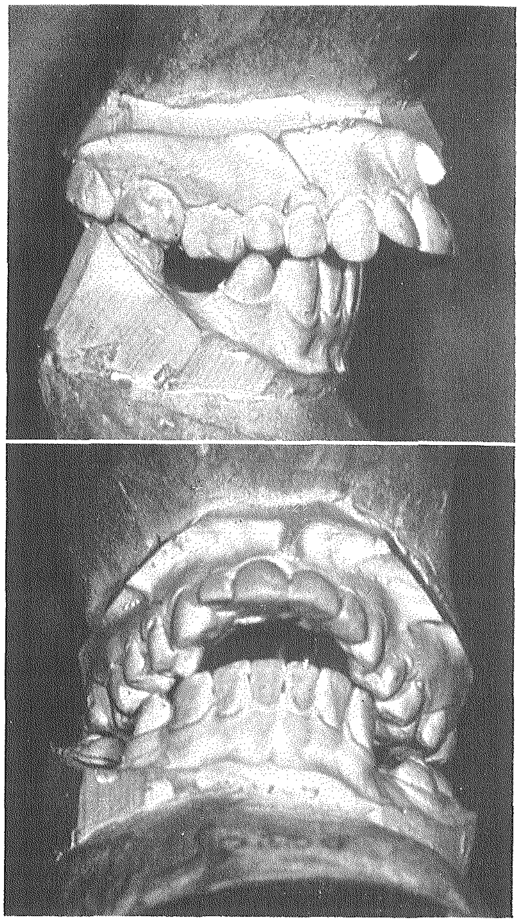


FIG. 437. Another case requiring rehabilitation by both orthodontic aid and bridge replacements.

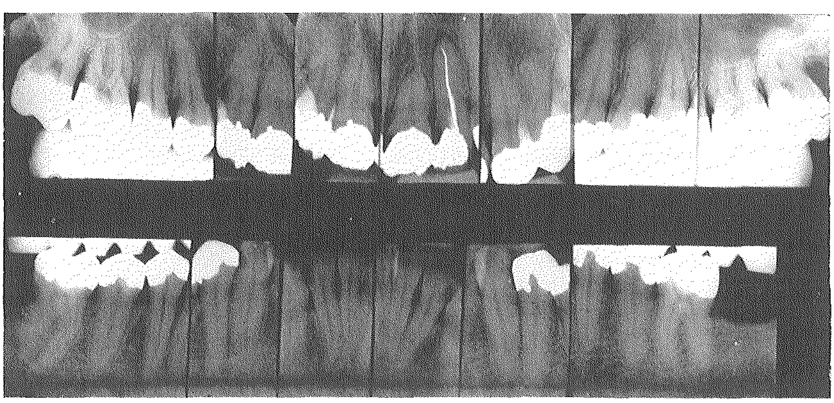


FIG. 436. The case shown in Figure 433 after rehabilitation.

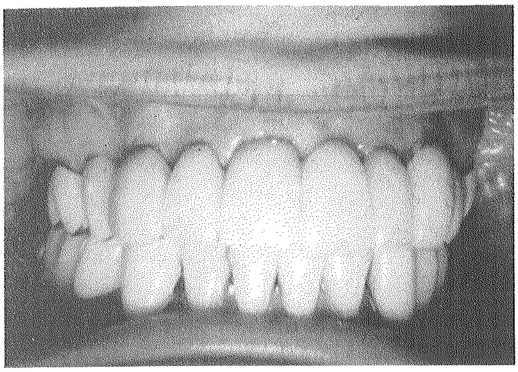


FIG. 438. The case shown in Figure 437 after treatment.

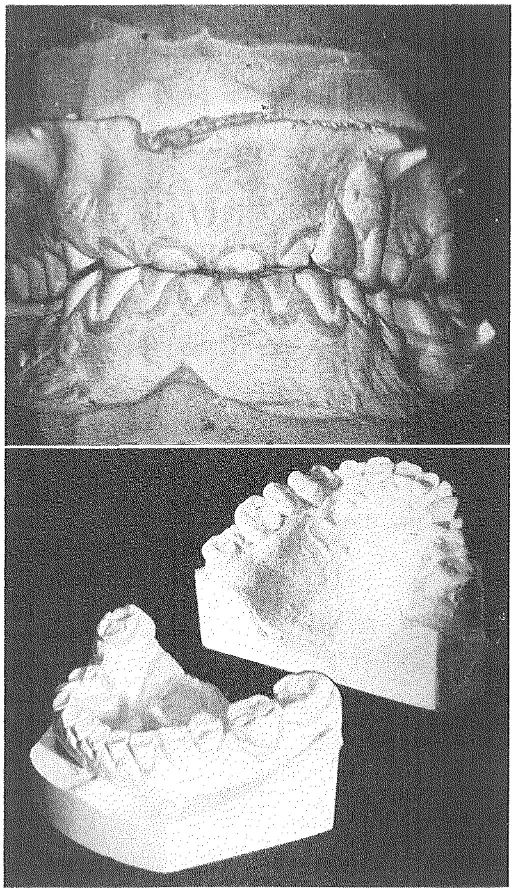


FIG. 439. A case of extreme abrasion.

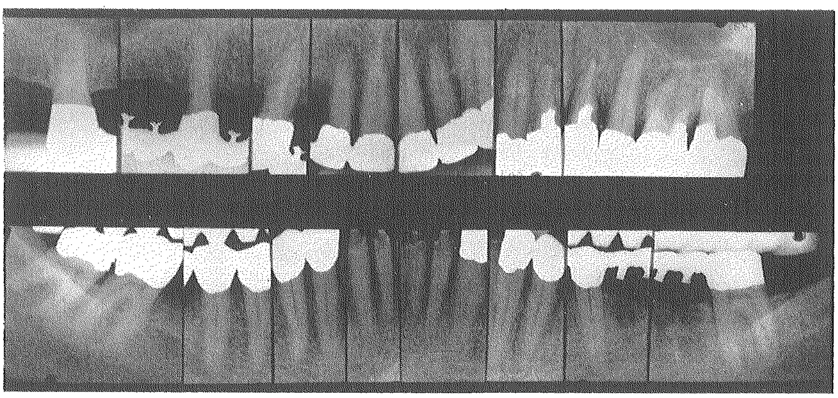


FIG. 440. There is some posterior periodontal involvement.

orthodontia had been completed, the rehabilitation was completed, with the result shown in Figure 438. The lower anteriors were not touched, although the picture gives the illusion of jacket crowns. These are the patient's natural teeth.

Cases of extreme tooth abrasion frequently require gingivectomy in order to have enough tooth exposed for adequate preparation and retention. This can be done at the time of preparation by the use of surgical diathermy with what is popularly known as the "radio knife." Temporary crowns are cemented with Ward's Wonderpak, and the excess pack is left between and around the teeth to protect the cut surface. An extreme case of abrasion is shown in Figure 439. This patient was a man in his late fifties, who had good bone, as is usually the case in such mouths. However, there was some posterior periodontal involvement in this case. Figure 440 shows the roentgenograms that were taken immediately after the preparation and the placing of temporary splints. In this case it was neces-

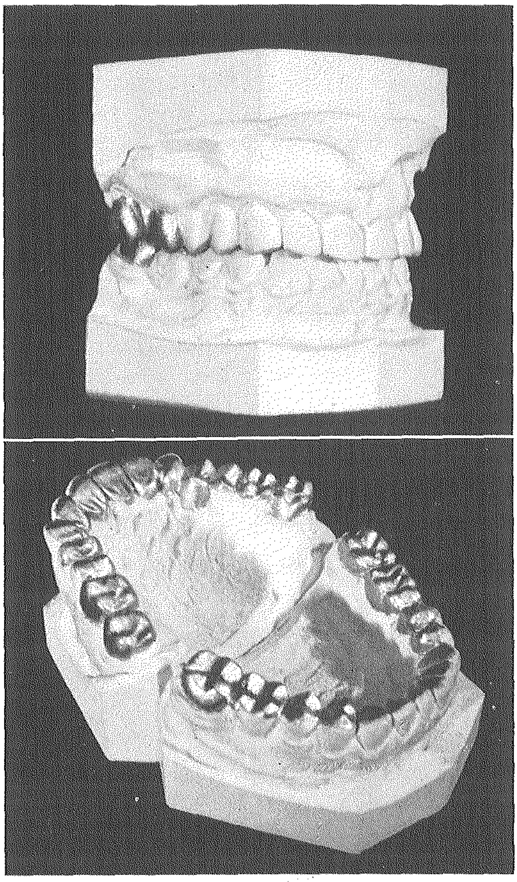


FIG. 441. Restoration of the case shown in Figure 439.

sary to raise the bite enough to be able to restore a normal cusp relation (Fig. 441). The clinical appearance (Fig. 442), and the roentgenograms taken 10 years after treatment (Fig. 443) show good bone retention.

It must be remembered that the preparation of large areas of sensitive surfaces that have been freshly cut on many teeth cannot be done as quickly or in quite the same way as the preparation of one tooth. The patient can protect one tooth from shock until the pulp has had an opportunity to recover, but he cannot protect a large number as effectively. The prepared surfaces must be protected adequately by the operator, and a sufficient time must elapse before these teeth are subjected to any further shock. The operator should not try to hasten the restoration. So-

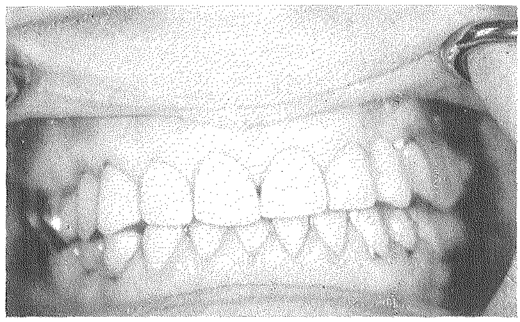


FIG. 442. The clinical appearance 10 years after treatment.

dium fluoride is effective as a desensitizer, but it is dangerous in close proximity to the pulp. The same thing holds true for silver nitrate, but the danger can be minimized by rapid reduction with potassium iodide. Copal varnish is effective, but it offsets the sedative effect of the eugenol cements. It is better to use it before permanent cementation.

## SPLINTING

Splinting is always indicated in fixed bridgework, and at times it is a necessary expedient in stabilizing natural teeth. Dummies on a fixed bridge exert a cantilever action on the abutments. No matter how well they are articulated, this cantilever force always exists. Therefore, they must be soldered at both ends. If extreme problems of parallelism make this impractical, a deep-locked dovetail rest, such as Stern's Precision Rest, should be used.

The splinting of natural teeth is not indicated as a substitute for good articulation. It is sometimes a necessary adjunct. By one means or another, the tooth must be stabilized in its socket to maintain a stable bone relationship. Many loose teeth do move in function, but that does not mean that they should—at least, not enough to be clinically evident. If, for any reason, it is not possible to produce an occlusal relationship which will stabilize the tooth in function, then splinting is indicated. The reason might be that the relation of the teeth to each other in the arch is such that extreme warping of cusps on loose teeth would require added sta-

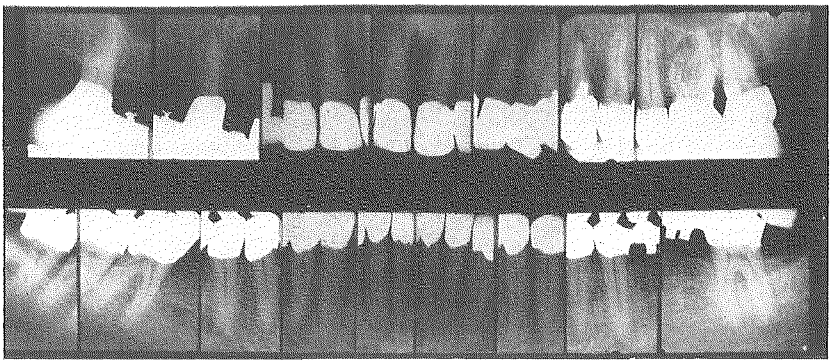


FIG. 443. Roentgenograms taken 10 years after treatment.

bilizing. It might be the physical inability of the patient to undergo complete treatment. It might be the lack of physical facilities to create a proper restoration. There are many other possible reasons. However, clinical experience in many cases that have extended over many years has shown that, when good articulation can be secured, which will stabilize the tooth in the bone, the bone response is better without splinting. This has been demonstrated in many cases which have been splinted for 2 or 3 years on articulated temporaries and then restored without splinting. On the other hand, if splinting must be employed, it will be better if it is done with the best possible functional relation. This is why it does not replace good articulation, but should be resorted to only as a necessary adjunct.

Restorations for splinting must have more retention than the same teeth need if they are unsplinted. The greater the mobility, the more the retention needed. A tooth should never be splinted without full occlusal coverage. Usually, a minimum of a three-quarter crown preparation, with good parallel grooves and walls, is required. This is frequently an indication for full crown preparations. Occasionally, M.O.D.'s with good box preparation, good accessory grooves and deep parallel occlusal locking, may be used with caution. They should always be cemented with Temrex and allowed to set for a sufficient time to be sure that they will not loosen. There is nothing more disconcerting than to have one tooth in a splint loosen.

If isolated teeth are standing in an arch, with spaces between all of them, then the 14-tooth bridge constructed as a full splint usually is best. It has stood the test of time far better than any removable partial denture has. Frequently, a unilateral splint may be used as an abutment for a unilateral removable partial denture that is supplying the other side.

Frequently, the teeth in older people which have been subjected to major orthodontic movement should be splinted for retention. If teeth have been moved orthodontically to bring them into a better relation for rehabilitation, usually they should be provisionally splinted for a few years before a final decision is reached.

Restorations frequently are constructed and temporarily cemented on a provisional basis. In a mouth with extensive periodontal involvement, there are always some teeth on which the prognosis is more questionable than on others, but which are borderline cases and worth attempting to save. This should always be made clear to the patient, so that there will be no hard feelings if the restoration is not successful. These teeth would always be splinted. In order to avoid problems and redoing a considerable amount of work, they are always kept on temporary cement for a long time—until the prognosis is clear. The loss of such a tooth, if it is part of a splint, then involves very little. It is merely necessary to remove the splint and process a root in the restoration to replace the lost root. Indeed, such cases can be maintained for many years on Temrex, with better results than from crown and bridge cement.

If teeth are to be splinted, the solder should not block up all the interproximal spaces. For permanent restorations they should not be cast in a group. Each one should be constructed and fitted as a separate restoration. Then a plaster impression can be taken to solder them together. This should be strong enough to withstand the stress, but it does not need to be as strong as a fixed bridge. A small amount of #615 solder, placed right at the contact point, is adequate. Higher carat solder will not discolor as much, but it is not as strong. The patient should be able to go through the interproximal spaces with the tooth brush and stimulators.

## TONGUE THRUST

The most difficult problem to treat is the tongue thrust. It is the one case in which the results can be destroyed by the patient, and the prognosis is very uncertain. It is one case in which closing the bite is never indicated. As a rule, nothing will stop the tongue thrust in an adult in whom it has been a long-standing habit. The most that can be hoped for is to prevent the damaging effects of the habit. The treatment is more likely to succeed if it does not make it impossible for the patient to pursue the tongue habit, but does attempt to stabilize the teeth against it. The worst of all is the protruding tongue thrust which forces the anterior teeth apart. Such cases almost invariably call for splinting. The use of spiked lingual arches may stop the habit in children, but I have never seen them work in an adult. They are likely to produce more psychological problems than they solve.

The lateral tongue thrust is more amenable to treatment, which consists in closing off the space and splinting all the posterior teeth to avoid orthodontic movement by the tongue. I have tried this repeatedly on anterior teeth, and even splinting is not adequate if the tongue space is closed off. I have seen such patients change the whole arch form to make room for the tongue thrust. Even upper and lower 14-tooth bridges have been separated orthodontically by the tongue thrust.

I well recall the case of a woman who had resorted to a variety of treatments. She had worn splints, had had her mouth equilibrated, and even had had her anteriors ground to make more tongue room. Her only dental complaint was soreness of the frenum under the tongue from constant rubbing on the lower anterior teeth. Primarily because of the equilibration, the posterior teeth were reconstructed. She wore an articulated splint for 2 years, with excellent results. The anteriors were not touched, thus leaving the tongue room. The case was periodontally successful, but she still was not entirely comfortable as far as her tongue was concerned. At her request, the anteriors were jacketed for esthetic reasons as the space was unsightly. After a lapse of time, they appeared to be holding well, so new posterior restorations were constructed that were slightly more open, for tongue room. After completion this was checked repeatedly over a period of 2 years.

She entirely disappeared from sight for about 3 years. Then she went to an endodontist for treatment of a pulp which had been exposed prior to the time of the original restoration and had been capped for many years. He opened through one of the restorations to treat the pulp, and sent her back to me to have the inlay replaced. When I examined her mouth, I was shocked to see that her bite had opened up and that she was touching only on the distal of the second molars. The anterior space had returned, and she again had a sore tongue. This is typical of such cases. It had taken her time to accomplish the tooth movement, but it did not stop until she had created space again for the tongue thrust. Experimentally, we closed her a little by equilibration, thinking that we could conquer the habit by gradual elimination of the space, but the procedure was not successful. Since then, I have come to the conclusion that, in all cases of this type, some allowance must be made for the habit to continue. As one psychiatrist remarked, if we did stop it, the patient probably would acquire a worse habit.

A somewhat different tongue problem is the case shown in Figure 444. This patient

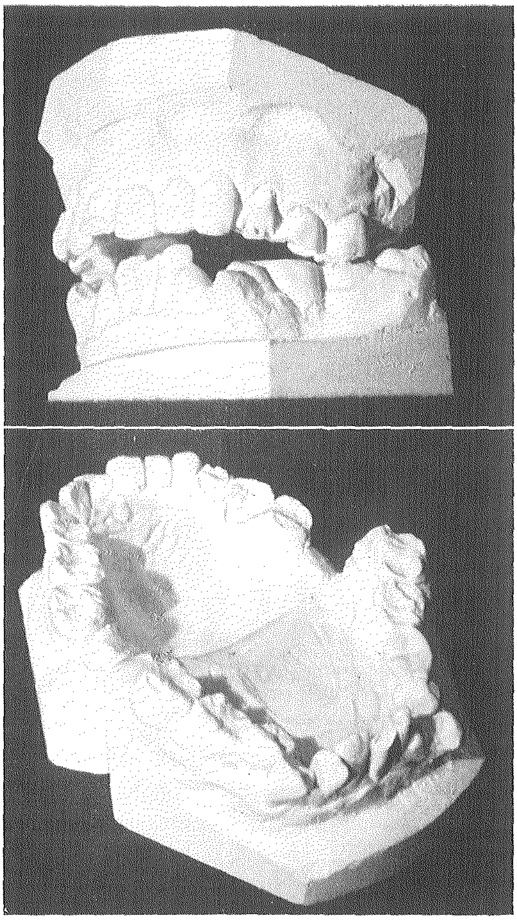


FIG. 444. A case of tongue abrasion.

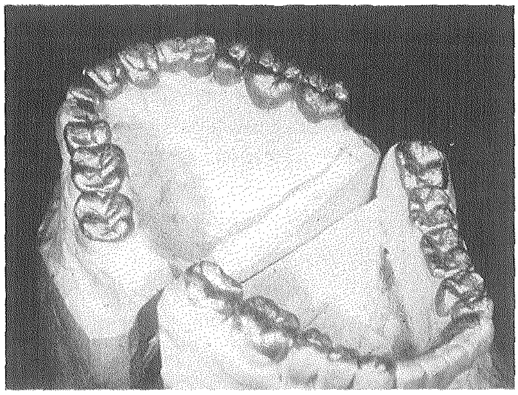


FIG. 445. Restoration of the case shown in Figure 444.

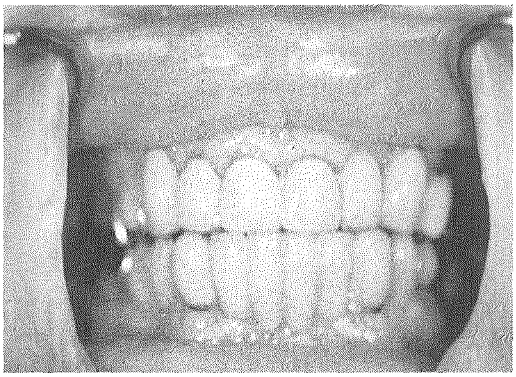
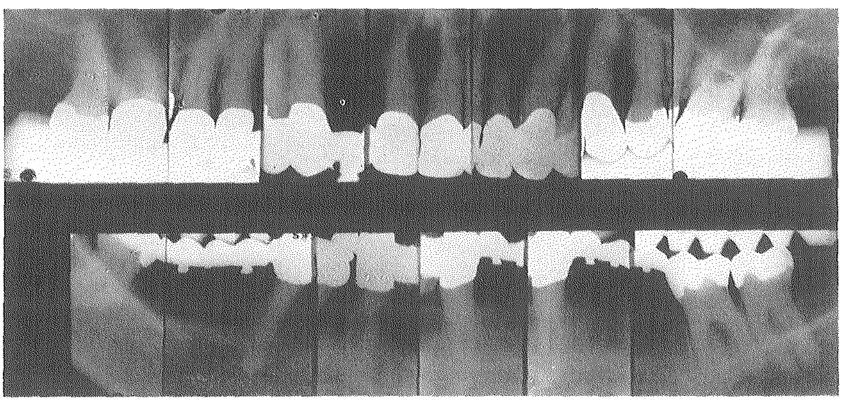


FIG. 446 (*Above and Below*). Clinical and roentgenographic appearance of the same case (Fig. 444) 15 years after treatment.



had developed the habit of rubbing her tongue constantly over the occlusal surfaces of her teeth. She had worn them down so that inlays were left standing with no tooth structure around them. The lower incisors and the lower first bicuspids were extracted. These were replaced by a fixed bridge, and a fixed bridge also was used to replace the missing upper central incisor (Fig. 445). The rest of the teeth were restored with crowns and inlays, resulting in the appearance shown in Figure 446, 15 years after treatment.

## TEMPOROMANDIBULAR JOINT CASES

Handling the temporomandibular joint case presents not only technical problems but also patient handling problems. Patients with temporomandibular joint problems are always dubious, and one of the important aspects is to win and hold the confidence of the patient. The end-results of treatment are physiologic. The patient's acceptance of treatment is psychological. But a physiologic result is never obtained without psychological acceptance by the patient. Many problems arise during treatment. If they destroy the confidence of the patient, even though they have nothing to do with the finished result or treatment, this can spoil all chance of success. On the other hand, obtaining the confidence of the patient without obtaining a physiologic result is not adequate treatment. Psychological therapy alone cannot solve the problem, but it must accompany the treatment. The confidence of the patient is all-important. The operator should never place in a patient's mouth any restoration, temporary or not, with known errors related to occlusion, on the assumption that he will correct it later, or that the patient will adapt to it. He knows that changes will take place later which will require correction. The patient should be aware that the operator knows this and that it is all part of the treatment problem. When this happens without previous warning, the patient is likely to believe it is because the operator has made some error. Even if the operator should discover some error and correct it, he should never let the patient tell him that it is an error. Once the patient believes that the operator has made a mistake, he always will be testing and trying to see if he can find more errors, and the case is a lost cause.

Many joint patients have learned to hold their teeth apart, in the belief that they will avoid hurting the joint. The mandible will be held, for hours at a time, suspended between the opening and the closing muscles. The muscles are not at rest—they are in constant opposition. This can produce muscle problems that are worse than the joint problem itself. The operator should be wary of patients who come in with wads of tissues or cotton or similar devices to hold between the teeth, saying that they are more comfortable that way.

The temporomandibular joint case presents both dental and mental problems, but psychotherapy will be of no help unless the patient is willing to accept it. Unfortunately, those who need it most are frequently those who are least willing to accept it. All too often, patients who believe that the whole problem is psychological, and eagerly accept psychotherapy in the hope that it will cure them, are those who need it least.

## PERIODONTAL ROUTINE

A large majority of the patients who present for rehabilitation have some periodontal problems. Often that is the reason that motivates them. In other cases it is a secondary part, but nevertheless a part, of the problem. Deciding when, how, and what to do is a part of the treatment plan.

Usually, the first step, prior to any other procedure in the mouth, is a thorough prophylaxis, with good, deep scaling and curettage. If it does not shrink of its own accord, swollen hypertrophied tissue is removed with the radio knife. This will give better accessibility during the preparation and the impressions for the temporary restoration. More extensive therapy is deferred until after all the teeth have been prepared and temporary restorations have been constructed. There are two advantages to this procedure. The temporaries are always splinted; and the splinting will aid by stabilizing the teeth during periodontal treatment. The splint is removed during treatment. Since each tooth is isolated, treatment becomes much easier.

After the temporaries have been completed and adjusted, treatment is carried out, one quadrant at a time, under local anesthesia. The temporary is removed with a Crescent back-action hammer. Every root surface is curetted, planed and, if necessary, smoothed with files. The tissue lining the pocket is curetted thoroughly and vigorously with sharp Gracey curettes to eliminate the epithelial lining, which literally is scraped off and broken up. Some observers have characterized this procedure as an internal gingivectomy. However, the gingival margin is not cut back, although the treatment does result in a considerable shrinkage of the gingival margin. A decision on doing a gingivectomy is postponed until after the final restorations are completed. The result of the treatment, observed some time after its completion will influence this consideration.

Following curettage, each pocket is thoroughly saturated with modified Talbots Iodo-Glycrol, rubbed deep into the pocket with a small ball-end applicator. This is kept in place with cotton rolls and a saliva ejector for 3 minutes so that it will absorb into the freshly cut tissue. The excess is washed out with warm water, and the temporary is replaced. The patient is warned to expect some soreness, but a pack rarely is indicated. Usually patients will report some discomfort during the first evening, followed by rapid healing and pocket shrinkage. If soreness and inflammation persist, Box's Periodontal Pack is applied in the pocket.

At the time of this procedure the patient is given instructions on home care. Usually this takes the form of vigorous brushing with a medium-sized multitufted brush and using interdental stimulators. The patient is warned that neither one alone is adequate. He must do both. Experience has shown that more people will follow this routine than the Charters system. The patient must be impressed with the importance of home care as an essential part of treatment.

He is advised that he must return for regular prophylaxis at frequent intervals, which must be spaced close enough to prevent the accumulation of deposits on the roots. Usually this is started on a 2- or 3-month recall and, as the condition improves, is lengthened out to 4 or 6 months, depending on the home care. At each return visit the patient is taken through the toothbrush and stimulator explanation again in order to drill it into his head thoroughly. Likewise, at each prophylaxis he is given a new brush and enough stimulators to last until his next visit.

After the case is completed, he is checked at frequent intervals between prophylaxes to see how well he is executing his home care and how the case is progressing. This is continued until we are satisfied that he is making progress.

## BRUXISM

Like the tongue thrust problem, bruxism can be a decided factor in the degree of success of our best efforts. Clinically, there appear to be two kinds of bruxism, or, perhaps it would be better to say, two kinds of patient problem. There is one type in which the bruxism appears to be the result of irritation from malocclusion. Whether the response is psychological or not, I do not know. Children grind their teeth; animals grind theirs. It appears almost as though nature were trying, by some reflex mechanism, to get rid of the offending members, either by abrading them away or by loosening the teeth. Almost all these patients vehemently will deny grinding their teeth. Most of them do it in their sleep, and it can be detected in several ways. Objectively, one can see on the teeth heavy, brightly polished points of wear in excursive relations, in excess of what would appear to be normal tooth contact. Subjectively, careful inquiry will show that the patient awakens with a tired feeling in the facial muscles. Frequently, a husband or a wife will be aware that the other is grinding by the noises that he or she hears when the other is asleep.

This type of bruxism is almost always grinding, rather than clenching. More people fall into this category than into the second group. This kind of bruxism frequently will cease when the occlusion has been properly articulated, lending credence to the belief that it may be some kind of reflex. If it does not entirely disappear, it recedes to the point where its effects are no longer clinically evident.

The second type, which is less common, appears to be the result of a deep-seated psychological or emotional problem. The prognosis is much more difficult to make in this type. It is difficult to diagnose, and there is more uncertainty about how much damage it can do to the treatment. Even though the patient is known to be a bruxer, it still is hard to say in which group he belongs. But since there are fewer patients in the second group, it does not present as great a clinical problem. In the majority of patients in this group, it is safe to say that proper articulation will reduce the damaging effects and perhaps bring them within physiologic limits. To some extent this will depend upon how gross the destruction is before treatment. I have seen some cases, in which the bone loss was about fifty per cent, who have been maintained for 20 years without further damage. I have seen others in which the destruction continued, but at a much slower rate—cases in which there are signs of bone change at 5-year intervals, and yet the bone change is hardly evident at 1-year intervals. Certainly the rapid, acute symptoms subside and are replaced by a slow, chronic process. Periodontal therapy appears to make no difference in these cases. Frequently they are what Box has characterized as "clean pyorrhea."

Unscientific spot-grinding can also cause bruxism. Indeed, many patients who were not bruxers before become addicted to bruxism after equilibration by spot-grinding. Whether or not this is because they become tooth-conscious is not known, but the fact remains that they will cease when the teeth are properly articulated.

## VERTICAL DIMENSION

Within the normal limits that usually occur in practice, vertical dimension is not a critical factor. It is better to alter the vertical dimension in order to produce a better functional relation than to adhere to a fetish about the sanctity of rest position and freeway space. In the majority of cases that are placed in centric relation, it will be necessary to close the bite slightly. Frequently, as the condyle goes back and up, the molars will be so high that the opening anteriorly will make it impossible to produce any kind of proper anterior relationships without closing the bite. What this amounts to is closing posteriorly and opening anteriorly. To say that the bite has been opened or closed is meaningless, when judged from the appearance of the teeth.

The determining factor in vertical dimension is the muscle length at the occlusal contact in centric relation. In most cases this length actually is shortened by rehabilitation, even though anteriorly the bite may appear to be opened. Indeed, many cases of equilibration end up with an overjet, which, when looked at casually, would appear to be "bite raising."

Opening a bite is not an end in itself; there is no point in opening a bite merely for the sake of opening it. On the other hand, there is no reason not to open a bite if it will make it possible to produce a better functional relation of the teeth. Many of our previous ideas about rest position and freeway space have been shown by electromyographic studies to be the result of erroneous observation.

Moyers points out that there is no such thing as a rest position. A muscle is never at rest, so it is a misnomer to refer to the dropping of the mandible as "rest" position. The length of a muscle at any given moment depends upon the stimuli that are supplied to it. In the case of the mandible, it is the occlusion which supplies the stimulus. When it is not in function there is a freeway space, but it is not a rest position. This freeway space can be changed rapidly by changes in occlusion. In malocclusion there is far less freeway space than in the same mouth when it has been restored properly. The restoration itself increases the freeway space, even though the occlusal height is raised. In addition, the freeway space involves a dropping of the condyle as well as the anterior section of the mandible. To exceed this freeway space muscle length by "bite raising" would in most cases mean an increase in tooth length anteriorly of at least ½ inch. The reason is that when the mandible is lifted from this position to tooth contact, there is a relatively small change in the muscle length—usually about 2 mm. But if the 2 mm. of change in the muscle length are used to build teeth which open in an arc around the hinge axis, the anterior opening would be many times 2 mm.

This is illustrated in Figure 447. Position #1 shows two outlines of the mandible, in "rest" position and drawn up in functioning position. The upper line from the axis to the tips of the lower incisors shows the length of the temporal muscle in functional contraction. The lower line shows the length of the same muscle at the freeway space. Although only one muscle is shown, the same would hold true for all the muscles. Position #2 shows the condyle when the axis is drawn up to its functioning position. The lines drawn from #1 to #2 show the length of the muscle at the two positions. As seen in #2, to exceed the resting length of the muscle, the mandible would have to be opened at the incisor region at least ½ inch.

There are some cases of deep overbite and no overjet in which the mandible does not go back enough in centric to permit normal anterior guidance. In such cases it is frequently necessary to open the bite. But if bite-opening alone is used, sometimes the mandible will go too far back as it opens, resulting in too long an overjet. In general, as the mandible opens, the lower anteriors also go back an equal amount. In such a case, it frequently is desirable to secure some of the change in anterior guidance, some by opening and some by shortening the lower anterior teeth, and some by reshaping the upper anteriors with pin ledges or jacket crowns. Rarely would one factor alone be used to the exclusion of all the others.

Cases of severe abrasion require some opening. The objective is not to restore the original length of the teeth; the purpose is 2-fold. It is necessary to have room enough for the restorations, and also, for the sake of function, to produce an increasing cusp height from posterior to anterior. Beyond these requirements, there is no point in opening any more than necessary.

It is permissible to alter the vertical dimension and the freeway space only if the restoration is constructed with a proper centric mounting, which means hinge axis and centric bite. If this is not done, then the freeway space becomes a critical matter.

## OCCLUSAL ADJUSTMENTS

If the procedures described have been executed faithfully, adjustments in the mouth should be almost nonexistent. So-called

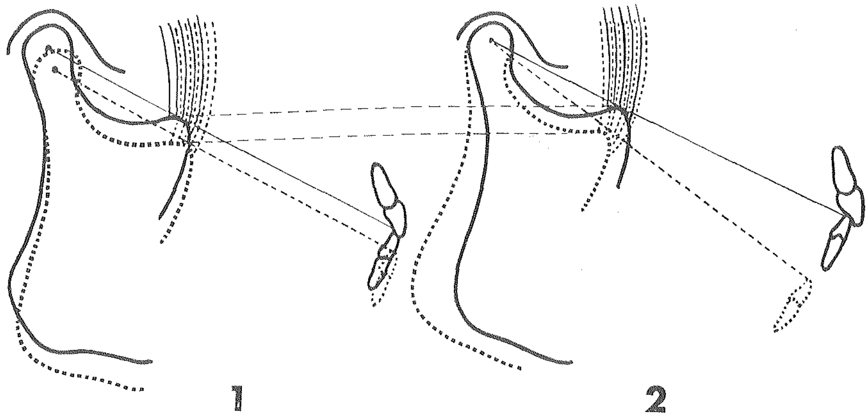



FIG. 447. Bite raising does not increase muscle length.

"grinding in" of the occlusion in the mouth should never be done. The mouth should never present the situation which was the rule 25 years ago. In those days, after a restoration had been constructed using check-bites, it was considered a normal routine to spend more time in the mouth attempting to grind the restoration to occlusion than it required to construct the restoration. Frequently the adjustment was so extensive that, by the time it was completed, the original restoration had been so macerated that it might just as well have been done on a plain line articulator in the first place. The tedious, frustrating hours of chair time made rehabilitation a formidable task.

Today that situation is all changed. Whatever minor adjustments might be required should not be attempts to alter or correct errors in jaw registrations. Adjustment in the mouth should never be used to circumvent remounting. This is self-delusion, but "there's many a slip 'twixt the cusp and the lip." Minor errors and changes can creep in after it is too late for a remount, when the case is permanently cemented. This is the reason for keeping the restorations on temporary cement for a sufficient time to detect any errors while there is still an opportunity to remount for adjustment. Except for rare occasions, the most that should be called for is the kind of minor adjustments which could be made with an abrasive rubber wheel. Even this should be comparatively rare.

There are three possible sources of this kind of error. There can be minor discrepancies between the temporary cementation of individual restorations and the final permanent cement. Generally these would be so slight that they could be detected only after the restorations had been cemented for some weeks or months. They would appear as brilliant facets on the metal, showing heavier contact in some spots than in others in the same excursion. Excessive grinding with stones could make these spots too light and other spots too heavy. It is better to proceed cautiously by polishing them gradually with rubber wheels, and then checking later to see whether or not more polishing is required. Many of these spots are self-correcting and should be checked carefully before grinding is started. One small, high spot will not long sustain an entire occlusion. If it is slight, the metal can be swaged enough to eliminate the spot. The mere presence of some shiny spots is not enough in itself to warrant adjustment.

A second, more likely source of possible change is shifting of periodontally involved teeth. In the adjustment of occlusal contact on the remount, there is no such thing technically as perfectly equal contact of all surfaces in every excursion. Even the thickness of the film of rouge used for the final checking introduces a microscopic error. There is no practical means of detecting this clinically in the mouth. Sandblasting the surfaces is better theoretically, but, as a practical matter, it can lead to endless adjustments and can wind up doing more harm than good. In the mouth these slight inequalities of contact can lead to a slight shifting of teeth, which may require some adjustment. It has been suggested that this be corrected by a slight, final milling with fine pumice, just enough to equalize the contact without destroying the cusps.

The objection to this brings us to the third possible source of error. There is no such thing as a perfect remount impression and model. Three problems intervene: stabilizing the teeth while taking the impression, re-seating the restorations in the impression, and holding them while pouring the model. As a result, there can be minor discrepancies between the remount model and the mouth. No matter how perfect the adjustment is on the model, this will result in some differences in the mouth.

Another correction can be necessitated by teeth which can be depressed in their sockets. Even though they are correctly positioned in the remount model and bite, as the initial healing starts the periodontal membranes will thin out and the teeth will settle in the sockets. In time, no doubt, a single tooth would erupt into occlusion and no correction would be required. But if many such teeth are involved, in the initial healing the remaining teeth will be high, perhaps leading to some stress on these teeth.

In no case should mouth adjustment be an attempt to correct a wrong centric bite or to change the fundamental articulation. Errors of this kind cannot be corrected properly in the mouth. Rather, minor high spots should be corrected to maintain the original articulation, as executed on the articulator. It is not in the province of this book to detail the methods of adjusting. In general, they follow the technics developed by Dr. Stevens Brown of Ashtabula, Ohio. The detection and the adjustment of these spots are very precise procedures and should not be attempted by haphazard grinding. It is far easier to make another remount and adjust the spots in the laboratory.

## PATIENT-HANDLING

Thus far we have been considering the technics of treatment. There is more than this involved in treating the patient. Here we are dealing with a human being, with all the human problems and variables—both physiologic and psychological variables. Every patient deserves the best service that the dentist is capable of rendering. There should not be various grades of professional skill that are based upon what the patient can pay.

The best service which can be rendered is not dependent only on the knowledge and the skill of the operator. Not all patients are physiologically, psychologically and/or economically equal to all the treatment that the operator might feel would be the ideal solution to his problem. To turn away from it because it does not fit into some ideal scheme of practice is not real treatment of the patient. Treatment is an attempt to determine the best which can be done for the welfare of the patient, under the circumstances. Every case, no matter how ideal the situation, presents some compromise between the theoretic ideal and the practical situation. Not a compromise for the convenience of the operator, but a recognition of what can be done in the light of an understanding of what the ideal treatment would be.

This becomes a matter of putting first things first. This is the problem of expressing the judgment of the operator in tangible terms and deciding what the treatment should be. The patient with a caries-free mouth and a bad periodontal breakdown does not have the same primary requirements as the patient with rampant caries. Yet their other problems and attitudes might be very much alike. There is the patient with a nervous, apprehensive approach to dentistry; the patient with a low pain threshold; the patient who cares little whether he keeps his teeth or not and who, therefore, has little appreciation of dental services; the patient who is interested only in esthetics; the patient who will not co-operate to help maintain the result; the patient who thinks he is buying a piece of merchandise; the patient with a dental phobia; the chronic complainer who is always looking for something with which to find fault; the aging matron who is looking for some magic cosmetic transformation—all these and many more, ad infinitum.

When these problems are evaluated as part of the whole treatment problem, it becomes obvious that they are much more of a factor in complete rehabilitation than in a simple restorative procedure and are some of the elements which mitigate against complete treatment, regardless of how much the operator might desire to follow an ideal treatment plan.

On the other hand, there are some procedures which can aid the operator to overcome some of these problems, no matter what type of full mouth work is being undertaken. In a broad sense, whichever of these procedures can make the restoration more acceptable to the patient from a comfort standpoint will aid the operator, provided that it is not grossly objectionable esthetically to that patient. There is little comfort in a physiologically acceptable result if it is so psychologically unacceptable to the patient that it will be destroyed.

In complete denture work, such things as

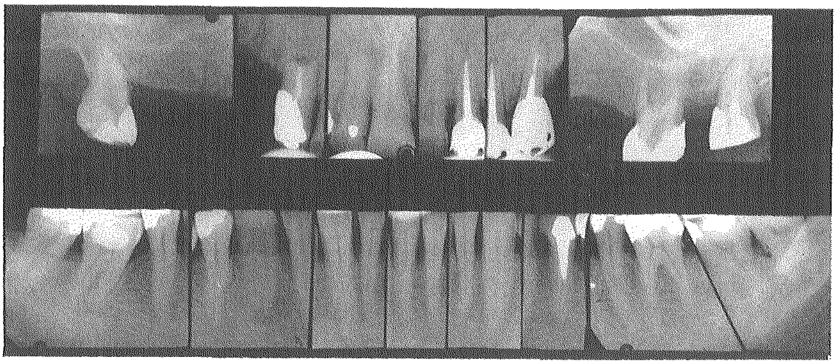


FIG. 448. Roentgenograms of a case involving both periodontal and temporomandibular joint problems.

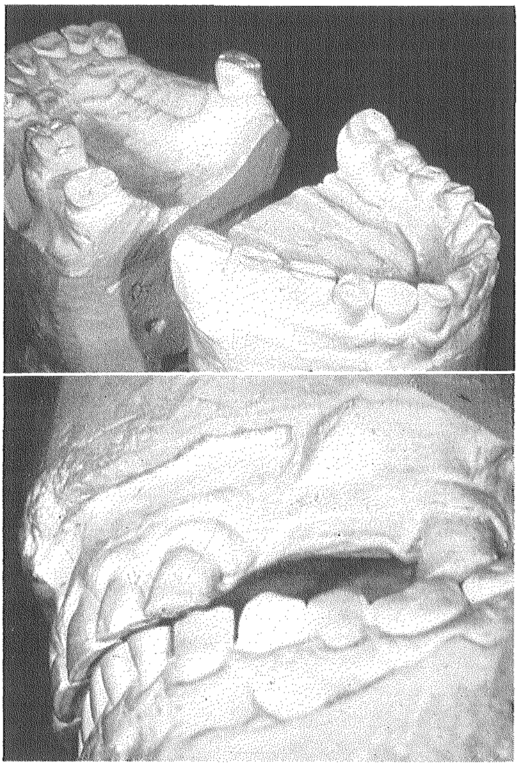


FIG. 449. Study models of the case shown in Figure 448.

a good, stable base, a good centric bite, a hinge axis mounting, cannot help aiding the operator. He will be better off in the long run and the patient will be better off in all respects; and this leads to a healthy, happy practice.

The patient who will have a receding chin in centric, but who does not want to accept this inevitable requirement, will be a constant problem. An attempt to place a full mouth restoration at some place in front of centric for esthetic reasons can be disastrous to both patient and operator.

Psychological evaluation of the patient can be very difficult. Many people have learned to conceal their true natures and problems very well, and not until it is too late does the operator realize that he is dealing with mental problems as much as with dental problems. Worse than that, the mental problems all too often increase the dental problems. It will repay the dentist well to spend time with the patient to try to evaluate him, even though it may seem like wasted time in a busy practice. Even at best, some patients can fool him, but he will spot others and come to realize that they are not amenable to treatment. Many of these patients are not true psychiatric problems—they are just problem people. This is their nature, and psychotherapy cannot change it. They are treated best by simple routine procedures. More complicated procedures will never work with them—they will only lead to more problems.

## PRACTICAL CASES

Seldom does a case present itself with only one treatment problem and a standard solution. It is unusual to see a periodontal and a temporomandibular joint problem in the same mouth. Uusually the joint patient has strong bone and hard teeth. However, I have seen several temporomandibular cases which also exhibited periodontal problems, and they all came about in the same way. In each case the patient had started treatment as a periodontal problem. As a part of the treatment, he had

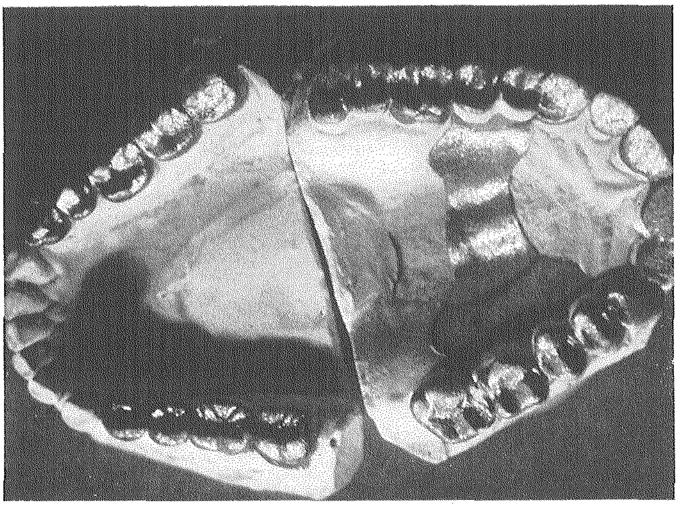


FIG. 450. The first restoration for the case shown in Figure 448.

extensive occlusal equilibration by spot grinding, and ended up as a temporomandibular joint problem. No matter how it came about, the treatment problem was the same. Such a case is shown in the roentgenograms in Figure 448. This is the mouth of a dentist, who was treated about 12 years ago. The missing teeth in the upper had been replaced by two separate, removable bridges. As seen on the study models (Fig. 449), the teeth had been ground virtually flat. The restoration shown in Figure 450 was constructed with a removable bilateral partial denture, primarily because the teeth were so loose that it was hoped that the base would give them some support. The case was satisfactory from the periodontal and the joint aspects, but the patient was very unhappy with the removable appliances. Inspite of some misgivings, this was replaced by the 14-tooth fixed bridge shown in Figure 451. Now, about 10 years after treatment, both the joint and the periodontal problem are still under control. The most recent follow-up roentgenogram is shown in Figure 452.

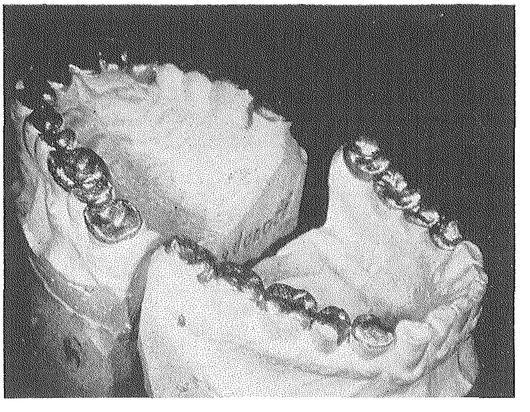


FIG. 451. A fixed bridge replacing the removable partial shown in Figure 450.

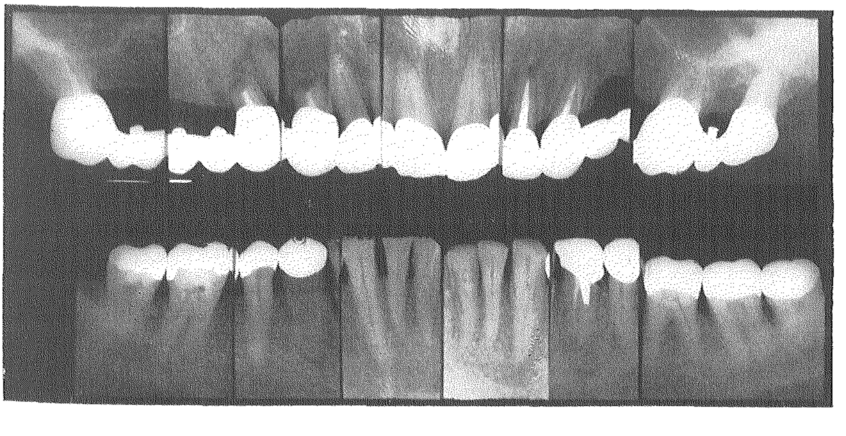
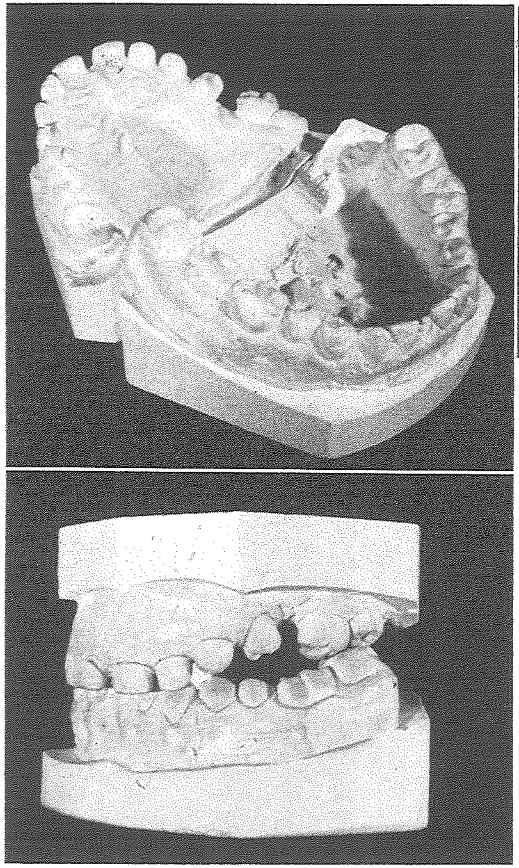
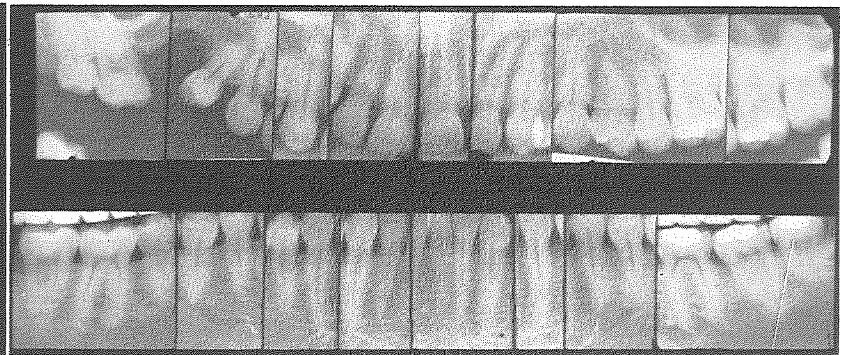


FIG. 452. Roentgenograms taken 10 years after treatment.





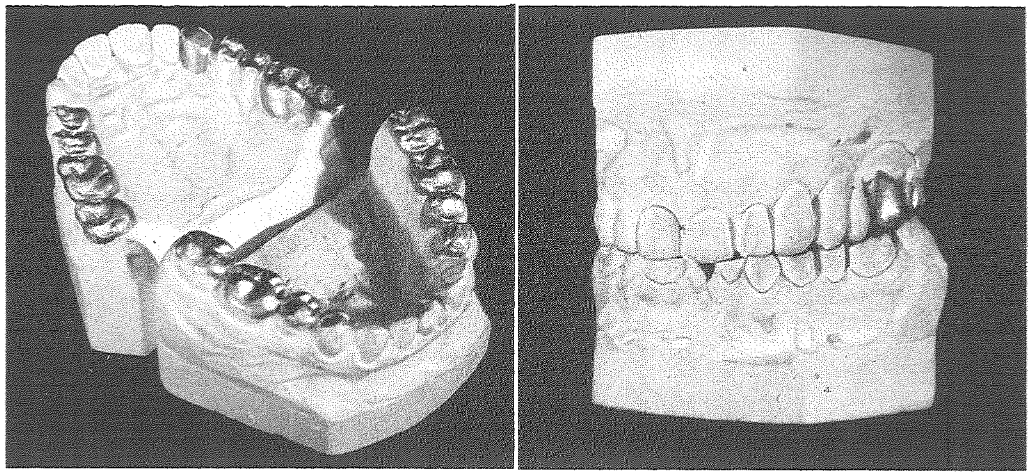
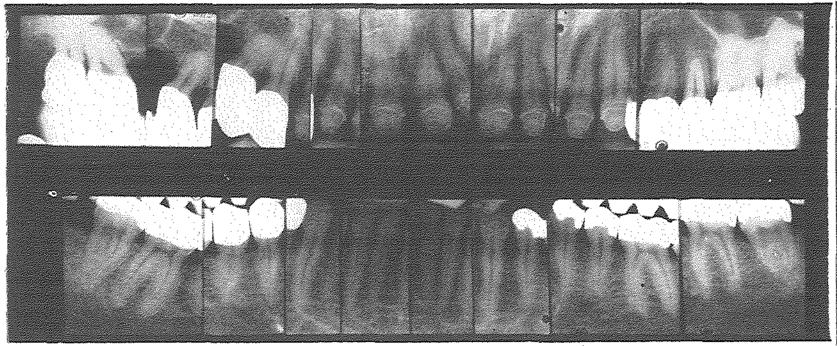
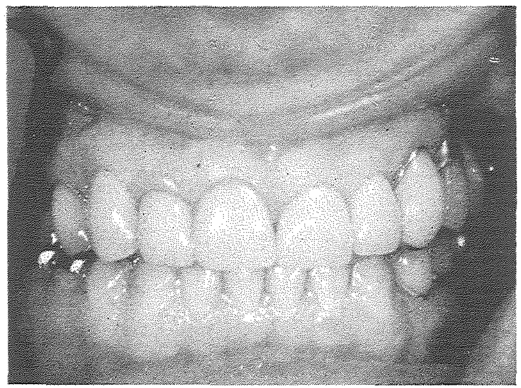


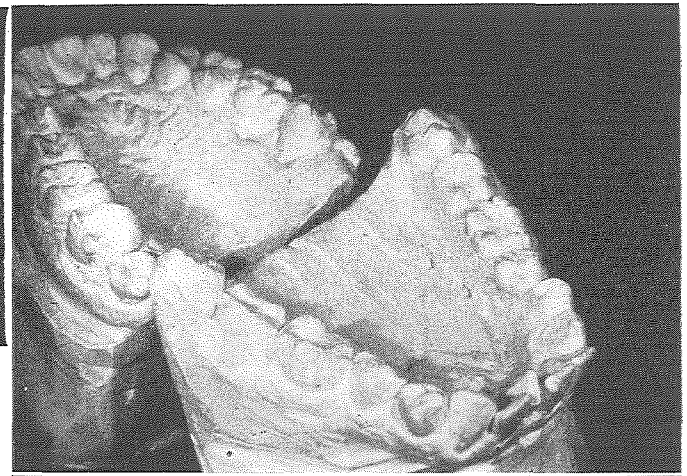
FIG. 453 (*Extreme left, top and bottom*). A tongue-thrust and bruxism problem.

FIG. 454 (*Left*). The teeth pushed by the tongue have poor bone support.

FIG. 455 (*Bottom, left and below*). Restoration of the case shown in Figure 453.







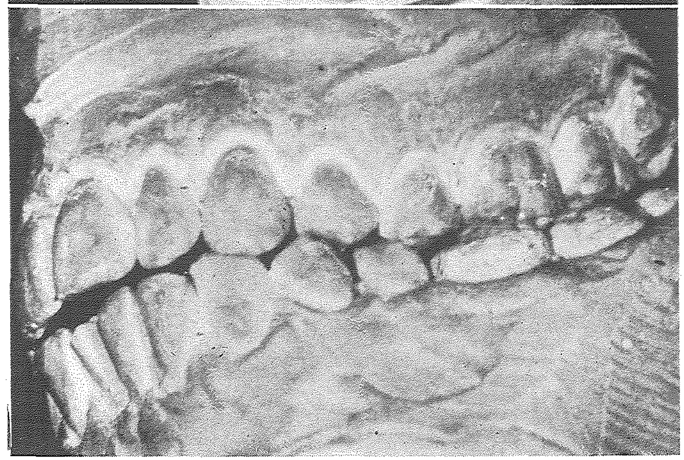


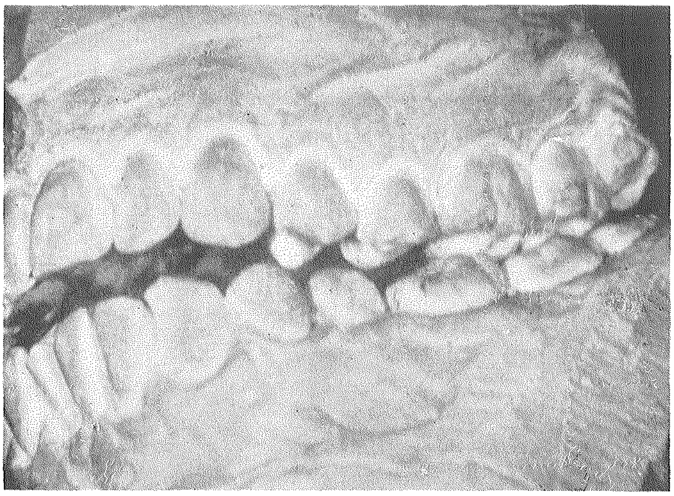
FIG. 456 (*Top, left*). Roentgenograms taken 10 years after treatment.

FIG. 457 (*Bottom, left*). The clinical appearance 10 years after treatment.

FIG. 458 (*Right, top and bottom*). *Study* models before treatment. Note the periodontal breakdown on the upper left side.

FIG. 459. The roentgenograms show bone loss.

FIG. 460. Mounted models show the upper left molars in premature contact.



A severe tongue thrust case, of the type that could be treated by splinting, is shown in the models in Figure 453. This patient is a highly tense individual with tremendous drive and energy. He was one of the Spitfire pilots of whom Winston Churchill said, "Never have so many owed so much to so few." He chewed perpetually on his tongue and ground his teeth, thus creating the space on the left that is shown in the study models. The roentgenograms in Figure 454 show that he had been able to tolerate the stress, but the teeth that had been pushed out of place by the tongue thrust were clinically quite mobile. In order to bring the teeth into occlusion, it was necessary to lengthen the crown so much that the crown-root ratio would require splinting anyhow. The restoration is shown in the study models in Figure 455. Roentgenograms taken 10 years after treatment show that the bone had held well (Fig. 456), and that the tissues were in excellent condition (Fig. 457).

A good illustration of combined treatment is the case shown in Figure 458. The patient, in her mid-thirties, presented with a complaint of impaired mastication. She had no pain or tangible discomfort, but merely found mastication to be a slow and tiring process. The tooth relationship, as it would appear in the mouth, seemed reasonably good. Virtually all the teeth were filled with old, leaking restorations, but these were not a source of discomfort and apparently were not related to the complaint. Although the mouth showed some general periodontal involvement of a moderate extent, the study models showed extensive destruction on the upper left first and second molars when compared with the rest of the mouth. The roentgeno-

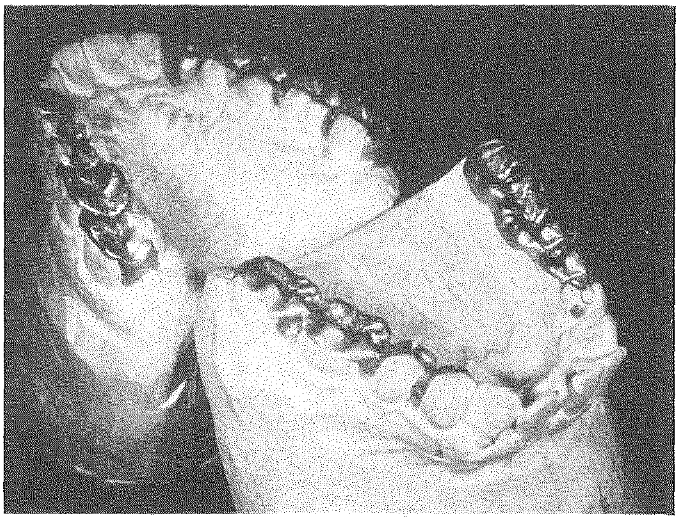


FIG. 461. A model of combined equilibration and rebuilding.

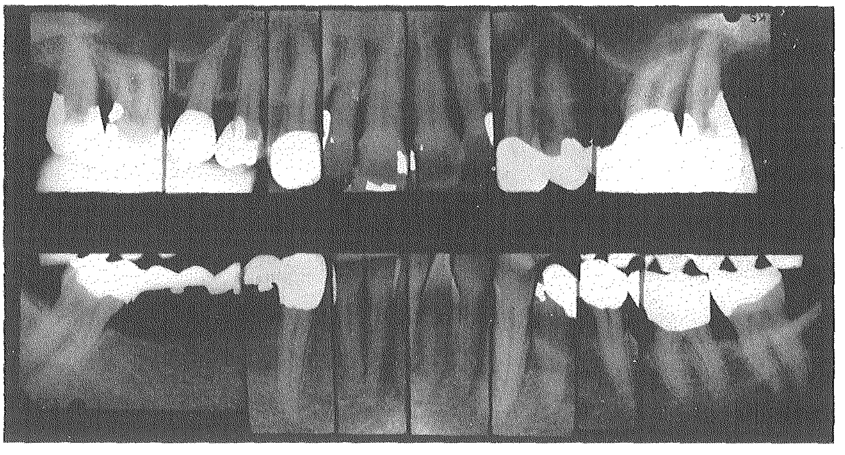


FIG. 462. Roentgenograms taken 20 years after treatment. Note the new lamina dura and the heavy interseptal bone.

grams (Fig. 459) likewise showed marked destruction in this area. That there was an active periodontal breakdown going on in the rest of the mouth is shown by the lack of lamina dura and the moth-eaten appearance of the interseptal bone. When the study models were properly mounted after registrations (Fig. 460), we can see that the first and the second molars were the only teeth in contact in centric relation. The fact that we can see the same characteristic relationship in clinical signs, roentgenographic evidence and functional mounting would appear to indicate that this was not mere coincidence.

Because of the excessive opening in centric relation, it was decided to close this bite. The mouth was treated by a combination of equilibration and building, that is, teeth which could be brought into correct functional equilibrium by grinding were treated conservatively. Since it was necessary to replace all the restorations anyhow, those teeth in which the tooth structure needed replacement and rebuilding were covered. In spite of the roentgenographic appearance, the lower left first bicuspid was so loose that it came out in the clutch when registrations were being made. This case was treated in 1941, before the days of antibiotics. The second bicuspid and the first molar were nonvital, so it was decided to extract them rather than use them as bridge abutments. A model of the treatment is shown in Figure 461. The most recent follow-up roentgenograms, taken 20 years after treatment, are shown in Figure 461. Note the lamina dura and the changed appearance of the interseptal bone. The tissues also show excellent periodontal health (Fig. 463).

Treatment of a somewhat similar case, which had quite different treatment requirements, is shown in the study models in Figure 464. This patient was also in her middle thirties. Her history is quite different. Five years before she presented for treatment, her dentist had removed all the amalgam fillings from her teeth and replaced them with inlays. The inlays were nicely carved, fitted and finished. Then, quite suddenly, she lost the three teeth shown in the study models from "pyorrhea," and she had been told that it would be necessary to remove the remaining inlays in order to construct bridges to replace the missing teeth. Immediately the question arose in her mind, If I do this, will I lose the other teeth in a few years and be

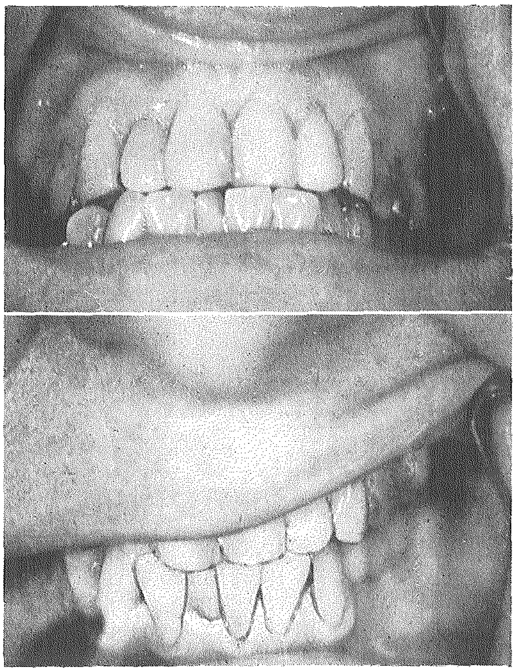


FIG. 463 (*Above*). The clinical appearance 20 years after treatment.

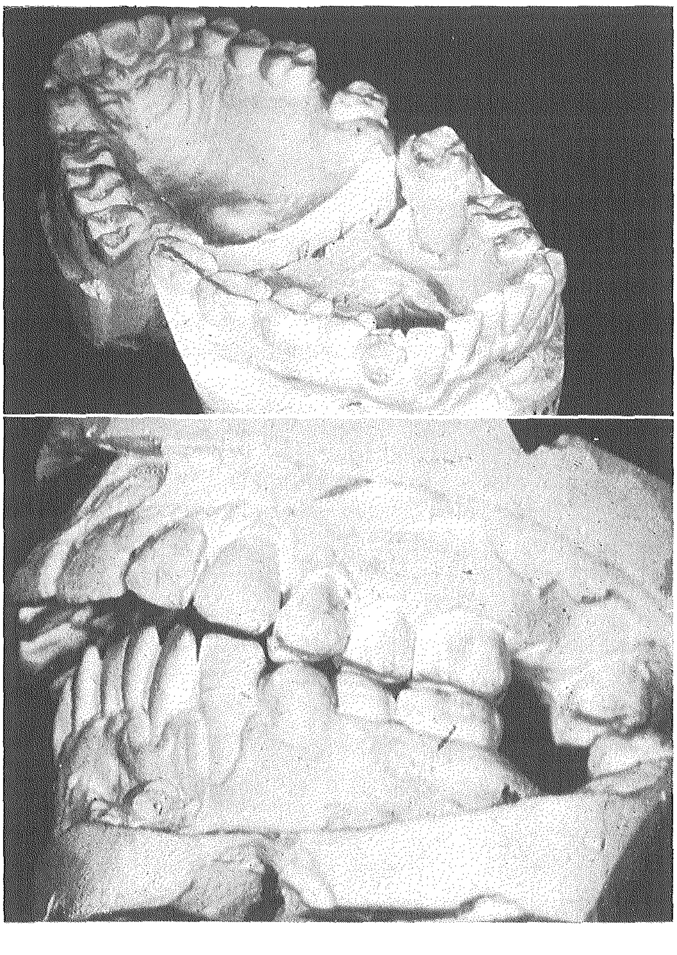


FIG. 464 (*Right*). The loss of isolated teeth in a periodontal problem.

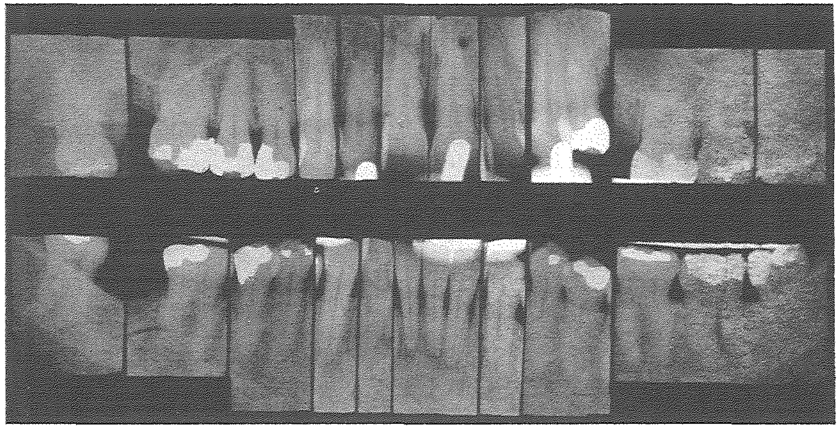
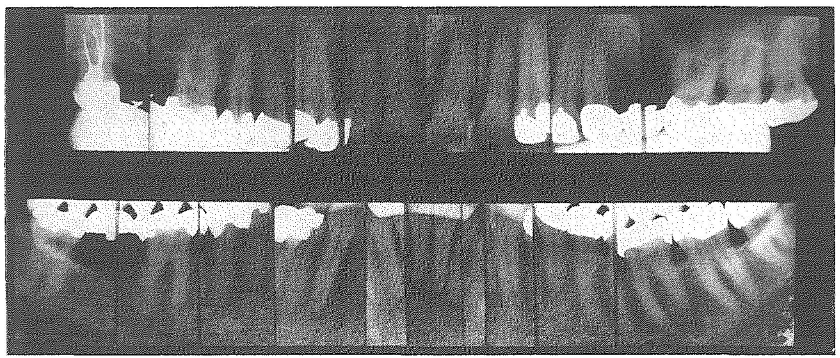
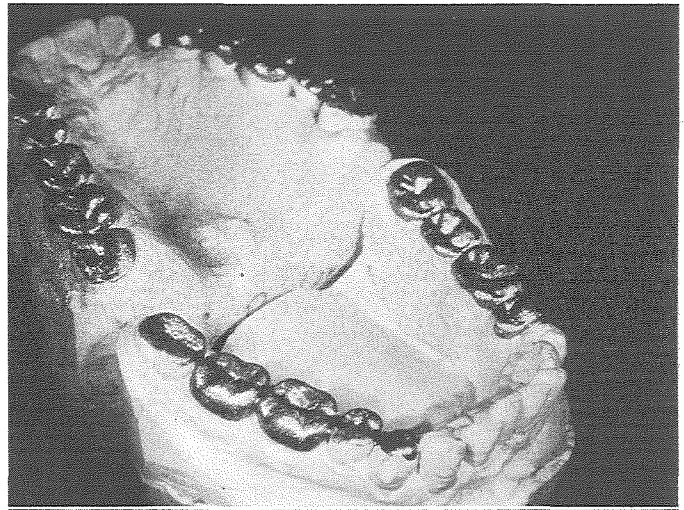


FIG. 465 (*Above*). Roentgenograms of the case shown in Figure 464 taken before treatment.

FIG. 466 (*Right, top and bottom*). Restoration of the case shown in Figure 459.

FIG. 467 (*Below*). Roentgenograms taken 10 years after treatment.





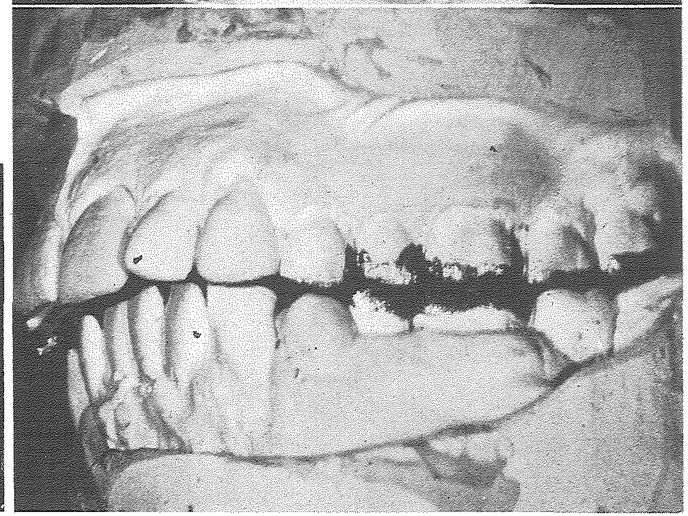


FIG. 468. The clinical appearance 10 years after treatment.

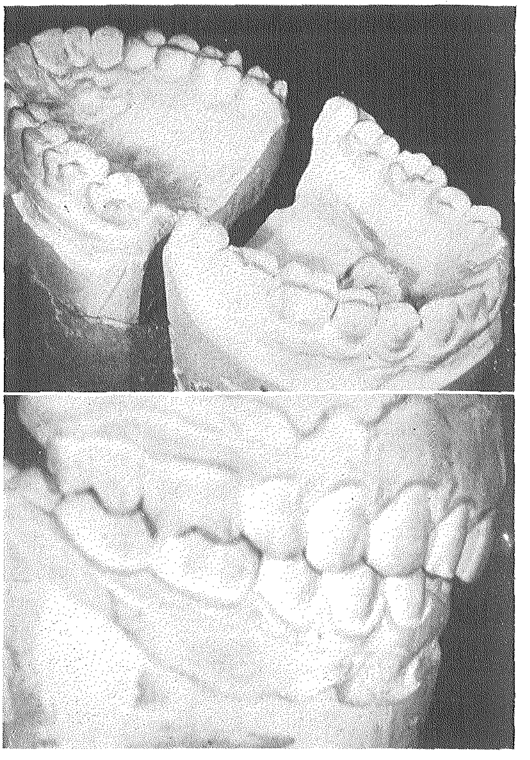


FIG. 469. A case in which it was necessary to open the bite.

wearing dentures? A logical deduction, difficult to answer. There was some periodontal involvement (Fig. 465), but it was by no means gross, and the prognosis was good.

This bite was also closed, and the case was treated as shown in the study models in Figure 466. It was necessary to restore all the occlusal surfaces in this case, but the only splinted teeth were the bridge abutments. The roentgenograms (Fig. 467) and the mouth pictures (Fig. 468) show the state of her periodontal health.

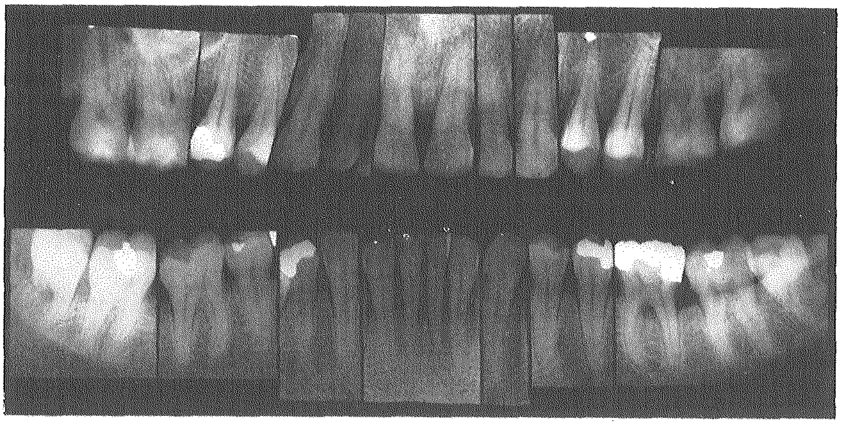


FIG. 470. Roentgenograms show that the periodontal problem is worst around the anterior teeth.

A case in which it was necessary to open the bite is shown in Figure 469. This was a young patient who had suffered constantly from trench mouth during World War II. It was a case of deep overbite and no overjet. This patient already had a good centric occlusion, so no anterior space could be gained to change the anterior guidance by a centric mounting. The posterior teeth were virtually unworn, and there was relatively little restorative work on these teeth. As might be expected, his worst periodontal problem was around his anterior teeth (Fig. 470).

The restoration (Fig. 471) was executed

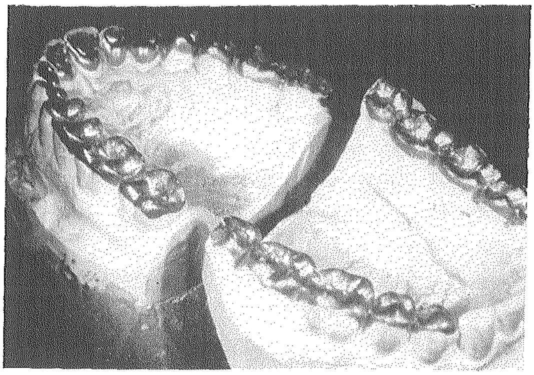


FIG. 471. The restoration of the case shown in Figure 469. Note the pin ledges in the anteriors for maintaining the functional contact.

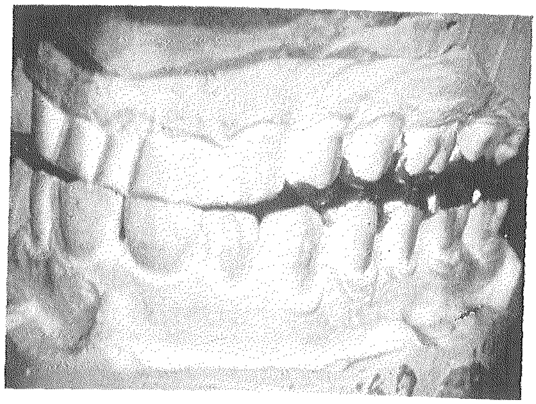


FIG. 472. The bite was opened enough to permit free contact for half the width of a cusp.

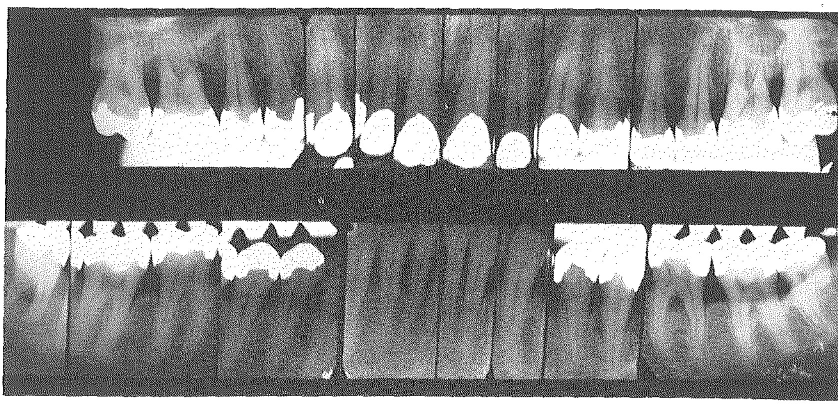


FIG. 473. Roentgenograms taken 10 years after treatment.

with M.O.D. inlays and with pin ledges on the lingual of the anteriors. Comparatively little opening was required. It was determined by the space required to permit a protrusive range of the posterior teeth half the width of a cusp (Fig. 472). This determined the pin ledges that were required to maintain function on the anterior through this range. The roentgenograms taken 10 years after treatment (Fig. 473) show excellent improvement in the quality of the bone. The tissue health is excellent (Fig. 474).

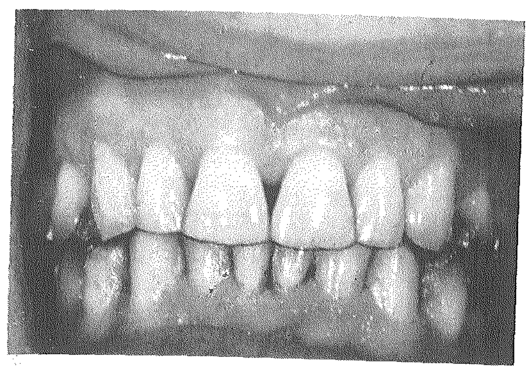


FIG. 474. The clinical results 10 years after treatment.

## PRACTICE MANAGEMENT

This is usually thought of in terms of office efficiency, auxiliary personnel, recall systems, and similar details of office management. There is another aspect of this in rehabilitation practice which is rarely mentioned. In general practice it is quite customary to multiply a laboratory fee by a fixed percentage, as if a piece of merchandise were being priced. In rehabilitation, not only will this not work economically, but it is not professional practice and is a good way to discourage this type of practice.

The procedures outlined in this book delegate a major portion of the work to the laboratory, where it can be more efficiently and economically handled by trained auxiliary personnel, and this gives the operator more time to devote to other patients. This is not done at the sacrifice of good treatment. On the contrary, its primary objective is to improve the treatment. The fact that it frees the operator to assume more cases calls in turn for more laboratory help. At the same time, it does not increase the requirements of office personnel and handling.

This creates a totally different picture of office management and dental economics. The dentist who deludes himself into thinking that he can decrease his laboratory problem by "simplified" means is hiding his head in the sand. He can circumvent the problem only by sacrificing the standards of his treatment or cutting down deliberately on his own efficiency and productivity. The simpler the technic and the less it aids the operator, the more he must compensate for it at the chair by his own skill, time and energy. Simplification is desirable. But it should be true simplification of the operator's effort, not a short cut to circumvent the best treatment. Simplification which demands hours of difficult, tedious chair adjustment is not true simplification. It is a snare and a delusion.

In the final analysis, what counts is how much the operator can accomplish in a given period with a given expenditure of precious energy. The more that he can delegate, the more the operator can accomplish, provided that, because of delegating work, he is not going to be called upon some time later to spend a lot of time correcting errors. This is the major role which good rehabilitation procedures play in practice management. It should accomplish the two objectives of better quality of service and the expenditure of less time and effort. This is sound dental economics.

To accomplish this requires a different approach to fee-thinking. This type of work changes the usual relationship of laboratory fees to dental fees. The best approach is to deal with them as separate items. A given case which requires a certain number of chair hours might require twice as much laboratory time as another case with the same chair time. This calls for more laboratory expense, which is a part of the fee problem, but that does not mean that it should command twice the fee. The operator is better advised to figure his own professional service fee and whatever laboratory expense is involved. This may increase his cost per laboratory hour but still should be relative to the laboratory hours plus the chair hours.

This type of work calls for more laboratory hours than simple restorations, but not all of it needs to be performed by people with equal training. This also calls for adjustment of laboratory fees to meet the particular case in question.

This approach does not lend itself well to the man who would like to treat an occasional case when the fee is adequate, but he should ask himself if it is really "treatment," or merely an opportunity to collect a large fee without adequate means for proper treatment. This does not imply that treatment does not belong in the realm of general practice—that it belongs to the specialist. Quite the contrary. It must be an important part of general practice if the public is to receive genuine treatment instead of a lot of inert, unrelated repairs to teeth. To accomplish this, the dentist should possess the necessary physical equipment and an understanding of it. This does not mean that all patients will receive the same mechanical routine. It does mean that, in all his service, the operator's approach will be that of treating the health of the mouth, not repairing and replacing teeth. There is no immediate hope of such an upheaval in dental thinking, but it is our only hope for a future as a healing art.

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