PRECISION WORK FOR PARTIAL DENTURES

A Technical Manual for Office and Laboratory

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INTRODUCTION

The present manual has been written to satisfy the demand of the practitioner and the dental mechanic for a detailed technical instruction in the construction of CSP (Channel-Shoulder-Pin) Attachments and Resilient Partial Dentures as developed by ALFRED A. STEIGER. This presentation will therefore not deal specifically with the *biological* aspects of mouth rehabilitation which must guide all planning of bridge and partial denture construction. Such aspects will be dealt with only as far as they are immediately related to the technical planning.

The construction designs and technics are the result of thirty years of development and experience. Earlier or extreme solutions, which might lead to misinterpretation have therefore been deliberately omitted, but the authors have endeavoured to always point out possible mistakes and difficulties which were eliminated over the years of practical experience but which are still to be found in office and laboratory practice.

For advanced prosthetics, the basic knowledge of general prosthetics must be presumed and will not be found in this book. On the other hand, certain modifications in cavity and abutment preparation and a specialized set of partly unpublished instruments makes it necessary to go beyond the description of the technic alone. Also, the knowledge of the basic functions of cutting instruments will make their choice easier for the practitioner.

The informed reader will find—in the chapter on resilient partial dentures—the emphasis placed on the constructions developed by ALFRED A. STEIGER. This should in no way be interpreted as a prejudice against the use and special indication of constructions developed later and by other workers. It is a tribute to the original ideas of A. A. STEIGER, if others have tried and succeeded to reach the same goal by other means; they have helped to establish what is sometimes referred to as the Swiss School of Resilient Partial Dentures. A certain measure of discrimination is necessary regarding the use and applicability of the different stressbreaker joints, a discrimination which cannot always and completely be reached by theoretical knowledge and evaluation. Only practice and experience can solidify it.

The following pages are dedicated to the practitioner who wishes an introduction into a field of partial denture prosthesis heretofore known only to a small circle within the profession. The benefit of it will reach those who appreciate the prognostic value of such work and are not deterred by such difficulties as the art of fine mechanics may involve.

The authors wish to express their gratitude and appreciation to the following persons who have helped in the development of technics and the realization of this book:

Dr. Beat Müller, Dr. Augusto Biaggi, Dr. Marc Frey, and Prof. Eugen Dolder, for their respective chapters in this book.

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R. H. Boitel

CONTENTS

CHAPTER I

TASKS AND PROBLEMS OF DENTIST AND DENTAL MECHANIC

Medecine, engineering and art are the sources from which good dentistry lives and develops. The art of healing alone does unfortunately not suffice to replace lost tissue. In general surgery, it is possible to replace tissue defects by closing them or by shifting or implanting living tissues. The smallest defect in a tooth however can never be closed again by homologous tissue or living matter at all. Dead matter alone is the substitute for lost dental tissue. Therefore, engineering along with the art of imitating nature in shape and shade must blend with medical knowledge, in order to serve humanity in the dental profession. The unfathomable variety of nature with its illimited variations in forms and color refinement must fill with awe and admiration every friend of nature. To stand in the service of this wondrous world must ever and always be considered a special privilege which is a commitment for the highest sense of responsibility whenever an intervention into functions of life is undertaken. Just as the surgeon will try to eliminate disturbances of vital functions by the most intricate methods of surgery, the dentist in his field must search to solve his problems with the utmost preparedness. This calls for knowledge from the most various disciplines of science.

The term "Precision Work" itself implies that this type of work takes special place among dental work in general. It demands, of dentist and of dental mechanic, a *higher technical standard* than in any other branch of the dental science. If either of the two is uncapable or unwilling to satisfy the requirements needed for this kind of work, the result will be failure, disappointment, and loss for dentist and patient. Training, along with a certain measure of manual skill and "mechanical mind" is therefore basically necessary. Training in new technics always means a sacrifice of time and money. Therefore, it cannot be emphasized enough that model work should at all cost preceed clinical practice. Every practitioner with a true interest in the work of his mechanic will have the personal wish to make at least one precision attachment himself, in order to familiarize himself with the difficulties his mechanic will encounter. He will have a basis for discussing the work at hand and also, he will know how his preparation of abutments will affect the practicability of the planned work. *Planning is purely and entirely a task of the* *dentist.* While in clasp denture technics he may not always meet with failure by leaving the planning and design to a laboratory, such an attitude is inadmissible in the precision work described here. The plan of treatment is then followed by a discussion with the dental mechanic on the technical realization of the plan.

The technic for *CSP* (Channel-Shoulder-Pin) attachments involves a certain amount of engineering. Once the principles are understood, the range of possibilities and varieties is almost unlimited. The designs described in this book are the ones that solve most of the daily problems. However, they are but a choice from a great variety which was planned and built for the hundreds of cases of the past. There is no "standard model", there are only standard principles after which every individual design is made. Thus, each dentist and in particular the dental mechanic have their own "personal handwriting" in making CSP-attachments. Warning must be given however against fantasy which oversteps the limits of the principles involved. Very often, such fantasy has led towards discrediting of the method because of failures or frequent repairs. Although the constructions shown may appear delicate, repairs are the exception.

Success in precision work is assured if some basic rules are observed by both dentist and dental mechanic.

Rules for the dentist:

(1) Allow for sufficient time for planning according to the biological evaluation of the case, for study models, for careful abutment preparation, for immaculate impressions and for collaboration with the dental mechanic.

(2) Do not economize on materials such as sharp instruments, burs, impression materials and laboratory equipment.

(3) Be critical of your abutment preparation, repeat a mediocre impression, admit mistakes, because only correction eliminates them. Consult with your fellow dentist if you encounter difficulties in planning or laboratory work; you improve *your* work.

(4) Planning is the dentist's job, but do not neglect your training in laboratory work, you will better understand its difficulties and your criticism will have more weight and judgement.

Rules for the dental mechanic:

(1) Check the impressions of your dentist and criticize them correctly if necessary. Consult with your employer before starting a case. Ask questions during the working procedure, this will prevent misunderstandings.

(2) Make use of the small hints and tricks shown in this manual, they will prevent failures and misunderstandings.

(3) Be patient, patience is the biggest lead towards success.

(4) Be a jeweller, your work should be fine and perfect.

CHAPTER II

THE CHANNEL-SHOULDER-PIN (CSP) ATTACHMENT OF ALFRED A. STEIGER

A precision attachment in dentistry is a means of bodily junction for a removable bridge or partial denture, an appliance consisting of two congruent parts which may be assembled and separated from eachother in one direction only. Precision attachments may be concealed within the anatomical crown of an abutment tooth. Such attachments are called internal attachments. If the attachments are positioned to the outside, the mesial or distal of a crown, they are external attachments. Both internal and external attachments consist of two parts, the *matrix* (♀) and the *patrix* (♂) (sometimes referred to as female and male). The matrix of an internal attachment is incorporated into the abutment construction, while the patrix is part of the removable bridge or partial denture. External attachments usually have the reversed arrangement, with the patrix soldered to the mesial or distal of the abutment, and the matrix as part of the removable appliance. Many of the internal attachments may be used as external attachments, although the leverage created by this reversed arrangement, is undesirable in most cases. The invention of both internal and external attachments has been an attempt towards concealing the attaching element of a removable appliance within the body of the abutments or of the prosthetic appliance, and to replace the clasp with its various unsatisfactory properties respective to hygiene, tooth mobility, caries susceptibility and aesthetics.

DEVELOPMENT

Modern concepts of partial denture prosthesis demand a functional junction of the artificial replacement with the natural abutments which is based on the principles of biostatics. Materials used for this purpose must be chosen and shaped according to principles of general mechanics in order to withstand the stresses to which they are subjected. Partial dentistry owes its main development to the invention of adequate metal alloys, which, used for clasps, offered the first stable and practical attachment between denture and abutments.

The disadvantages of clasps, such as the lesions of the hard tissues of the abutment teeth, the promotion of caries in susceptible individuals, food impaction and poor aesthetics obliged the dental profession to search for other means of attachment. Coverage of the clasp bearing areas of the natural crowns by metal (inlays, overlays, threequarter crowns, full crowns, or the replacement of the natural crown by post crowns were the first attempts to eliminate clasp damage to abutment crowns. By the indiscriminate sacrifice of live pulps one evil was however only to be replaced by another.

The solution against the caries problem and the poor aesthetics of clasps along with the solution for preserving the vitality of abutment teeth was only found when the junction between denture and abutments was built into metal fillings and veneers which protected the abutments. This idea led to the invention of what is now generally referred to as precision attachments.

The basic design for the great majority of such attachments was taken from the T- or I girder used for building purposes. Such girders have a cross section which is able to withstand a maximum of stress with a minimum of material (fig. 1). The girder used for building purposes is used both horizontally and upright. For dental purposes it is used upright only and its outer flange is surrounded by and separable from a metal coat. Usually, an adjustable frictional element is included to compensate for the wear of the contacting metal surfaces. The rectangular cross section of the outer flange of the classical girder was modified in dental attachments into rectangles with rounded corners, with different proportions, with curved, convex-concave or concave-concave long sides, into cylindrical or dovetail cross sections. The best commercial precision attachments not only used the surfaces of the outer flange (fig. 1, *f*) but also the surfaces of the web (*w*) and of the adjacent surfaces of the inner flange as frictional surfaces between matrix (♀) and patrix (♂) of the attachment.

The transmission of forces within this system of attachment is left entirely to the cross section of the web (fig. 1, *w*). It follows that the junction between outer flange and web is the area most exposed to strain.

Fig. 2, shows a frontal, sagittal, and horizontal section through an abutment piece with incorporated attachment matrix (♀) and patrix (♂). It is readily recognized that a force *V* is transmitted to the tooth on a surface determined by the horizontal cross section (*F*) of the attachment patrix and which is resisted, on the abutment tooth by a corresponding plane of resistance. It may suffice for the moment to say that such a small plane of support and slender web of the attachment patrix seems inadequate for the strain to which it is being submitted. An analysis of the different strains of pressure, traction and torque will follow (see p. 20 et seq).

The history of precision attachments for rigid anchorage has been well and sufficiently described in many textbooks of the past, and if a few of the best remembered or presently used designs are shown here (fig. 3), it is mainly in

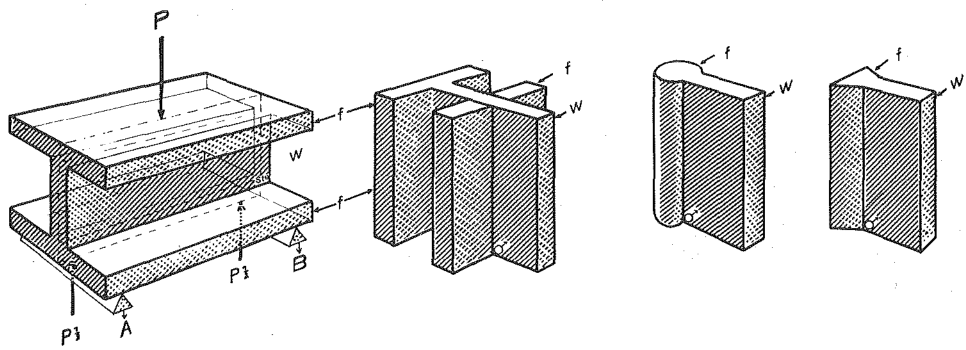


Fig. 1 The I-girder furnished the basis for all precision attachments of I or T-shape or their modifications. A girder which receives in its middle portion the force *P*, distributes this force over its two supports *A* and *B* which each receive half the force $P\frac{1}{2} \cdot w$ web, *f* flange. In an attachment, the I of the girder is upright, and the forces applied to it are entirely different from those in the horizontal girder. While the I-shaped attachments offer comparatively large contacting surfaces to the box of the attachment and the interproximal outside wall of the abutment, the two models on the right in fig. 1 with a cylindrical respectively dovetail web have very reduced contacting surfaces and are therefore more exposed to wear.

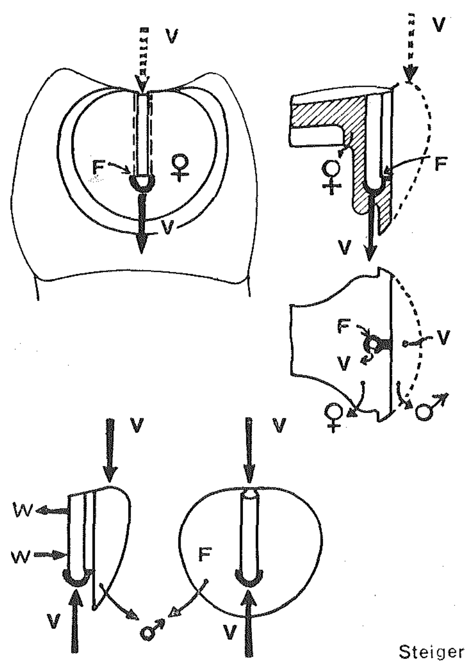
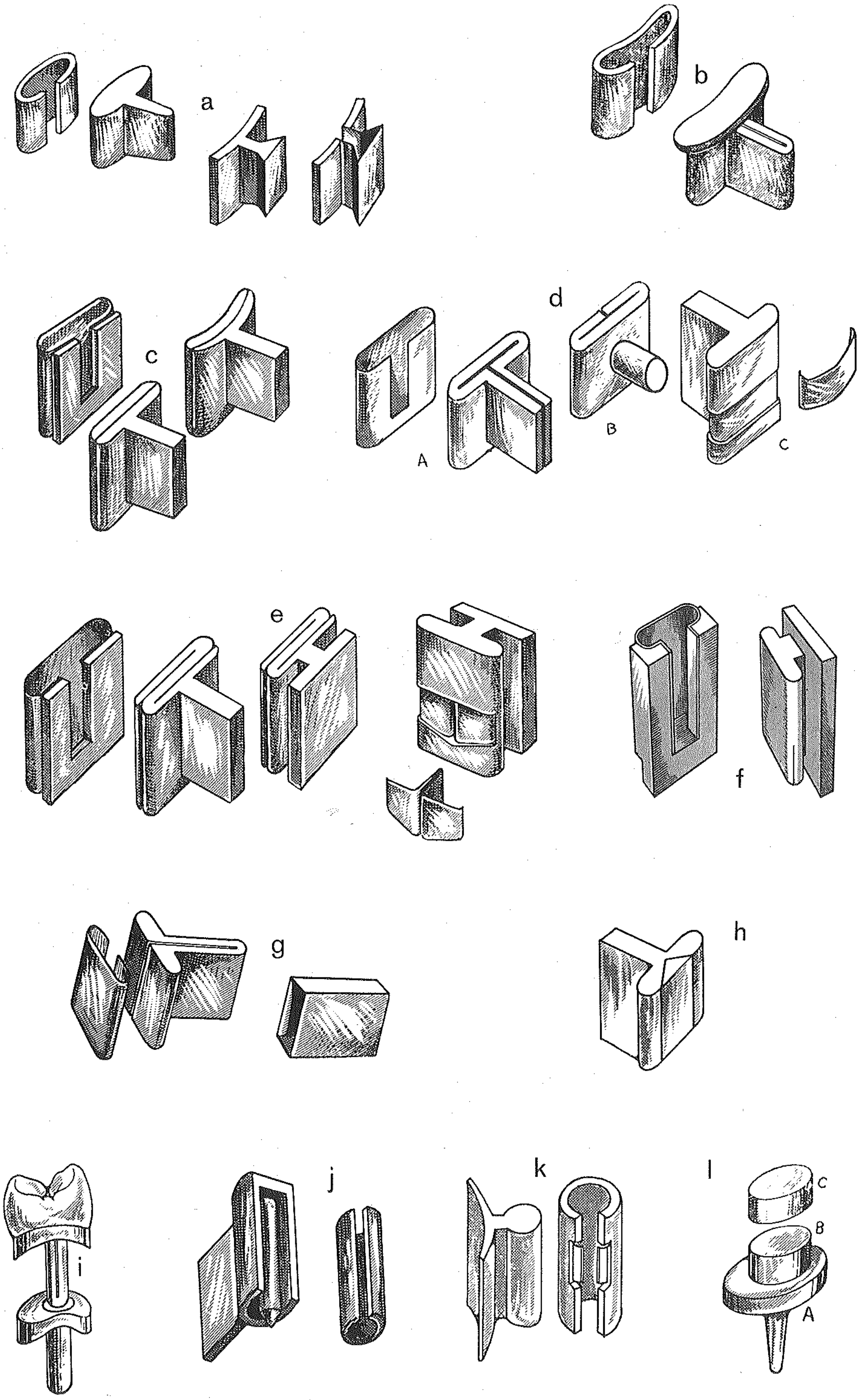


Fig. 2

order to show that the design of modern attachments are mostly modifications, sometimes improvements, over previous constructions. A few representatives of the class inspired by the I or T-girder is shown in fig. 3 a–h.

Fig. 3a shows two early attachments which were entirely made by hand and which may be the prototype for many later inventions, 3b, the Morgan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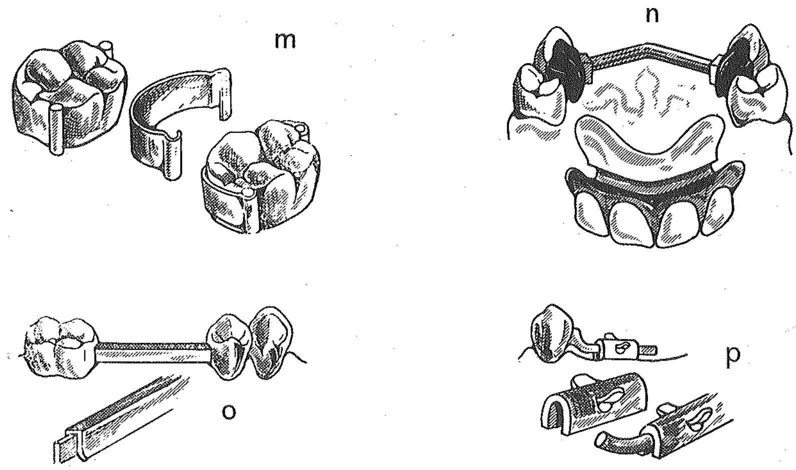


Fig. 3

a = two early attachments made entirely by hand
b = the Morgan attachment
c = the Brown-Soerensen attachment
d = early and later forms of the Chayes attachment
e = early forms of the Stern G/A attachment
f = the new Stern attachment
g = the McCollum attachment
h = the Gollobin attachment
i = the Peeso split post attachment
j = the Condit attachment
k = the Supplee attachment
l = the Kelly attachment
m = the Bryant attachment
n = the Fossume bar
o = the Bennet blade
p = the Gilmore attachment

attachment, 3c the Brown-Soerensen attachment, 3d the early and the later forms of the Chayes attachment, 3e the early forms of the Stern attachment, 3f the newest Stern G/A attachment, 3g the McCollum attachment and 3h the Gollobin attachment. All have the T-design as a basis.

A second category, the group of cylinder-and-tube attachments, is here represented by 3i, the *Peeso* split post attachment, 3j the *Condit* attachment, 3k the *Supplee* attachment and 3l the Kelly attachment.

A third category is the horseshoe shaped attachment which embraces more than half of the circumference of the abutment crown. A representant in the past was the Bryant attachment (3m).

Finally, the last basic form, the bar, is represented by 3n, the Fossume bar, 3o the Bennet blade and 3p the Gilmore attachment.

All the attachments described have been or are still being made in standard models, e.g. with certain defined dimensions which allow mass production. The variability of circumstances under which a precision attachment may be used, often makes the use of standard models a problem. Variable factors are: the space in which to conceal the attachment, height and width of the abutment crown, depth of preparation, the desirable continuity of a removable splint over several abutments, considerations of statics and dynamics of a removable denture. As one crown never is identical with another, the design of precision attachments should be adaptable to the circumstances. The CSP system of attachments is widely adaptable to most all variable factors described.

Every precision attachment must have an adjustable frictional element which is able to compensate for the frictional wear resulting from the frequent insertion and removal. Most conventional internal attachments have their frictional element incorporated in their patrix. Friction is increased by widening one or more slits in the body of the patrix, thus increasing its volume. In all cases, the retentive element of the attachment patrix is identical with the frictional element. When such an attachment is new, no play of the patrix within the matrix is possible, but as the gold surfaces wear away, frictional retention is lost. The slit parts must be slightly separated so as to restore contact between the surfaces of patrix and matrix. Thus, the elastic part, after insertion, is in a status of spring tension which is released only after removal. The larger the slits must be opened, the more the apex of the slits is endangered by breakage. When retentive and frictional elements are materially identical, certain stresses applied to the attachment patrix therefore produce a movement of the legs of the split patrix. Every material such as elastic gold shows, after a certain number of bending movements, signs of fatigue well visible under the microscope on ground specimen. Fatigue eventually leads to breakage. Therefore it follows that the more the number of movements opposing the spring action is reduced, the longer it will take to fatigue the metal. If such movements only occur during insertion and removal, it will take a long period of time until breakage occurs. If on the other hand, such movements occur practically on every stroke of chewing, the number of movements is considerably increased.

Such movements are particularly violent if precision attachments are being used as attachment for distal extension saddle cases. The resilience of the tissue under the denture saddles allows for stronger movement than that of the abutments, and the precision attachments wear away to become a stressbreaker, a function for which such a design is unfit. Roach tried to find an attachment which would at the same time function as a stressbreaker joint (open flat tube and button-attachment, and the open round tube and ball attachment) but the excessive movement resulting from wear gave insufficient retention to the dentures. A precision attachment is designed for *rigid* attachment, otherwise the precision is lost after a short time. If movement of a tissue born denture is desired, a stressbreaker joint must be built in between attachment and denture (see p. 143). In CSP attachments, the frictional element is not identical with the retentive element and therefore an adjustment of the frictional element does not affect the retentive quality of the attachment.

Another weak region of the conventional attachments is the stem (the vertical beam of the T) of the patrix. The stem, the part between the soldering surface of the patrix and the frictional and retentive part is the portion which has to resist shearing forces and torque. With respect to the attachment, a shearing force can be a masticatory force directed axially onto the attachment patrix. Lateral forces, oblique forces and certain movements of free end saddles result in torque for the patrix stem. A proof for the weakness of the stem was recently given by a new model of one of the conventional precision attachments in which the width of the stem has been considerably increased.

During the years of the First World War the commercial precision attachments (prevalently made in USA) were unobtainable in many countries. Some practitioners helped themselves by making similar constructions in their own laboratory, a procedure which at that time required considerable skill, because casting methods were not yet as refined as nowadays.

The present design of CSP attachments was preceeded by years of development. The first design inspiring the present day technics was a hook clasp (fig. 4). In the early thirties, wrought wire clasps with straight or hairpin shaped spring wire connections between abutments and partial denture offered the best stressbroken retention for resilient partial dentures (see p. 148 *et seq.*). In the endeavour to eliminate clasp wires from the surface of live tooth tissues, the hook clasp was conceived which kept the greater part of the junction within and on the outer surface of a gold restoration. The matrix of this "attachment" consisted of two axial bores in the occlusal surface of the inlay, out of which two parallel channel grooves led towards and along the interproximal surface of the inlay. The patrix consisted of two parallel hooks made of 1–1.2 mm ⌀ platinum wire, soldered to an elastic clasp arm. The hairpin arm served as a stress breaker. This attachment could be used for tissue born dentures, but was too weak for supporting a toothborn appliance.

The next step was to make an occlusal rest in the inlay, comparable to a dovetail attachment. The wires of the previously described hook clasp were used as frictional elements within the body of the inlay. Each pin fitted into an axial bore in the floor of the dovetail box. This design was an improvement, but the vulnerability of the weak stem of the dovetail patrix and the insufficient resistance of the attachment to torque necessitated further development.

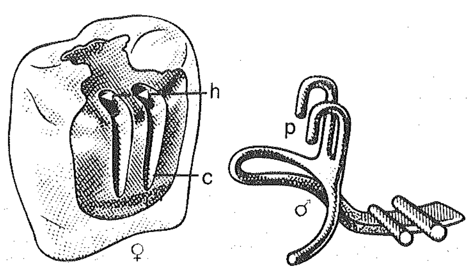


Fig. 4 The hook-clasp. ♀ matrix, ♂ patrix, h axial holes for hooks, c channel grooves, p platinum hooks.

On the interproximal outer wall of the inlay, a shoulder was made, by soldering a piece of wire horizontally near and above the gingival margin. This shoulder was made hollow, like the gutter of a roof. Thus, the casting of the patrix not only rested in the dovetail box, but also in the gutter of this shoulder. Finally, to facilitate insertion, and to still increase resistance against torque, two channels were placed into the interproximal wall of the inlay, channels which run parallel to the direction of insertion and terminate gingivally, lateral to the shoulder. Thus the horizontal gutter in the shoulder runs into two vertical gutters, made by the channels. In the replica of the matrix, the casting of the patrix, the shoulder portion of the matrix is bodily held by the patrix, and offers a resistance to stresses from all directions, many times as large as the resistance of the previous designs. The result of this development is the unilateral CSP attachment shown in fig. 6.

A comparative study was made between one of the newest conventional attachments (fig. 5) and the smallest attachment of the CSP family (fig. 5), in order to determine the retentive quality and strength of the CSP system of attachments.

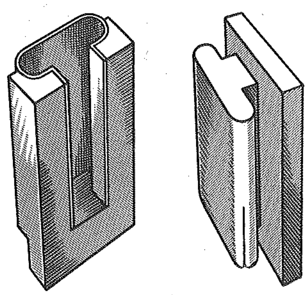


Fig. 5 The new Stern attachment.

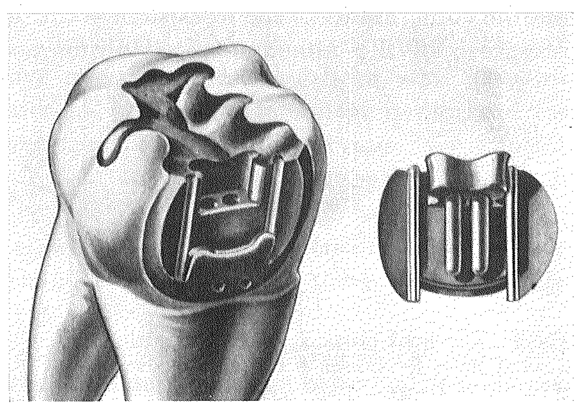


Fig. 6 Unilateral CSP attachment.

COMPARATIVE STATIC CONSIDERATIONS BETWEEN STERN G/A PRECISION ATTACHMENT AND CSP ATTACHMENT

The following illustrations fig. 7 to 21 serve for the functional comparison between precision attachments built on the principle of the T- or I-girder and the smallest precision attachment built after the CSP method.

The specimens used for these examinations are (*a*) the *G/A* STERN *attachment 1957*, the latest, reinforced factory built commercial attachment (fig. 5), and (*b*) a *CSP attachment*, hand-made in the laboratory (fig. 6). This study is in no way aimed at the Stern G/A attachment, which was on the contrary, chosen because it belongs among the finest ready made attachments obtainable.

Every material *repeatedly* stressed by traction or torque, is liable eventually to break. This danger may be eliminated if the tension within the material, brought about by repeated stressing, is kept sufficiently below the tension which would cause a fracture on the *first* stress.

Hence, the *durability* of an attachment would be warranted if the tensions within its whole volume, and especially in all places which transmit forces from patrix to matrix (♂ to ♀), are kept as low as possible. The transmitting *surfaces*, therefore, must be as large as possible.

The following comparative study, therefore, is examining the *stress transmitting surfaces* (F, F_1, F_2) in relation to different kinds of stresses, in both systems of attachment. In the illustrations these surfaces are easily recognized as black planes or black lines thicker than the contour lines. The comparative ratio of size of these surfaces is given for the chief measure of stress. Thus the advantage of both systems, relative to the different kinds of stress application, may be evaluated comparatively, though not in absolute values. Most important among stress application on precision attachments are those where forces, individual or combined, are applied in a strong degree and repeatedly.

Let us now consider, by way of comparison, fig. 7 and 8, 9 and 10, etc. Odd numbers concern the *Stern G/A* attachment, even numbers the *CSP* attachment.

Explanations to the following illustrations:

Fig. 7 to 20: In all diagrams the drawings at the *bottom* show the forces acting on the patrix (♂). For instance: in fig. 11, the force H (being the cause for the remaining forces) and the reactions H_1, H_2 which act reciprocally from the *matrix* (♀) upon the *patrix* (♂). The drawings at the top of each illustration, however, show the forces acting on the matrix (♀) from stress applied to the patrix (♂). In fig. 11, e.g., the forces H_1 H_2 in the *top drawing*, act in a reversed direction to the forces H_1 H_2 at *the bottom*. At the top H_1 and H_2 result in the (hatched) force H, which corresponds exactly to force H in the bottom drawing. Thus force H is transmitted to *the matrix* (♀) and to the tooth abutment.

The *reactions* in fig. 7 to 12 are drawn only schematically as *individual* forces. Actually they *would be distributed* over the stress transmitting surfaces (compare fig. 13 and 14).

In fig. 13, bottom drawing, the upper, hatched triangle represents the *distribution* of reactions from the upper part of the attachment, viz. reaction from the force H in fig. 11 and an analogous force which develops from the *excentric direction* of force V.

Besides the reactions shown in the illustrations, there are yet additional tensions caused, because the patrix ♂ is situated excentrically from the matrix ♀. In fig. 7 left bottom, there would an equilibrium only be given if *both forces V* would act within the *same plane.* Thus there are additional horizontal forces W acting on the pin, which secure the rotary equilibrium, and are acting on the upper part of the attachment as tractional components.

Analogous considerations may be applied to all illustrations.

From the large variety of forces which may act on such a detachable joining device, the precision attachment, a few of the most important—potentially causative for breakages—were chosen for this comparative study.

Fig. 7 and 8	vertical force V
Fig. 9 and 10	shearing force V
Fig. 11 and 12	horizontal force H
Fig. 13 and 14	oblique force P
Fig. 15 and 16	tractional force Z in the gravity center of the contacting surfaces
Fig. 17 and 18	load of pressure D in the gravity center of the contacting surfaces
Fig. 19 and 20	rotary component M in a sagittal plane, causing traction Z in the occlusal zone, and pressure D in the cervical region

Deduction:

Fig. 7 and 8: In fig. 7 force V is transmitted into the surface F, in fig. 8 into the surfaces F_1 and F_2. The ratio between these surfaces is

$$\frac{F}{F_1 + F_2} = \frac{1}{2.8}.$$

This means that the resistance to the forces applied is *2.8* times larger in the CSP attachment than in the Stern G/A.

Fig. 9 and 10: The shearing forces developing from force H are resisted in fig. 9 by the cross section web of the patrix ♂ (F). In fig. 10 the load is distributed over the massive cross section F_1 of the dovetail isthmus, and on the shoulder F_2 in the matrix ♀.

This means that the ratio between the black surfaces F, F_1, F_2 in fig. 9 and 10 is:

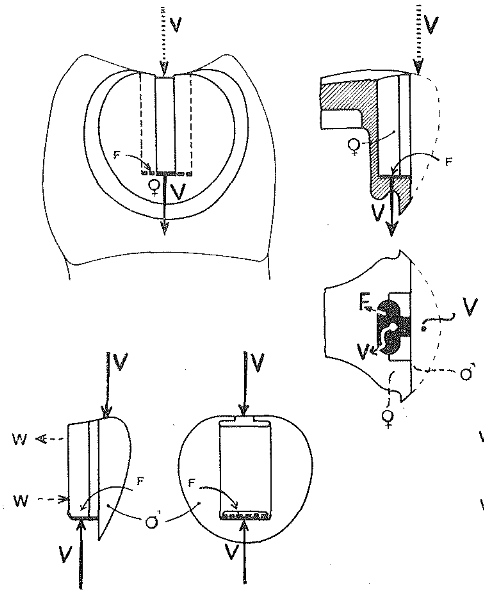


Fig. 7

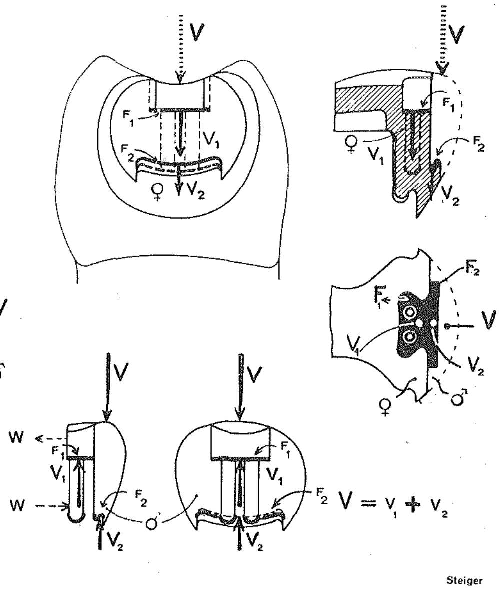


Fig. 8

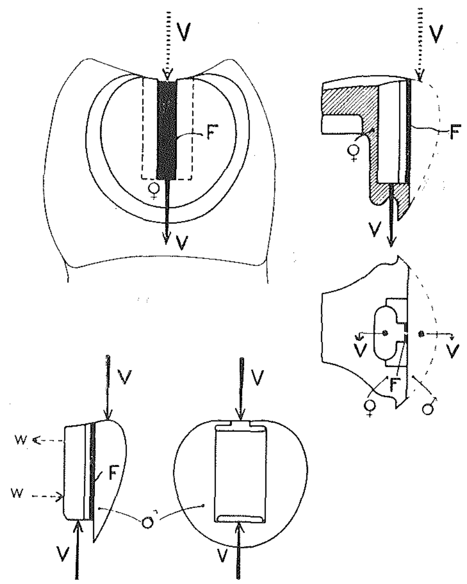


Fig. 9

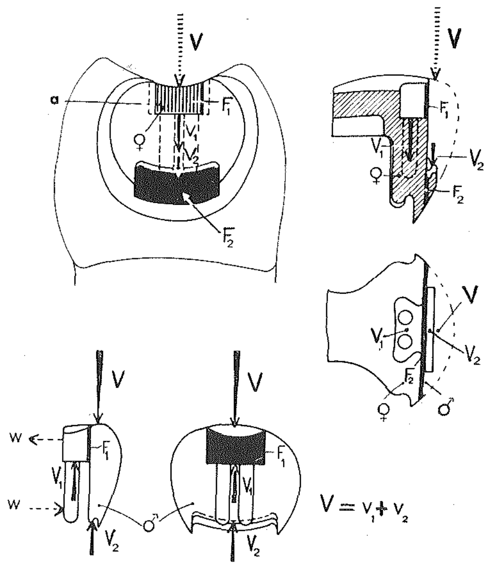


Fig. 10

$$\frac{F}{F_1 + F_2} = \frac{1}{2}$$

in favour of the CSP attachment.

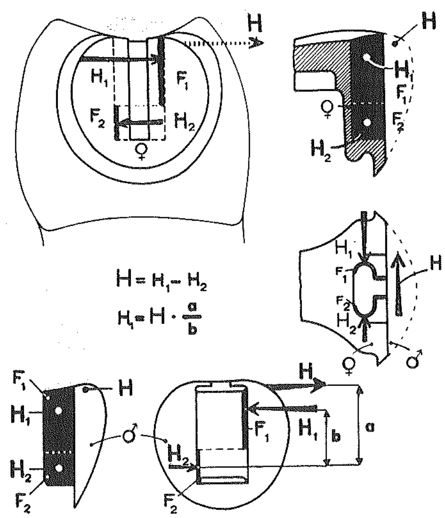


Fig. 11

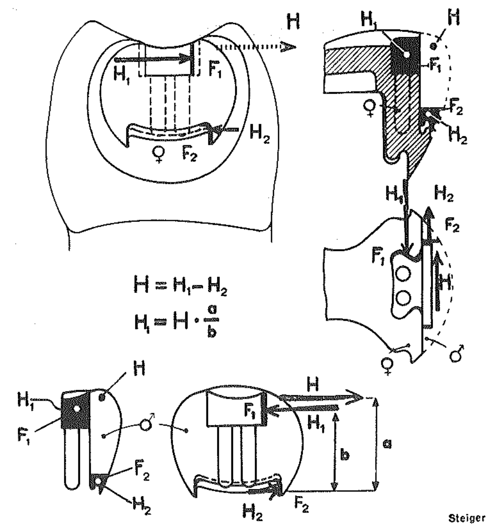


Fig. 12

The principal function of all attachments lies precisely in this *shearing* resistance. A similar comparison of any other conventional attachment with the CSP, yields a result of not only *1: 2*, but at least *1: 4.*

Fig. 11 and 12: Under the influence of force H, a torque is caused between matrix ♀ and patrix ♂. This force of torque is resisted by the lateral contacting surfaces F_1 and F_2 of matrix and patrix. In the attachment fig. 11 two forces result therefrom, H_1 and H_2 which counterbalance the force H and act as a stress on the lateral surfaces F_1 F_2. In fig. 12 these partial forces H_1 H_2 act on the stops F_1 F_2 analogously as in fig. 11. However, the size of the lateral stop surfaces in fig. 11 and 12 is less important than the fact that the web of the attachment patrix is strained for shearing while in the CSP there are stop surfaces arranged in a triangle which prevent shearing.

Fig. 13 and 14: The force P acting on the attachment with its components V and H, is causing tensions which are indicated by the arrows, and which concern the lateral surfaces of contact. In fig. 13 the contact surfaces are partly larger than in fig. 14, but since the shearing cross sections are of chief importance, the comparative value of the capacity of resistance between the two systems remains the same as above. Fig. 14, moreover, shows a remarkable resistance to torque in the isthmus bar between dovetail and the approximate portion of the patrix ♂, which is most efficacious.

Fig. 15 and 16: At the level of the center of gravity of the contacting surfaces, a traction force Z is acting in sagittal direction. This force is directed (in fig. 15) one half to each of the stops ($\frac{1}{2}Z$) in the interior of the attachment. Thereby the cross section of the web is being loaded to traction. In fig. 16

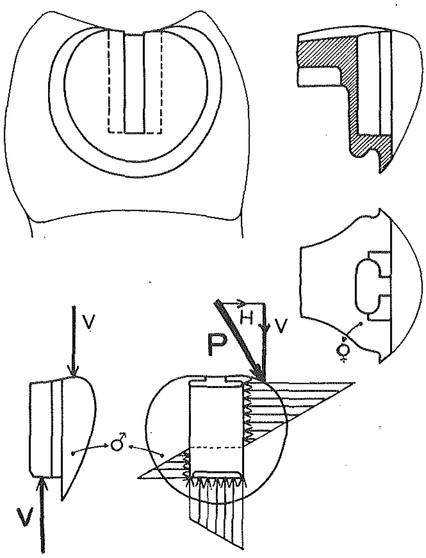


Fig. 13

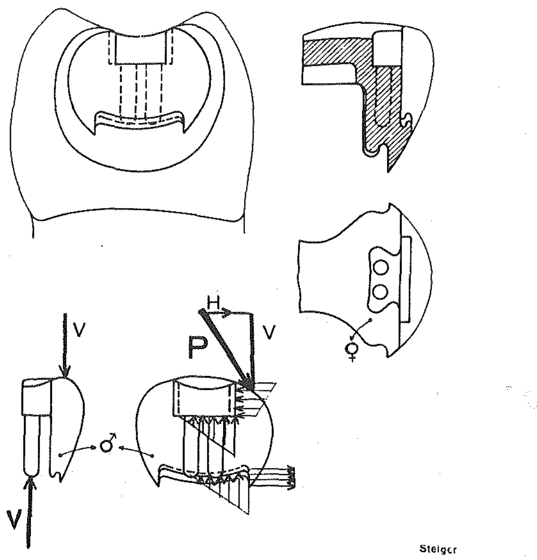


Fig. 14

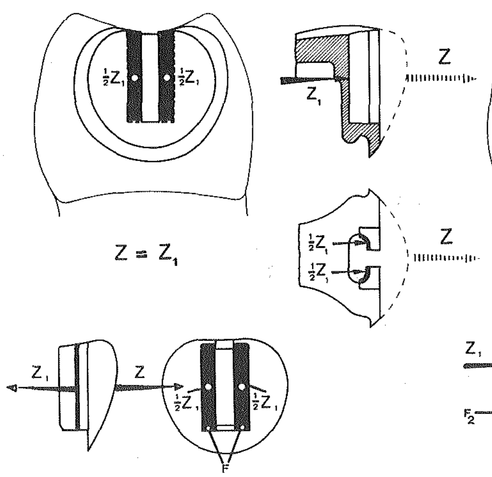


Fig. 15

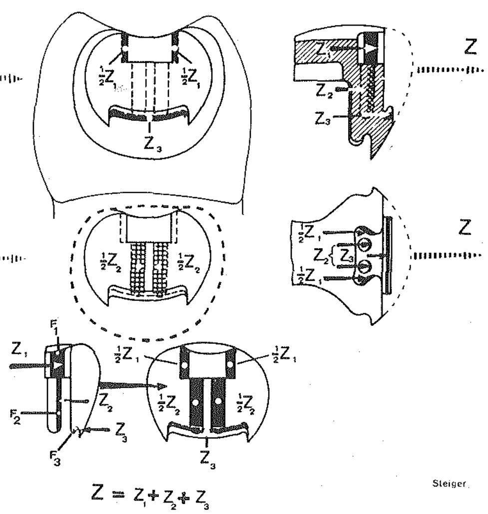
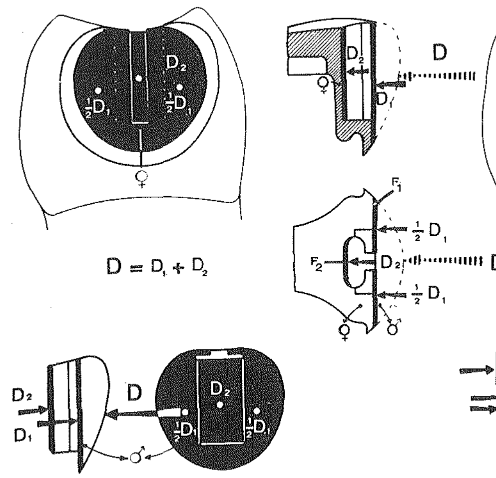


Fig. 16

traction force Z is distributed over the stops in the dovetail section F_1, the spring pins F_2, and the fillet in the shoulder F_3. Here too, the ratio between the individual stop surfaces is of no importance. Important is the degree of traction resistance of the locking devices.

Fig. 17 and 18: Here the load ratio is shown under the influence of a sagittal pressure D, which in both cases is being caught by the total of the contacting surfaces which are opposed to this direction of force. In fig. 17: $D = D_1 + D_2$, whilst in fig. 18: $D = D_1 + D_2 + D_3 + D_4$.



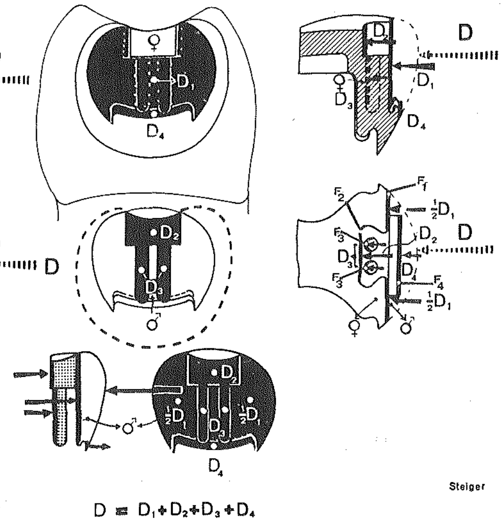


Fig. 17

Fig. 18

Fig. 19 and 20: Here it is assumed that a torsional moment M is acting in the sagittal plane. Hereby the occlusal part of the attachment in fig. 19 receives $2 \times \frac{1}{2}Z = Z$ tractional force and the cervical part of the attachment $2 \times \frac{1}{2}D = D$ pressure force. In fig. 19 the tractional force is being transmitted by the upper part of the web of the patrix ♂, in fig. 20 by the particularly massive web of the dovetail patrix. This zone is the danger zone for all attachment systems if the structure of the material is not uniform, or if there are some shrinkage cavities caused by soldering.

All the particular cases of loading described in fig. 7 to 20 usually occur in various combinations, and are generating correspondingly combined forces in the attachments.

It seems important to demonstrate how such forces act on a combination of anchorages such as is the case in a bridge. Fig. 21 a and 21 b show a bridge in which an oblique force K is divided into its two components P and L. According to fig. 21 c *force* H generates on the left side the sagittal force of traction Z and on the right the sagittal force of pressure D. Force P, furthermore, generates, according to fig. 21 c, the vertical pressure values V, V' and the hatched bending moments of the bridge, especially its *setting moments* M *and* M' *in the attachments. These* moments are causing considerable additional forces

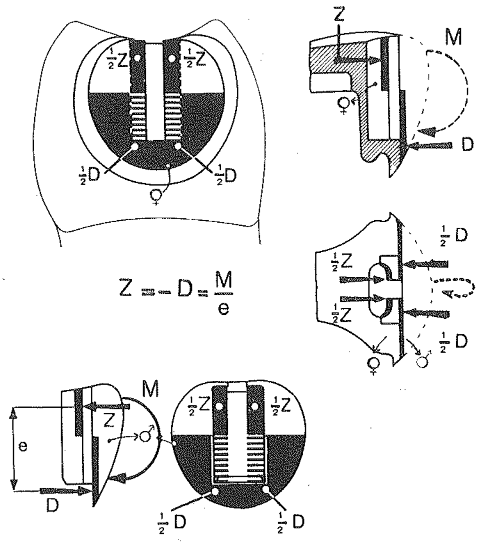


Fig. 19

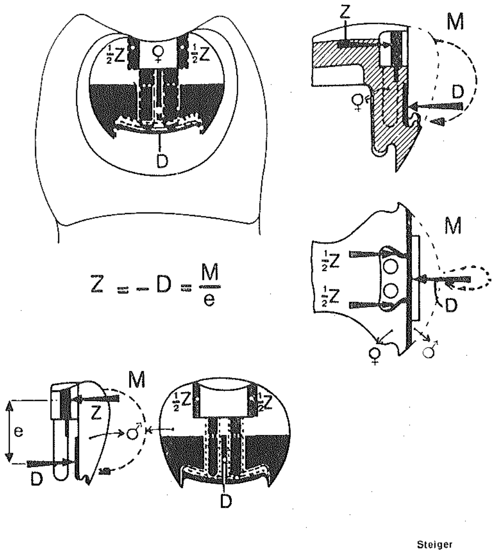


Fig. 20

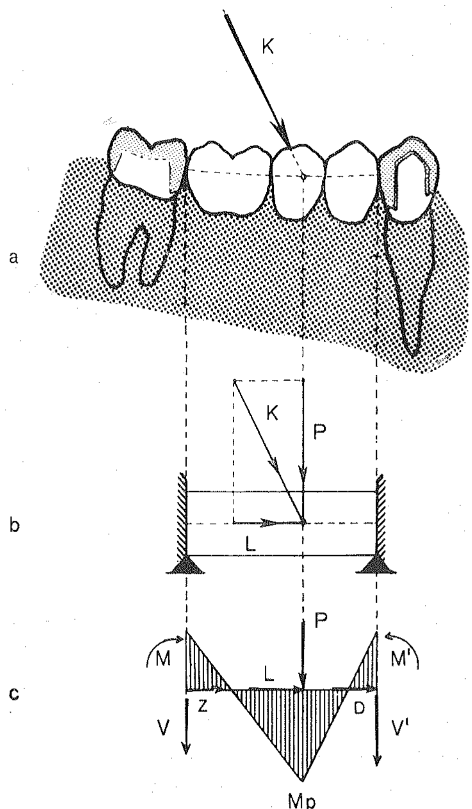


Fig. 21

or tensions which superimpose themselves over the tensions resulting from Z, resp. D. This combination illustrates the advantages of the *CSP system in a still more enhanced way.*

In fig. 21 a–c we have assumed, in order to simplify, that the abutment teeth neither sink nor tilt. In reality such movements do occur, however, and they considerably change the forces V, V', Z, D and the moments M, M' in fig. 21 c.

Assuming for instance, the abutment on the right would sink, this would cause V to increase, and V' to decrease. Simultaneously M would be enlarged, and M' diminished, under which circumstances the situation would be reversed. If on the other hand, both abutments tilt towards each other, M and M' would be reduced, and the bending moment M_p in the bridge increased instead.

DESIGN OF THE CSP ATTACHMENT

The Channel-Shoulder-Pin attachment (CSP) as conceived by Steiger already indicates by its name the elements of which it consists: The *channels*, the *shoulder*, the *pins.*

The *channels* are the *guiding element* which guides the patrix into its seat on the matrix, it determines the direction of insertion.

The *shoulder* is the *supporting element* which receives and absorbs the above mentioned shearing forces or vertical stresses.

The pin, or rather the pins in their interarrangement are the soft *frictional element* which opposes a reasonable measure of resistance to the separation of matrix and patrix. It must be added that the correct shape and design of the attachment is of greatest importance as an element of retention. Incorrect design leads to most of the failures observed in practice. It is therefore of first importance to discuss the principles of design, before the other elementaries of the CSP Attachment.

There is an almost boundless number of designs which, subdivided into three groups, all follow a simple rule: *The patrix—without the frictional element, the pins—must not be displaceable except in the direction of insertion and removal.* Except in this mentioned direction, there must not be the slightest movement possible, when patrix and matrix are assembled, even by strong lateral forces or torque. The three groups of designs are schematically: The cylinder, the horseshoe, the T. Fig. 22 shows in the uppermost two rows the schematic drawing of a round cylinder, horseshoe-cylinder and T-design, and below, the practical example of the respective CSP attachment.

The design most resistant to deformation having at the same time a maximum of contacting surfaces within the attachment is the *cylinder* or *frame design* schematically shown as a cylinder with a hollow cylinder fitting over it.

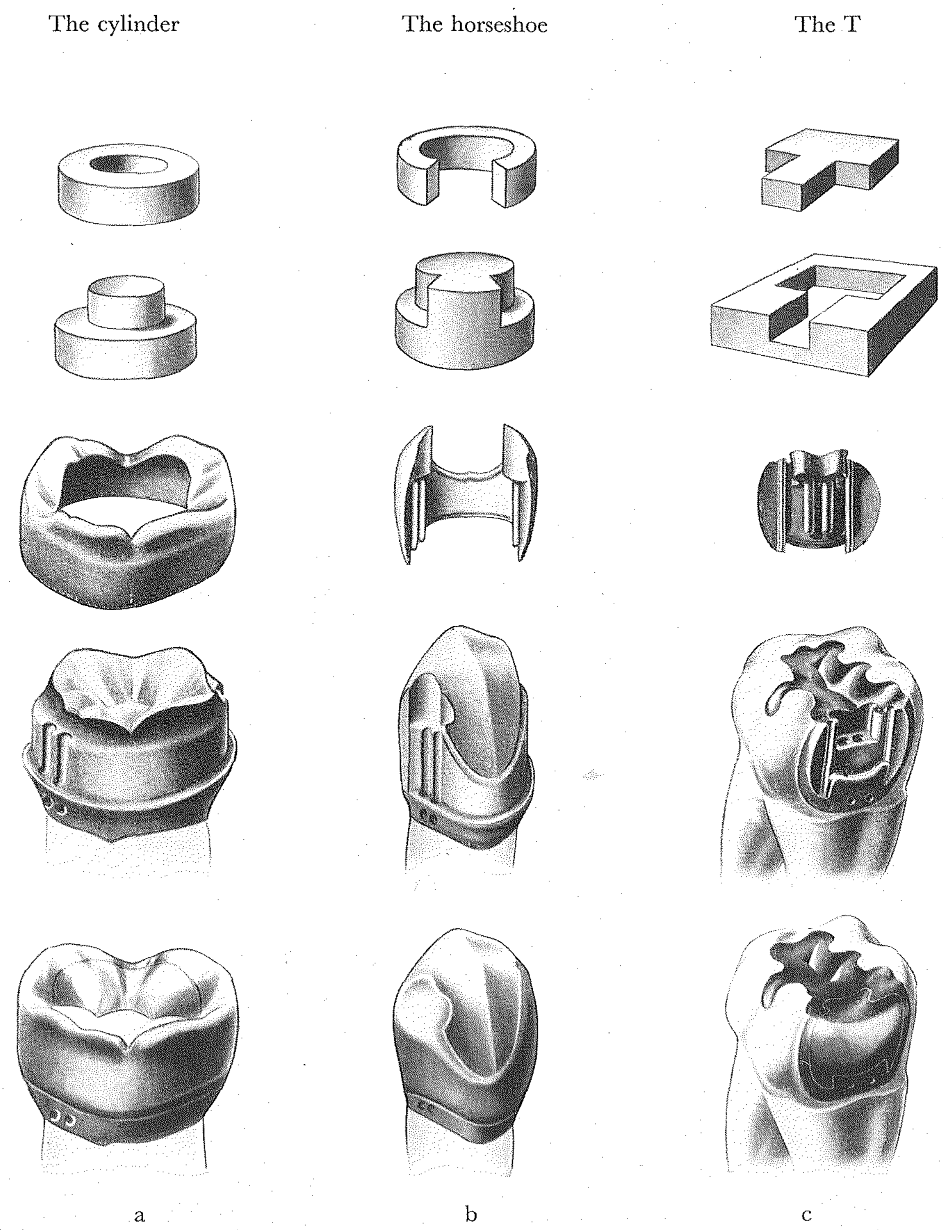
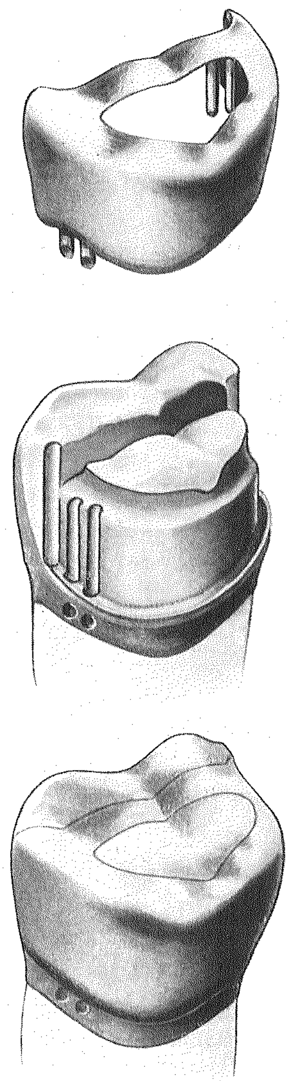


Fig. 22 From left to right the three basic designs of CSP attachments: a = Cylinder design b = Horseshoe design c = T-design. Above, the schematic principle, below, patrix, matrix, and assembled attachments. For modified cylinder design, see fig. 23.

This design in its truest practical application is possible on full crowns (fig. 22 a). It may be modified insomuch as the buccal face of the crown need not be touched by it, and the buccal part is then carried as a slot or bar across the occlusal part of the crown (fig. 23, 24).

This increases the range of application because with the buccal face of the crown untouched by the attachment, it may be used not only in full crowns, but also in various crowns with acrylic or porcelain facings, such as Richmond crowns, veneer crowns, three-quarter crowns. The groove across the occlusal of such crowns and the bar of the patrix lying in this groove is located con-

Fig. 23 Modified cylinder design, patrix, matrix, assembled attachment. The buccal surface of the tooth is not involved; the attachment may thus be used for three-quarter crowns or any crown with a buccal facing, in addition to its use on full crowns. →



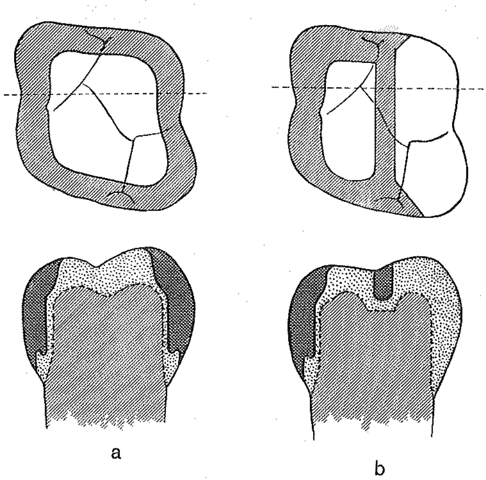
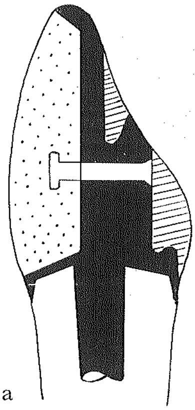
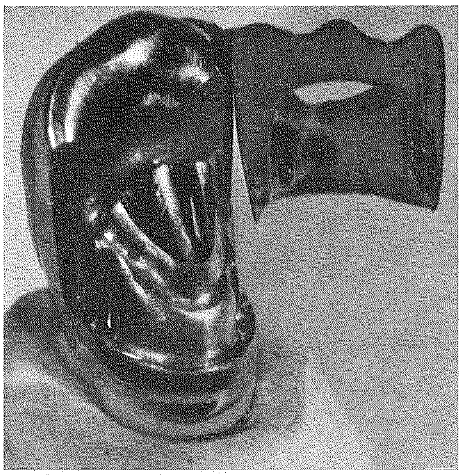


Fig. 24 Occlusal view and cross section of an upper molar with a = cylinder design, b = its modification to show the relationship of matrix and patrix.

Fig. 25 Modified cylinder design of CSP attachment on cuspid with Richmond crown. a = cross section, b = attachment disassembled, c = attachment assembled.



a



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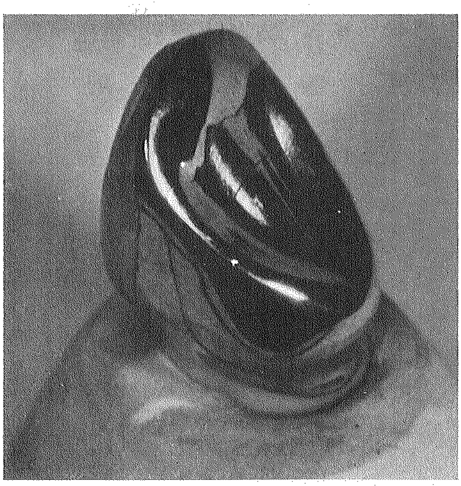
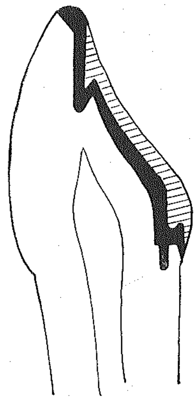
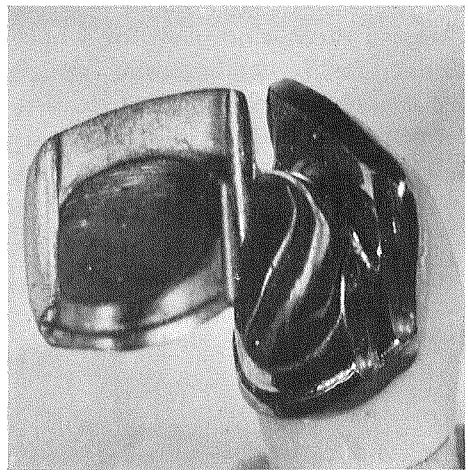


c

Fig. 26 CSP attachment on vital upper incisor. The lack of depth in the abutment preparation gives little space for the attachment. If the same design as in Fig. 25 were used, the patrix would be too weak. Therefore, the lingual surface of the matrix is completely covered by the matrix, which makes the attachment a double three-quarter crown.



a



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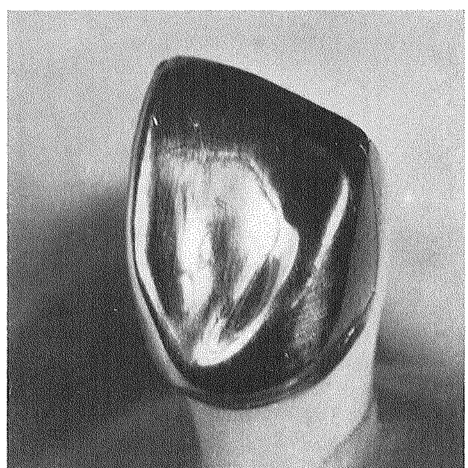


c

ventionally in the region of the main mesiodistal fissures, where there is usually sufficient space after removal of old fillings. In Richmond crowns of front- or cuspid teeth, this groove is placed into the middle or occlusal third of the lingual face (fig. 25). In three-quarter crowns it must correspond with the horizontal groove of the abutment preparation (fig. 26). The groove must not be less than 2 mm deep and not less than 0.8–1 mm wide. If the dimensions must be smaller because of lack of space, as may be the case in three-quarter crowns on front teeth, the frame of the patrix is reenforced by completely filling out its lingual face. This leads to the double three-quarter crown.

The horseshoe-design, schematically described in fig. 22b is in fact nothing else than the hollow cylinder slit open on the buccal side, in other words, the cylinder design without buccal or occlusal part. It is somewhat less resistant to deformation insomuch as if the casting is not strong enough, the ends of the horseshoe shaped matrix may open under certain stresses. Thus, the horseshoe design should only take the place of the cylinder of modified cylinder design if there is no place for a buccal part or an occlusal groove, and if the patrix may be made strong enough. This is the case: (1) When porcelain bicuspids or molars are used (fig. 27, 28). (2) In continuous CSP attachments on front teeth, where double three-quarter crowns would be too bulky and a hindrance to speech (fig. 29). (3) In short teeth.

It must be emphasized that in continuous CSP attachments on front teeth

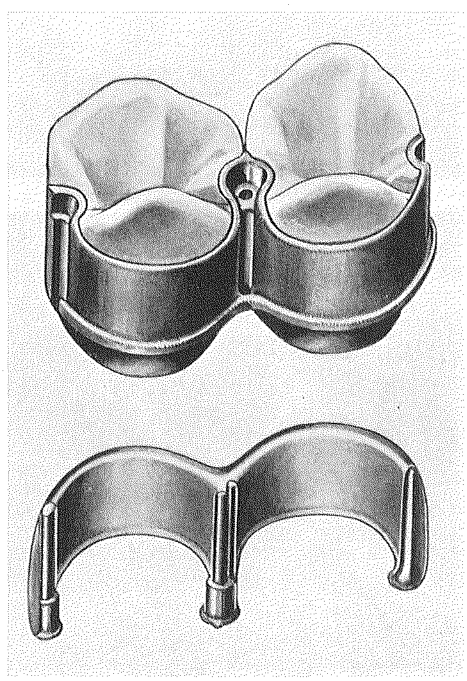


Fig. 27 Continuous CSP attachment on bridge or splint in the premolar region, where for aesthetic reasons porcelain pontics were used. Gold is invisible except for the lingual (palatal) surfaces. Note the selfretentive design with interproximal slots. The frictional pins are passive.

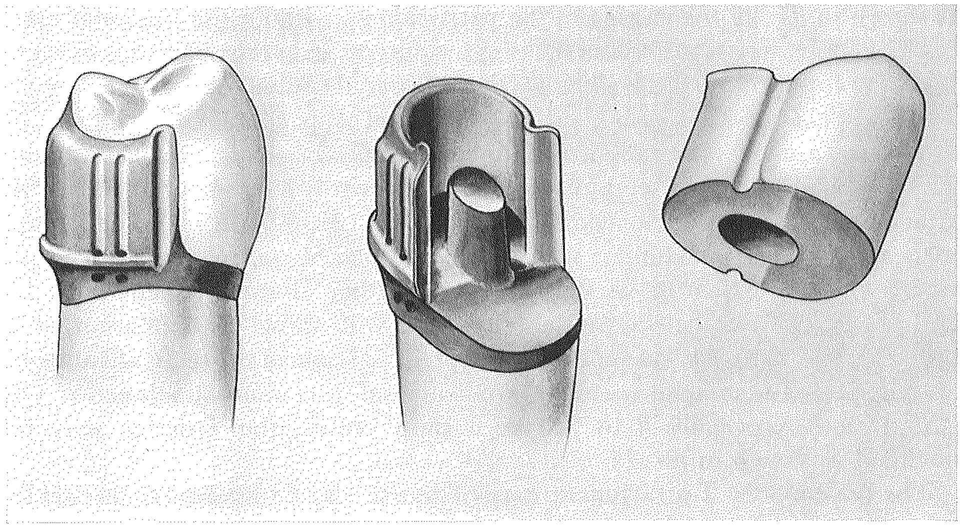


Fig. 28 Full porcelain pontic and corresponding casting for CSP attachment.

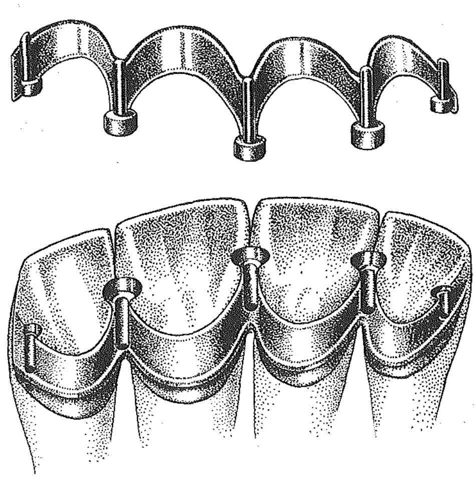
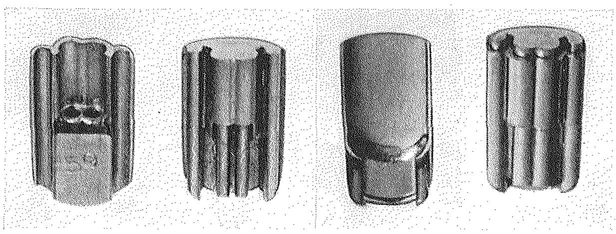


Fig. 29 Continuous CSP attachment on front splint of three-quarter crowns. Note again (as in fig. 27) the interproximal slots which make the attachment selfretentive before the pins are mounted (see p. 34).

as shown in fig. 29 the casting of the patrix alone, without the frictional pins. must be selfretentive, otherwise the pins are subject to overstress and breakage, Note the interproximal dovetails warranting such a retention.

The dovetail- or T-design is used only on abutments standing at the end of the dental arch and is designed for inlays. Under certain circumstances the T-design is also used on cuspid teeth, if the crown is long enough. This CSP attachment is the only one available readymade (fig. 30). In planning a case, such a unilateral attachment should only be placed on an abutment tooth where no later extension of the case over further abutment teeth must be anticipated. Only a mesiodistal attachment will allow the extension of a bridge over to the other side of an abutment. This is one of the main advantages of the CSP attachment over the conventional precision attachments. On cuspid teeth, especially if they have a short crown, the T-design may be modified as shown in fig. 24.

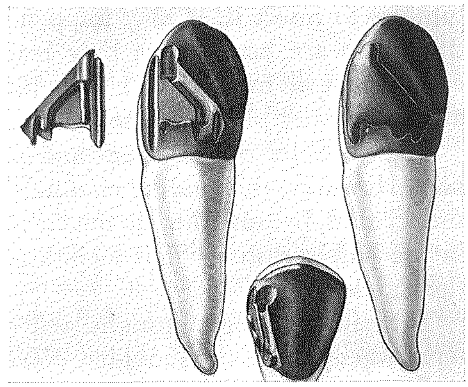
The dovetail- or T-attachment may of course also be used mesiodistally in an MOD inlay by joining the two attachments by an occlusal groove, resp. bar. Thus it is also a mesiodistal attachment. However, in most such cases preference is given to the three-quarter crown with the modified cylinder attachment (fig. 23). This preference is given for reasons of caries prevention.



a b c d

Fig. 30 The ready made CSP attachment, obtainable in two sizes. a = matrix. Note the hollow shoulder in the foreground of the pinholes. The pinholes are selfcleansing, their lower openings are invisible because they are placed at the bottom of the matrix. Lateral to the dovetail, the guiding channels. b = patrix. Dovetail, guiding ledges and frictional pins are visible. c = matrix and patrix halfway assembled. d = attachment from the back side, patrix almost completely inserted. This side of the matrix is incorporated into the casting of the abutment.
The attachment may be shortened on either upper or lower portion. Excessive shortening would impair either the retentive value of the dovetail or the frictional value of the pins, while the retentive quality of the hollow shoulder remains.

Fig. 31 CSP attachment, unilateral, on a vital cuspid tooth with a three-quarter crown matrix. It is a modification of the T-design shown in fig. 22, last row. The box preparation on the distal of the tooth gives only shallow depth for the attachment. Selfretention of the casting is given by the grooves towards buccal and lingual margins of the attachment, while the pin gives frictional retention.



THE CHANNELS

There are two different kinds of channels in a CSP attachment. As it was stated earlier, their function is the guidance of the patrix on the matrix. This guidance is twofold: guidance of the casting of the patrix and guidance of the pins of the patrix. Hence the dual nature of the channels. The first kind represents a channel in which a corresponding and congruent ridge in the *casting* of the patrix slides, the other is a channel along which a *pin* of the patrix finds its frictional contact. Therefore the first kind is called *guiding channels*, the latter *pin channels*. The guiding channels should, on insertion of the patrix, first get into contact with the corresponding ridges of the patrix so as to secure the proper direction of insertion. If the pins first contact the matrix and the patient, clumsy as he may be in first handling his denture,

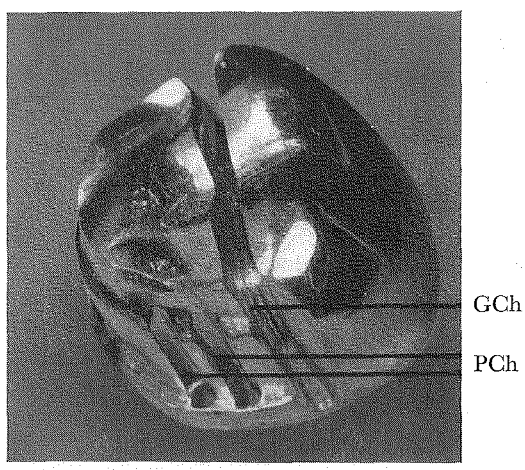


Fig. 32 Molar crown with CSP matrix, view from mesioocclusal side. Note, as a continuation of the occlusal slot, the guiding channel GCh, and to the left of it, two pin channels PCh perforating the shoulder.

fumbles to insert it, it may happen that with a faulty direction of insertion these pins are bent before they reach their proper channels. Naturally the case cannot be inserted with bent pins. This problem of placing the channels at their proper place will be dealt with later and in detail.

The diameter of guidance- and pin-channels is 0.7 mm, the same as the pins. However, the guiding channels may be *slightly* conical, opening towards the occlusal, because they do not correspond to straight pins but are reproduced in the patrix casting. This facilitates insertion. Guiding channels lie outside the shoulder.

The pin channel is straight, not conical. It perforates the shoulder, or it terminates just on the shoulder. Never should such pin channels have a dead end within the shoulder. They must be carried through the shoulder so as to be self-cleansing. If such pinholes in the shoulder have no opening on the gingival side of the shoulders the patient may get something into these holes while his removable appliance is removed. With any solid matter trapped in the holes, the case cannot be reinserted. The patient will try to use force and may damage something. This is therefore a very strict rule: *Make all pin channels self-cleansing* either by not carrying the channel farther than the surface of the shoulder or by perforating the shoulder completely.

Sometimes, it will be found that trying to carry the pinhole through the shoulder would perforate the matrix on the tooth side of the casting. This must of course be avoided. In such cases the lower part of the perforation in the shoulder is drilled from the outsides which might be called a drainpipe leading into the pin channel at an angle (fig. 33 o). Since the distance from the surface to the pin channel is usually smaller than 1 mm and the hole is protected by the shoulder from direct food impaction, it is insignificant which in larger dimensions might be termed a food trap.

On front teeth (fig. 26 b) there is sometimes insufficient thickness of the matrix to perforate the shoulder at all; then, the pin channel ends *on* the shoulder.

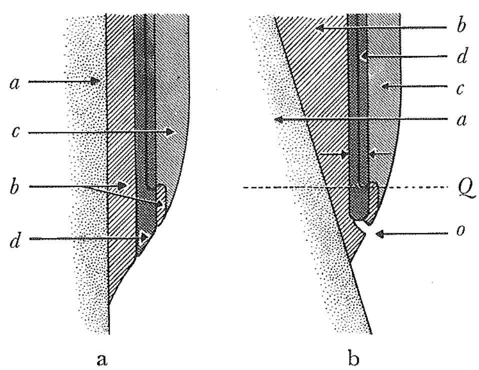


Fig. 33 a and b = schematic cross section of gingival portion of CSP attachment. *a* abutment tooth; *b* casting of CSP matrix; *c* casting of CSP patrix; *d* frictional pin. At *Q* cross section of shoulder. a shows the self-cleansing pin channel, where the pin goes straight through the shoulder; *o* shows the circumstances under which the pin cannot perforate the shoulder without damaging either the margin of the crown or without perforating the matrix into the abutment tooth. Therefore, a small oblique opening is made from the outside of the matrix.

THE SHOULDER

The shoulder, the supporting element of the CSP attachment, no doubt is making most difficulties in technic, because it is not a plane shoulder at right angles to the wall of the matrix, but has the shape of a gutter. Its outline in cross section is that of a lying S (fig. 34).

Precisely because of its gutterlike outline it can be held within a minimum of width which keeps the volume of the whole attachment within anatomical dimensions. The width of the shoulder should not exceed 1 mm, its depth should be between 0.3 and 0.4 mm or about half of its width. The outer part of the shoulder is shaped into a short wall parallel to the direction of insertion. It is called the *sealing wall* because there the patrix seals the matrix on its gingival border of contact. A clean seal along this margin is a fundamental necessity, if hygienic conditions are desired (fig. 34). The shoulder should if at all possible run at the same height on the matrix on its whole length, because this considerably facilates the technical procedure. On short teeth, the shoulder lies as gingivally as possible, while on long abutments, it may be placed further to the middle of the abutment. This is necessary in order to get sufficient, but not excessive height for the attachment. Occlusally from the shoulder, about $1\frac{1}{2}$ mm from the occlusal seal of the attachment, the matrix must have a rounded concave rabbet which has no supporting function but serves to give a certain bulk to the patrix occlusally (fig. 35R). Occlusally there is usually more space to work with than gingivally, and thus

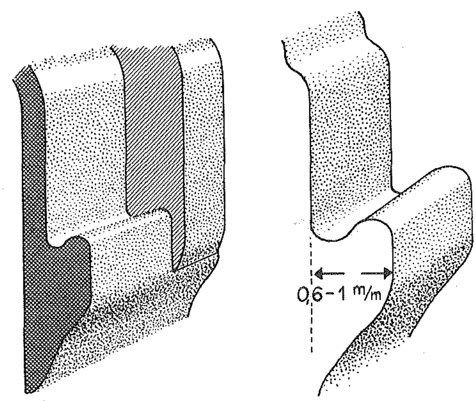


Fig. 34 Cross section of shoulder portion of a CSP attachment to show gutterlike shape of the shoulder, the sealing wall below the shoulder, the complementing patrix in cross section, and the average dimensions of the shoulder.

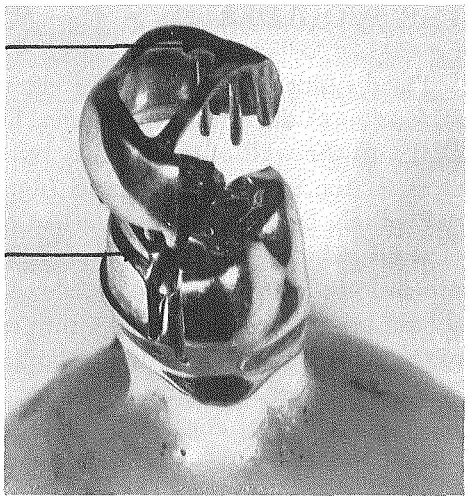


Fig. 35 A CSP matrix for full crown, to show the shallow rabbet (*R*) occlusally to the parallelized wall. Reproduced in the patrix, this rabbet represents the bulky part (*B*) of the patrix giving the necessary stability against deformation and shows the soldering sleeves for the frictional pins.

the patrix is given the stability necessary against deformation. It must always be born in mind that it is the patient who will handle the bridge or denture, a person usually without the proper understanding for the construction made for him. It is therefore most important to find sufficient stability of the construction without enlarging the attachments beyond the natural anatomical contours. This reenforced part of the patrix—as we shall see later—also includes the soldering surfaces for the frictional pins.

THE PINS

The pins are the frictional, the "braking" element which offers a definite resistance to the removal of the patrix from the matrix. If no such frictional element were incorporated, the patrix would—after a certain number of insertions and removals—loose its frictional retention until no resistance against removal would be left. The pins, of an elastic alloy, preserve this frictional retention. At this point, it cannot be overemphasized that *these pins must never have other functions than frictional retention.* The patrix without the pins must be retentive itself in its design, the pins must be passive as far as stresses transmitted from patrix to matrix are concerned. If this rule is followed, breakage of pins can be *completely* eliminated.

The pins must be soldered—*never cast*—into the already cast patrix, as it will be shown later (p. 128). They are soldered only at their base, in the bulk of the patrix, while the remaining length is free and may be activated when necessary. To activate a pin or pins means to very slightly change their direction which originally was truly parallel to the axis of insertion. This change of direction should not be noticeable by eye and is made in such a way that the free end of the pin contacts its corresponding channel more closely. This on the other hand obliges the mechanic to slightly taper the occlusal entrance of a pin channel. With an untapered channel margin, the pin would get stuck on the edge. The tapered entrance will guide it into the channel.

The material for the pins is an elastic gold platinum alloyed clasp wire of 0.7 mm diameter. Platinum pins are unsuitable for this purpose, because they are too hard and less elastic than a platinum-gold alloy. The material and gauge of the pins have over years of experience with other materials and sizes, proven to be the optimum between toughness and elasticity. The pins must have a minimum length of 3 to 3.5 mm with 1 to $1\frac{1}{2}$ mm for soldering within the "bulk" of the patrix, and 2 to $2\frac{1}{2}$ mm (as a minimum) for the free, elastic end (fig. 37).

Experiments were made by a manufacturer of the alloy used for the pins in order to establish the durability of the pins when subjected to intermittent bending stresses. The experimental pins were of a free length of 5 mm, and the bending distance was of 0.7 mm (the diameter of the pin). Breakage occurred after 128000 to 181000 bends. For one daily removal and insertion a day this corresponds to an average durability of 450 years.

Where, for lack of space, a CSP attachment must be made very slender and there is no space for soldering bulk on the whole circumference of the attachment, the soldering surface is found by making soldering sleeves at the site of the pins (fig. 36).

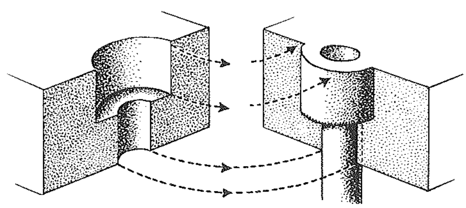


Fig. 36 Schematic drawing of soldering sleeve for frictional pins, where there is not enough space for a rabbet as shown in fig. 35. Special sleeved stainless steel pins (fig. 85m) serve to shape the pattern for these sleeves.

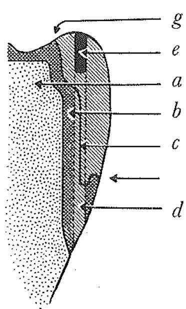


Fig. 37 Cross section of a complete wall of a CSP attachment on a crown. *a* abutment tooth; *b* matrix casting; *c* contacting surface of matrix and patrix; *d* frictional pin; *e* soldering area of frictional pin within the bulk of the patrix; *f* shoulder; *g* occlusally, matrix and patrix should angle off at 90 degrees if at all possible.

CHAPTER III

THE WORKING PROCEDURE FOR DENTIST AND DENTAL MECHANIC

The different working steps for this type of reconstruction work alternate between operative and laboratory work and vary according to the extent and size of work. Careful planning must always preceed the beginning of operative work. The planning phase will be dealt with at the end of this chapter, because the reader must first familiarize himself with the method of treatment and with the difficulties in operative and laboratory work in order to understand what planning involves for him.

CAVITY AND ABUTMENT PREPARATION

Topography of Dental Caries

Apart from the individual susceptibility to dental caries the lesions in their immense variability largely depend upon the interrelation of the teeth and their position within the masticatory apparatus. The self-cleansing action which is performed by the co-operation of salivary glands, the tongue, cheeks and lips during mastication makes certain tooth surfaces less caries-susceptible than others which are inaccessible. The smallest anomalies in the inter-arrangement of the tooth crowns increase the amount of inaccessible surfaces. Similarly, poor articulation between upper and lower arch reduce the self-cleansing action. Spaces and recesses retain food particles and allow plaques to form, whereupon the biochemical mechanism of dental caries begins to take effect. Another factor is the height of the gingival attachment. Interproximal recesses are formed by loss of gingival tissue or by pocket formation and after a number of years, even the roots may be attacked by decay. The bifurcation of upper, but also of the lower molars and bicuspids are then places of predilection. Furthermore, the topography of the tooth surfaces, deep enamel corrugations, grooves and pits from imperfect calcification prepare the way for the carious attack.

On inspection of the patient's mouth it is usually possible to judge his personal caries susceptibility and to determine how far the prophylactic measures must be carried.

Mutual understanding and comprehension during scientific discussions is made possible by a clear classification of carious defects in the natural set of teeth. Ever since G. V. Black issued his work on operative dentistry in 1914, his classification has reached world wide recognition.

Classification for cavity and abutment preparations

The fast development of modern technics in general and its influence on modern dental equipment brought about basic changes and new possibilities in cavity and abutment preparation. The cavity classification of G. B. Black was based on the use of certain hand instruments for specific classes of cavities. The change which took place in the technic of cavity preparation suggests a change in classification. Also, it seems reasonable to include the abutment preparation into the classification, because in reconstructive work, it goes hand in hand with and is inseparable from cavity preparation.

CLASSIFICATION BY G. V. BLACK

Class I	Pit and fissure cavities: On the occlusal surfaces or bicuspids and molars, in the buccal and lingual fissure of molars and on the lingual surfaces of upper incisors.
Class II	Interproximal cavities of bicuspids and molars.
Class III	Interproximal cavities on incisor and cuspid teeth which do not require replacement of the incisal angle.
Class IV	Interproximal cavities of incisor and cuspid teeth which require replacement of the incisal angle.
Class V	Gingival third cavities of the labial, buccal, lingual or palatal surfaces of tooth crowns.

NEW CLASSIFICATION FOR CAVITIES AND ABUTMENT PREPARATIONS (A. A. Steiger)

The current designation for prepared tooth surfaces uses the first letter of the word designating the location of the preparation on the tooth crown:

m for the mesial surface
o occlusal surface
d distal surface
l lingual surface
b buccal surface

The most frequently used letters are *m*, *o*, *d*, mainly used to explain the size and extent of an amalgam or gold filling. The whole surface of a tooth is thus gathered in "*modlb*". With these five surfaces per tooth a clear topographical definition of the carious lesions is not possible. Phrenology, Anthropology and Anatomy need the help of systems and landmarks in order to clearly and accurately define a topographical location. Caries topography does not make an exception to this rule. Just as this earthly globe was covered by a network of parallels, the tooth body may be subdivised by lines, an idea which G. V. Black already expressed and advocated for cavity description.

Also, G. V. Black undertook it to find a name for every angle and edge which is formed by the various surfaces of the tooth crown. For descriptive topographical use, networks of parallels for the subdivision of the surfaces and a nomenclature of angles and edges are most useful. They do not concern the classification of cavity and abutment preparation. The new classification qualifies cavities or preparations which include or involve the same number of crown surfaces. Thus class A includes all preparations involving one surface, class B two, class C three, class D four, class E five surfaces, and class F includes all preparations on crownless, devitalized teeth. The use of capital letters instead of numbers simply serves to distinguish the classification from G. V. Black's.

Class A (fig. 39a, 39b)

All cavities or preparations on one of the five surfaces belong to class A. Even if various cavities are located on one surface and are or are not included in the same preparation, they belong to class A. If several surfaces are affected but are prepared individually, each of them equally belongs into class A. The topographical designation may be added, A *m*, A *o*, A *d*, A *l*, A *b*.

Class B (fig. 40a, 40b)

If two surfaces are involved, the intraoral examination or X-rays will determine if the defects communicate with each other somewhere below the surface, or if a communication by preparation is desirable. Such preparations will be designated as B *om*, B *od*, B *ol*, B *ob*.

Class C (fig. 41a, 41b)

Cavities or preparations with communication over three surfaces belong into class C. Conventionally best known is the C *mod*, but also the gingival third cavity which extends over three surfaces C *mbd*, C *mld*. The same applies to C *mld* preparations on incisor and cuspid teeth (pinledges or three-quarter crowns without involvement of the incisal angle).

Class D (fig. 42a, 42b)

Cavities or preparations with communication over four surfaces belong into class D: D *modl*, D *modb*, including *mod* inlays with fissure extensions towards the lingual or buccal, and three-quarter crowns which do not involve the buccal (labial) surface. The involvement of the buccal (labial) surface would make it a Class E preparation.

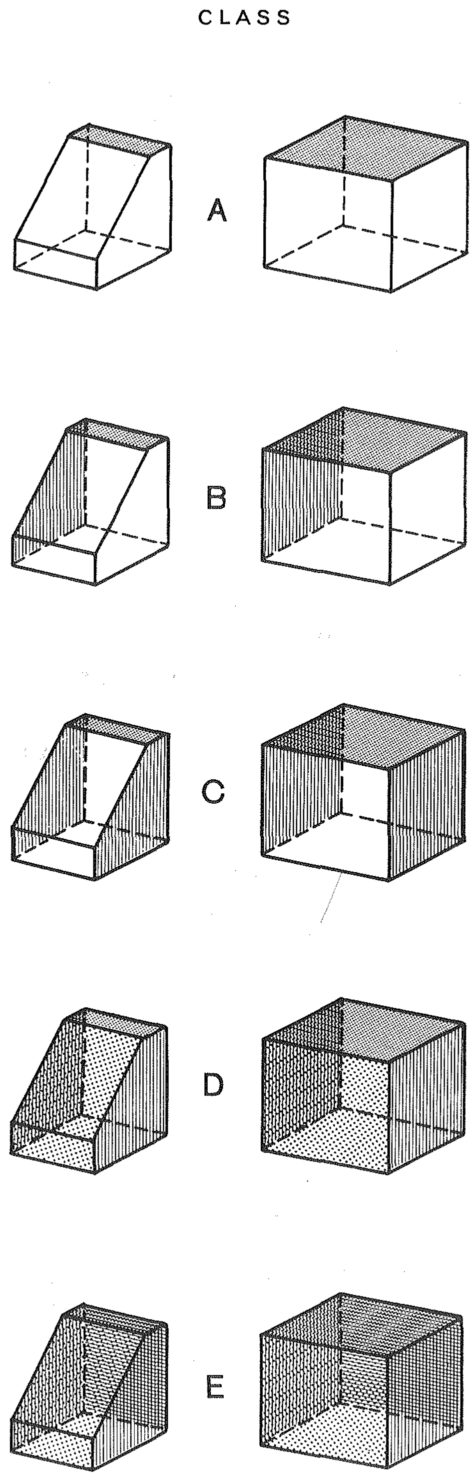


Fig. 38 Classification for cavity and abutment preparations. In the row on the left, the schematic drawing of incisor teeth, in the row on the right of premolar and molar teeth. One example for each class is given, while the text describes the various remaining possibilities for class A- to D-preparations.

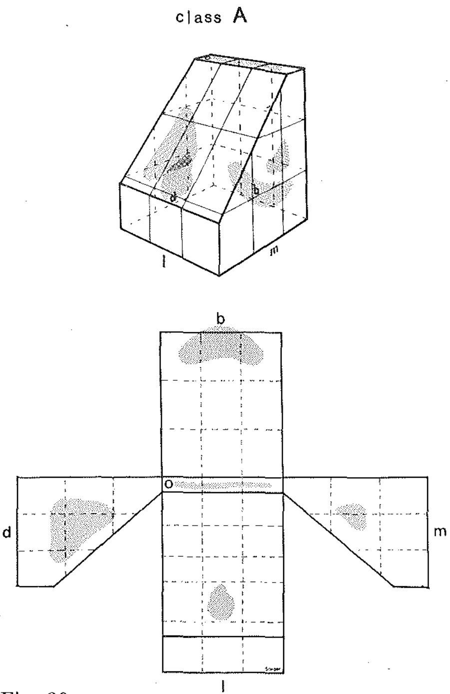


Fig. 39a

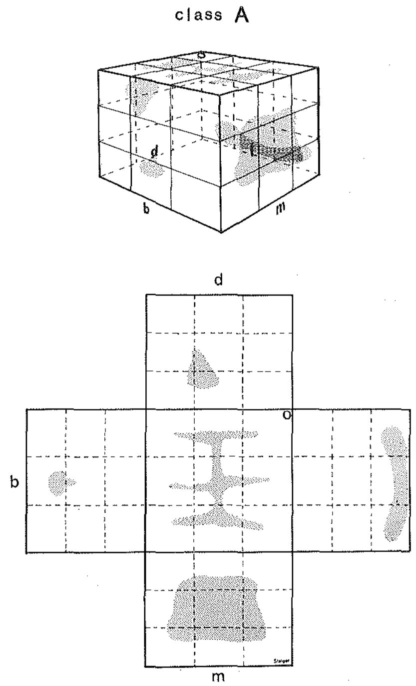


Fig. 39b

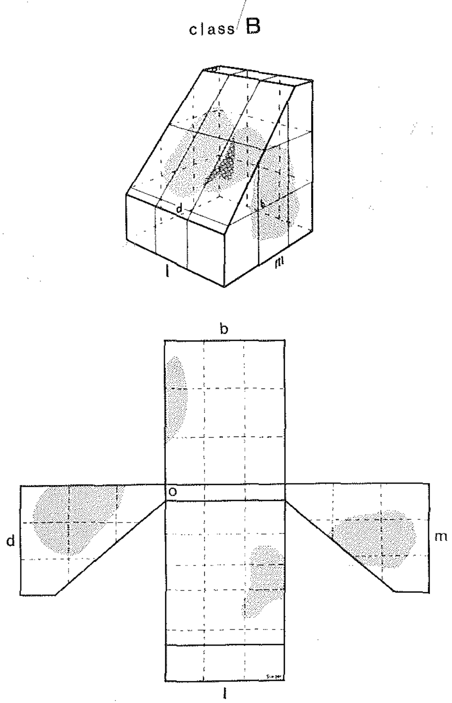


Fig. 40a

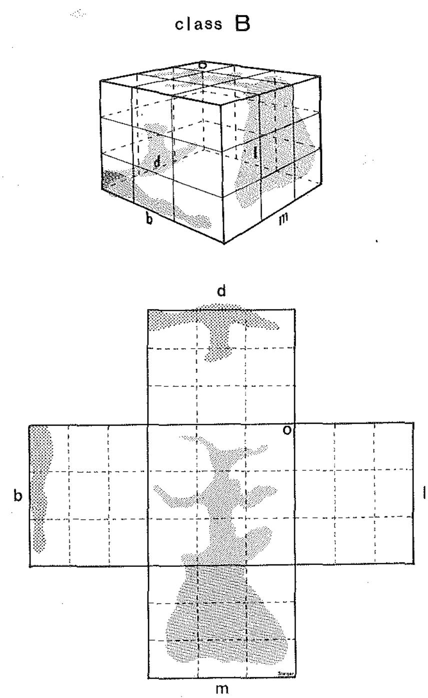


Fig. 40b

class C

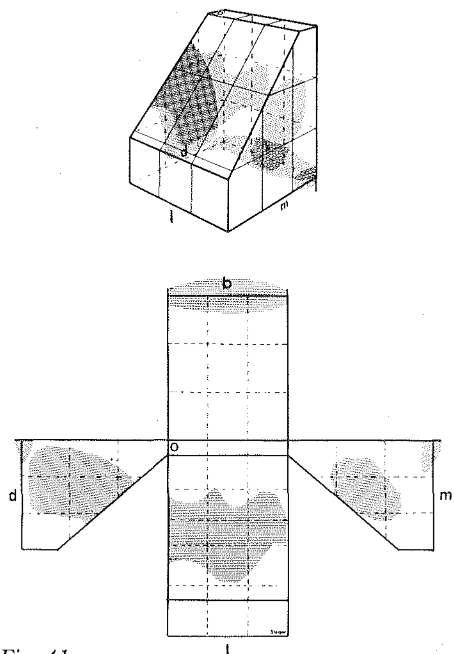


Fig. 41a

class C

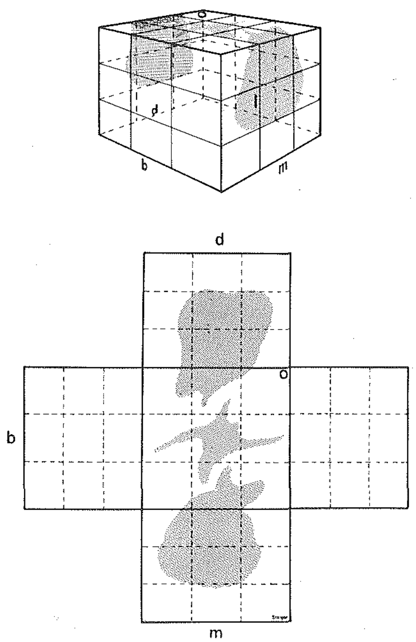


Fig. 41b

class D

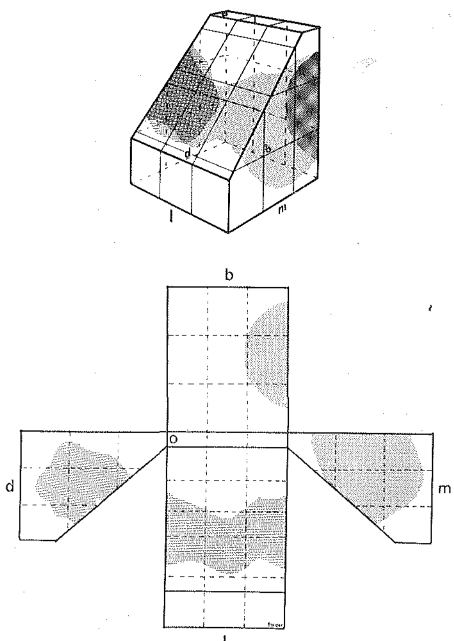


Fig. 42a

class D

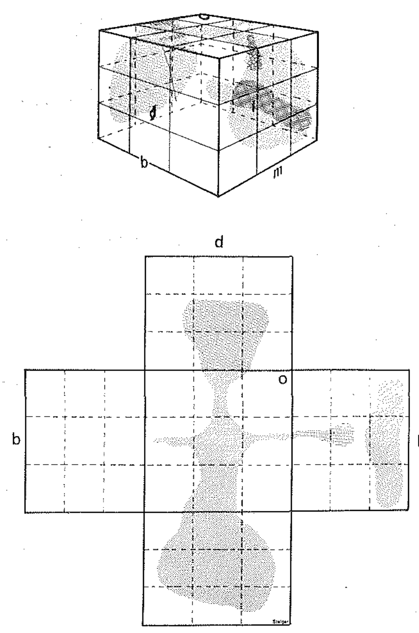


Fig. 42b

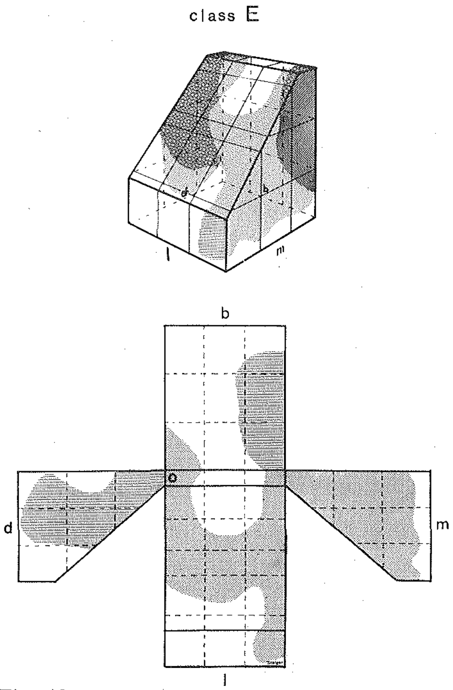


Fig. 43a

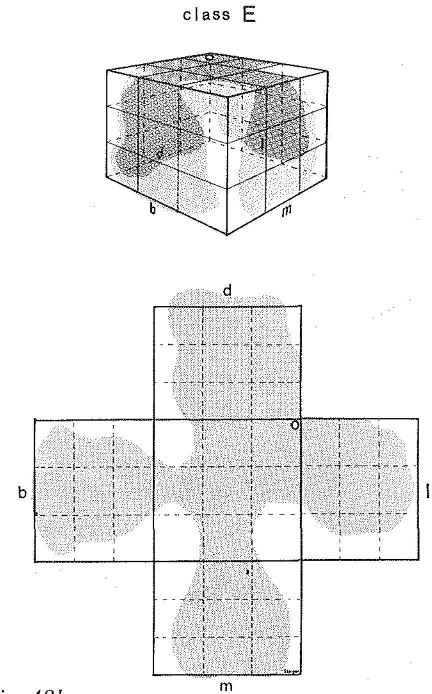


Fig. 43b

Class E (fig. 43a, 43b)

Cavities and preparations which involve all five crown surfaces, E *modlb* or simply E include inlays involving all crown surfaces, three-quarter crowns involving part of the buccal surface, all full crowns, veneer crowns with or without shoulder, thimble crowns.

Class F

All abutment preparations on crownless, devitalized teeth, post crown- and inlay crown preparations belong into Class F.

Thus, it is possible to distinguish for instance between a three-quarter crown without or with incisal coverage, a three-quarter crown with or without visible mesiolabial and distolabial extension, simply by calling it a C, D, or E crown or pinledge. The classification is easy to memorize because it involves only the counting of the surfaces and the addition of the first letter of the topographical designation. It is completely independent of the technic of preparation or groups of similar preparations.

In the description of the individual abutment preparations class A preparations will not be mentioned, because no one-surface preparation can serve as an abutment preparation. Only certain preparations involving two or more crown surfaces, which serve as abutment preparations, will be described.

During the last decades, working methods changed with the newer concepts and inventions concerning the working of materials in general. Efficiency tests helped to determine proper cutting and clearance angles for the cutting tools. It was found that for maximum efficiency these angles must have a certain relationship to the physical properties of the material to be worked. Between the working material and the working tool, there is a certain resonance relationship. Dentistry in recent years has taken over these experiences of the technical sciences.

PREPARATION OF DENTAL ENAMEL

Dental enamel with its unique physical properties has, ever since the beginning of dentistry, placed quite difficult problems before the dental scientists. Since dental enamel is a living tissue, it cannot be worked upon from purely mechanical principles. Its treatment requires special consideration of the dental pulp. Also, the patient requires painless treatment which still more complicates the problem.

Technical sciences, especially the working methods on metals, have developed with such speed that the layman usually has not been able to follow. The progress in the dental field has naturally always been lagging behind in some measure, carefully selecting from the variety of new inventions. Therefore, we may see today, in a dental office, the whole scale of instruments *in use*. The preparation of dental enamel may still start with chisels, in order to remove undermined enamel prisms. For detail work, high grade steel burs with proper cutting angles and clearance angles are being used, also rotary instruments of carborundum, or of steel with diamond powder incorporated in the surface.

The r.p.m. (revolutions per minute) of the rotary instruments has been increased by faster motors and various types of transmissions, from 3000 to 75000. The electric drive is well on the way of being supplemented or partly replaced by turbine drive without transmission. Various types of water or air turbines are being developed and the r.p.m. are increased to over 200000. With the increase in r.p.m., the working pressure is decreased to few grams, and heat production to a few degrees. The vibrations, so disagreable to the patient, are in a frequency range barely distinguishable by the human ear. All this is accomplished along with increased efficiency and reduced working time.

Water, spray or air cooling is necessary for the conventional preparation methods, and the modern units and handpieces are well equipped to this end.

The relationship between the peripheral speed of abrasive instruments and their efficiency on the working material "dental enamel" is tentatively, but not accurately determined. Certainly the formula will not say: The faster, the more efficient, because in the curve of acceleration of r.p.m. a definite optimal speed will be found which yields a maximum efficiency for each tool in relation to the molecular structure of dental enamel. Accessory factors are the pressure applied, the temperature developed and transmitted to the tooth, and the cooling system (water, spray or air). Heat is due to speed, pressure and vibration. According to NIELSEN, 90% of the vibration is due to eccentricity of the rotary instrument which therefore accounts for most of the heat developed. As long as the true centred bur or diamond point does not exist, a cooling system will probably be indispensable.

It is interesting to know what the actual peripheral speeds of rotary instruments are in order to visualize the difference necessary in the design of instruments and in the technic of preparation.

The formula for the peripheral speed in miles p.h. is:

$$\varnothing \text{ (diameter of bur)} \cdot \pi \cdot \text{r.p.m.} \cdot 60 \cdot 0.62$$

With a diameter of 1 mm at

3 000	r.p.m.	peripheral speed of	0.35 mile p.h.	=	0.56 km p.h.
30 000	r.p.m.		3.5 miles p.h.	=	5.56 km p.h.
90 000	r.p.m.		10.5 miles p.h.	=	16.68 km p.h.
150 000	r.p.m.		17.5 miles p.h.	=	27.8 km p.h.
200 000	r.p.m.		23.36 miles p.h.	=	37.68 km p.h.

This indicates that high speed instruments will be limited to small diameters, excluding discs, because the slightest desequilibration of weight at the periphery would result in a monstruous overstress of the bearings of the handpiece. Naturally, the technic of preparation is entirely different and training on the model previous to clinical experience is indispensable.

It is unlikely that high speed will eliminate low speed work because there are certain steps in operative work which still require low speed: Removal of deep caries, preparation of pits, channels, and pinholes, filling of root canals, preparation of root canals for post crowns, polishing, etc. However, the low speed engine will probably take the place of an accessory instrument to the high speed unit.

TURNING DIRECTION OF THE ABRASIVE INSTRUMENTS IN RELATIONS TO THE WORKING SURFACE OF THE MATERIAL

Two technics of grinding are known: In or against the direction of feed. For dental purposes the second technic (fig. 44b) is the safest, because if the grinding instrument should catch anywhere on the surface of the material—as it may happen when preparing interproximal surfaces or incisal angles—the instrument will have the tendency to "creep" into the already prepared area instead of "jumping" the obstacle it has caught. Thus grinding against direction of feed is such that the instrument is always guided from the safe area towards the danger zone: From the middle of the tooth towards the incisal, from the inside of a box preparation towards the margins, in areas near the gingival line from the body of the crown towards the gingivae. This is of course only possible with mounted grinding instruments, while instruments fastened with mandrels will unscrew when the drive is reversed.

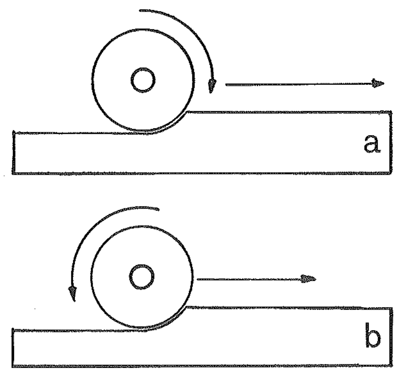


Fig. 44 a = grinding in the direction of feed. b = grinding against the direction of feed.

THE CUTTING OF DENTIN

Dentin, is a working material which can be cut, and not only abraded like enamel. "Revelation burs" are therefore still in use for cutting dentin. Various classical instruments are also used to prepare the retentive details of a preparation. However, the development in cavity preparation with high speed is eliminating any discrimination between the preparation of enamel and dentin, and the same instrument may be used for both. This means another step in the way of progress, simplification of instrumentation along with another reduction in operating time.

However, certain steps in the preparation of dentin are still preferably taken at lower speeds and with cutting instruments, because the grinding instruments can never reach the precision and slenderness of certain burs and drills used in cavity preparation. Dentin is, unlike dental enamel, a chipping substance like metal or wood.

Every cutting instrument has a blade consisting of two planes which meet at a certain angle, the *wedge angle* (fig. 45β). A wedge, in order to cut into a substance, must be placed at a certain angle to this substance in order to make the proper cut, this angle is called *angle of incidence* (fig. 46α). Each material which is to be cut, requires, according to its physical properties, its special wedge angle of the cutting instrument, and, for rotating instruments, a certain speed, in order to obtain proper cuts (fig. 45). When a blade starts to cut into a substance, it first compresses the body which offers a certain resistance. As soon as the compression surpasses the elasticity of the body, the two separating parts press against the surfaces of the blade (fig. 46).

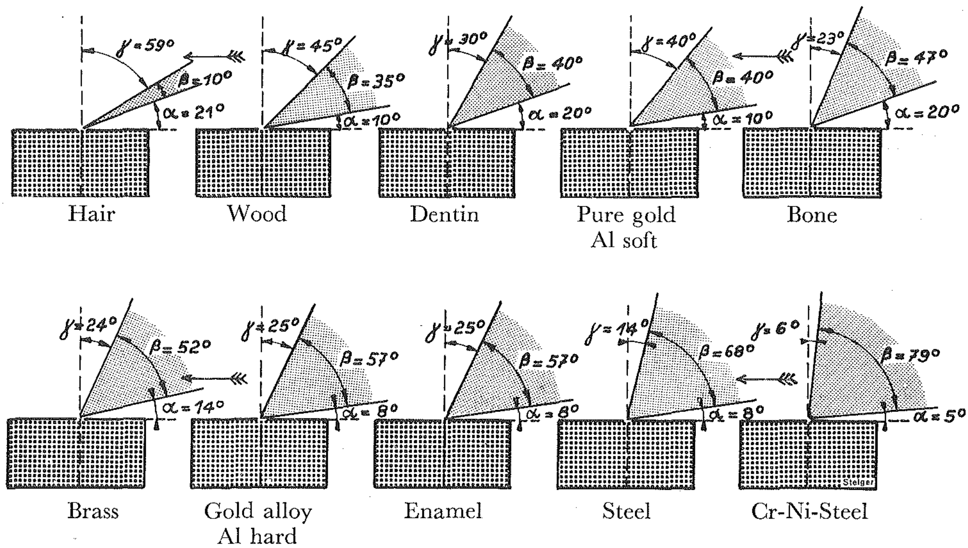


Fig. 45 Angle of incidence (α), wedge angle (β), and chip angle (γ) for different working materials

Hair	α	= 21°
	β	= 10°
	γ	= 59°
Wood	α	= 10°
	β	= 35°
	γ	= 45°
Dentin	α	= 20°
	β	= 40°
	γ	= 30°
Aluminum (soft)	α	= 10°
	β	= 40°
	γ	= 40°
Bone	α	= 20°
	β	= 47°
	γ	= 23°
Brass	α	= 14°
	β	= 52°
	γ	= 24°
Gold (Aluminum hard)	α	= 8°
	β	= 57°
	γ	= 25°
D.enamel	α	= 8°
	β	= 57°
	γ	= 25°
Steel	α	= 8°
	β	= 68°
	γ	= 14°
Cromium-Nickel-Steel	α	= 5°
	β	= 79°
	γ	= 6°

These angles apply of course to certain cutting instruments at certain speeds, and the list of angles for different materials should therefore be regarded as relative only, in order to understand that different materials require different angulation of the cutting tool.

As the blade progresses to separate the material, a shaving is detached over the *chip angle* of the instrument. Several such cutting instruments placed on a cylinder form the cutter. Since several blades are arranged one behind the other, the shavings must be guided to leave the periphery of the cutter. If the shaving hits another blade, it may obliterate the angle between the blades, and the cutting becomes inefficient. This necessitates a special profile of the front of a blade which in principle is an S-curve, and which helps to curve the shaving and to eject it (fig. 47).

The dental burs were constructed on the principles of the cutter, bearing in mind that the working process with a dental bur is slightly different than the cutting process on a bench. The bench fixes both cutter and working material in a rigid reciprocal position, and moves the material in a linear movement against the cutter. In dental work, neither the head of the patient is immobilized nor is the dental handpiece moved in a linear direction. Both partners of the process, material and cutter, are unstable. If a mechanical bench cutter were to be guided by hand, its blades would jump each time they would hit the material, because of the space between the blades. Dental burs therefore have a greater number of blades, and still, the "jumping" of the blades, viz. vibration is distinguishable. This vibration is especially pronounced in straight blade fissure burs, while fissure burs with helicoidal twist vibrate less. The explanation to this is simple. Imagine a slow motion picture of a bur with straight blades cutting into a dentin surface. Each blade starts to cut along its entire length at exactly the same moment which creates a shock, the next blade does the same, and the vibration is a function of the number of blades hitting the material per second. In the case of a bur with twisted blades, the top of the first blade starts to cut and as the cut runs down the first blade, the top of the second starts to cut. By the time the cut of the first blade has reached the bottom of the bur, the third blade has started to cut at the top. Thus most of the vibration from the cutting process is eliminated and a smooth and efficient cutting is the result of work with fissure burs with twisted blades (also called spiral fluted burs). The reason why approximately 80% of fissure burs purchased are straight fluted burs is probably that with straight cutting blades it is possible to cut better in the opposite direction than with twisted blades.

The design of burs still remains a very controversial subject, because angulation and profile of the blades vary with different speeds.

In the following illustrations on abutment preparations it is presumed that the carious defects have been removed, the measures for pulp protection taken and that the necessary lining of undermined cavity walls and for space unnecessary for retention has been applied. These are strictly operative measures, basic to any abutment preparations. In this preliminary preparation, chisels and spoons still offer invaluable service.

Healthy, undecayed teeth, or teeth with only small carious defects alone

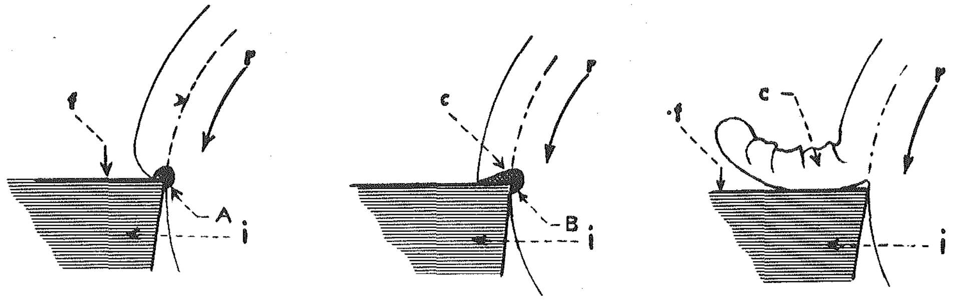


Fig. 46 Process of detachment of a chip by a cutting instrument

i instrument
f cutting plane
r direction of rotation of material
A entrance of cutting edge into material, zone of pressure
B separation of molecules as pressure builds up, formation of chip
C formation of chip

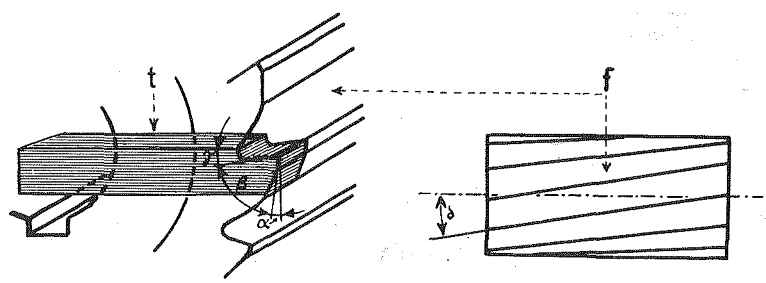


Fig. 47 Fundamental concept for the construction of a milling wheel with twisted edges.

t chisel as primary element
f milling cutter with twisted cutting edges
α angle of incidence
β cutting angle
γ chip angle
δ twist angle on a cutter

will permit to perform the classical preparations shown in the illustrations, while larger extension of decayed portions of the tooth will challenge the ability of the practitioner to obtain sufficient retention inspite of the loss of hard tissue. The foremost factor for the retentive quality of an abutment is the parallelity of preparation along with the length of the prepared tooth crown. While the beginner will always tend to obtain rather a conical than a parallel preparation, the skilled operator will try to approximate parallelism as nearly as possible. Apart from these basic requirements for a retentive preparation, there are several accessory factors which may help to increase retention: (a) Grooves, (b) pins, (c) locks.

Grooves

Grooves in a preparation prevent an abutment from removal in any other direction than that of insertion and removal. A mesial and a distal groove in a three-quarter crown preparation acts like an inverted dovetail preparation. Usually the grooves are prepared in excessive dimensions. The diameter of 0.7 mm which in this book is suggested as a standard measure for retentive pins, for frictional pins and for the corresponding instruments, may also be used for the retentive grooves in abutment preparation. Paradoxical as it may seem at first sight, a small groove is more retentive than a large one, under given circumstances (fig. 48). A cylinder which lies in a halfcylindric groove

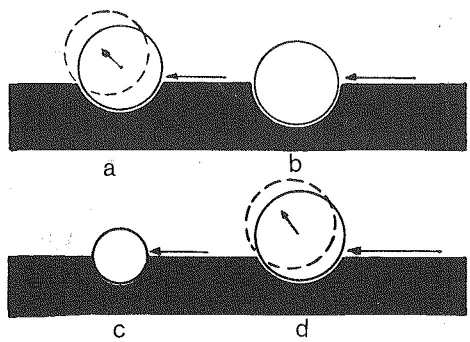


Fig. 48 A cylinder lying in a congruent groove with less than half its surface may be pushed out of the groove by horizontal forces (a), while if it lies in the groove with half or more of its diameter, it cannot be displaced horizontally (b).
Therefore, a small groove is more retentive than a large one, for the same depth of preparation (c, d).

may be pushed out of the groove by a horizontal force, if less than half the diameter of the cylinder lies in the groove. As soon as half (or more) of the cylinder lies within the groove, it cannot be pushed out by the same forces. Therefore, if we assume a given space of preparation, a thin groove will offer more retention than a thick one. The same principle applies for the sphere which in abutment or cavity preparations is represented by pits (fig. 52).

Pins

Retention by pins is a means of economizing with the hard tissues of the crown. Again, the size of 0.7 mm seems to be the optimal value between resistance of the material and size of the pinhole preparation. Pins may be used as the sole retention, as for pinledges, or combined with three-quarter crown or inlay preparations. Parallelism must be strictly observed, and the size of the pinholes must correspond to the size of the pins. Threaded pins offer still more retention than pins with smooth surface, because the cement locks in the thread. However, threaded pins break more easily if subjected to bending stresses.

Locks

A fixed abutment may be locked by a peg which is inserted through the casting and into the dentin of the crown in a direction which differs from the direction of insertion of the abutment. Most frequently, this direction will be at right angles to the direction of insertion. Another solution is to prepare a channel through the casting. On the tooth side of the casting, the channel runs half in the gold of the casting and half in the wall of the tooth, also transversally to the direction of insertion (see Fig. 55c). On very short preparations, increased retention is also obtained if fine grooves are cut transversally to the direction of insertion, into the inner walls of the casting before cementation. This locks the cement the same way as in threaded pins.

Instruments for Abutment Preparations

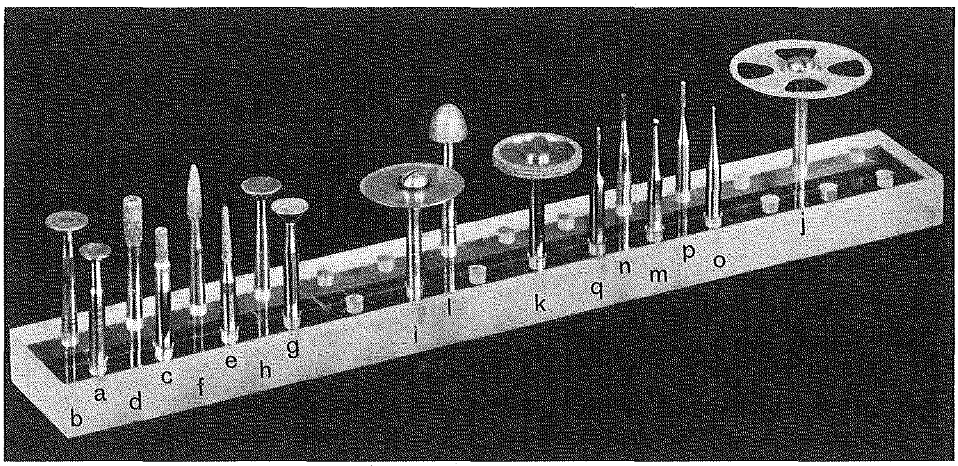


Fig. 49 Rotatory instruments.

a	= cutting wheel	∅ 6.5 mm	cutting width 0.5 mm
b	= cutting wheel	∅ 8.0 mm	cutting width 0.5 mm
c	= cylindric point	∅ 1.8 mm	
d	= cylindric point	∅ 2.5 mm	
e	= tapered cylinder	∅ from 1.5 to 1.2 mm	
f	= flame shaped point	∅ 1.5 mm	
g	= conical with cutting face	∅ 6 mm	
h	= conical with cutting coat	∅ 6 mm	
i	= disc (if possible perforated)	$\frac{3}{4}'$	
j	= disc (if possible perforated)	$\frac{7}{8}'$	
k	= grinding wheel	∅ 13 mm	
l	= barrel- or mushroom shaped point	∅ 6 mm	
m	= tungsten carbide bur round	∅ 1 mm	
n	= tungsten carbide bur fissure	∅ 1.5 mm	
o	= round bur	∅ 0.5 mm	
p	= "bout rond" (round end) fissure bur	∅ 0.7 mm	
q	= Spirec drill	∅ 0.7 mm	

The following procedures are intended as a general guide for those with average equipment. Provided that the end result is the same it is not suggested that newer equipment and technics and individual need should not modify the procedures.

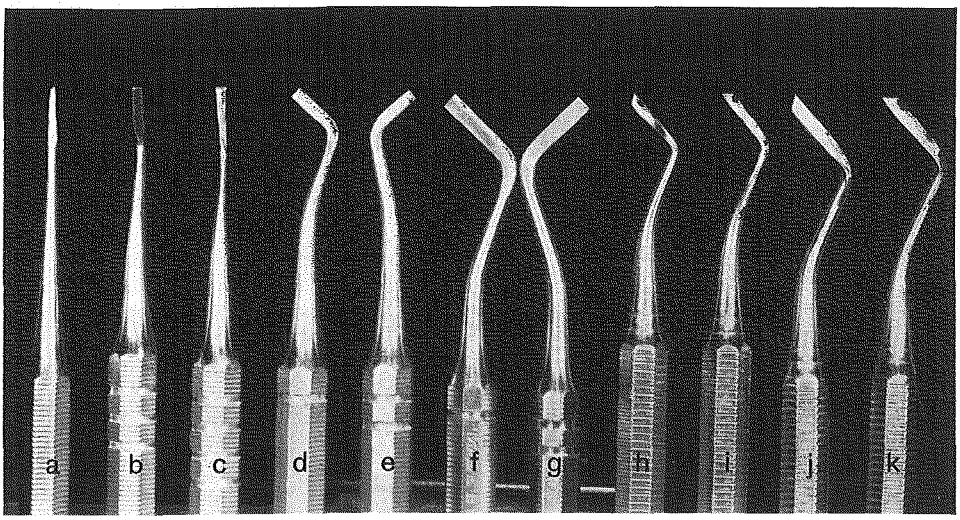


Fig. 50

a = chisel No. 12
b = chisel No. 12-6-49
c = chisel No. 12-6-6
d = hatchet No. 12-6-12 R
e = hatchet No. 12-6-12 L
f = hatchet No. 18-9-12 R
g = hatchet No. 18-9-12 L
h = margin trimmer No. 10(95)-6-12 R,L
i = margin trimmer No. 10(80)-6-12 R,L
j = margin trimmer No. 15(95)-9-12 R,L
k = margin trimmer No. 15(80)-9-12 R,L

Individual Cavity- and Abutment Preparations

Class A-Preparations:

No class A-preparations serve as abutment preparations.

Class B-Preparations:

Incisor and cuspid teeth:

(a) Dovetail and box preparation: Not used as abutment preparation.
(b) Unilateral pinledge preparation.

Bicuspids and molars:

mo and *od* preparations.

The unilateral pinledge preparation

This preparation has the great advantage over the conventional dovetail and box preparation, that a minimum of tooth substance is removed and a maximum of retention is given by the pins. Also, the direction of insertion may be chosen according to circumstances, while a dovetail preparation must more or less always be perpendicular to the labial wall of the tooth. For a single abutment, the desirable direction is one parallel to the labial wall of the crown. If the abutment is part of a splint or fixed bridge, small or large, the direction is dictated by the possible direction of insertion for all abutments in the splint or bridge. This direction will usually be in approximation to the axis of the teeth. Two unilateral pinledge preparations are shown in fig. 51.

Preparation: A small cutting wheel cuts a groove as closely behind the incisal edge of the tooth as possible (fig. 49a). The more the incisal portion of the tooth is slender, the more the groove must be carried into the body of the crown. A slice cut which should not appear on the labial surface of the crown but extends only towards the labiolingual "shadow line" (Conod) is performed or a box is cut, if previous fillings have been removed. The cylindric diamond point (fig. 49c) which cuts the box, also cuts the seats for the pinholes. The axial channel or channels are cut with the round end fissure bur (fig. 74a), in continuation of the occlusal groove. The whole center of the oral surface of the crown is then reduced with the barrel shaped diamond point (fig. 49 l). From cervical pinhole seat to occlusal pinhole seat, a groove is traced with the small diamond wheel (fig. 49a) in order to get sufficient thickness of the marginal casting. In the center of the pinhole seats, the pinholes are marked with the small round bur (fig. 49o) and drilled parallel to each other, parallel to the box and to the axial channels with the Spirec drill (fig. 49q and 74b, c). The preparation may include 2 or 3 pinholes and one or two channels.

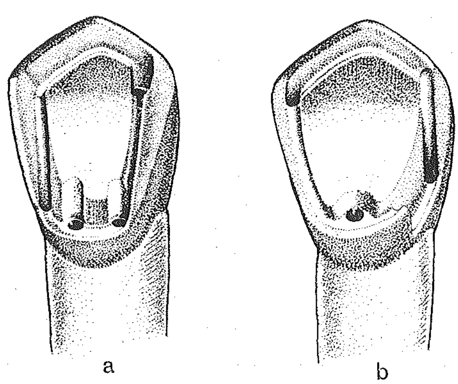


Fig. 51 Unilateral pinledge preparations
a = with three pins and one channel;
b = with two pins and a box with two channels.

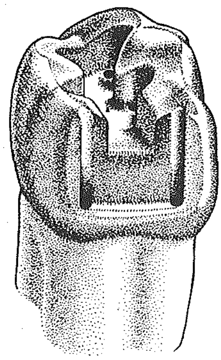


Fig. 52 *mo* preparation on a molar. Box preparation with two channels and hollow gingival step and with shallow pits in the occlusal floor of the preparation.

BICUSPID AND MOLAR PREPARATIONS

mo or *od* preparations (fig. 52)

Inside of either the mesial or distal marginal ridge, at the deepest point of the fissure, an axial hole is cut with a tungsten round bur (fig. 49m). The tungsten fissure bur (fig. 49n) cuts towards the buccal and oral side just short of the completion of the extension for prevention. Chisels (fig. 50a–c) remove the portion of enamel thus separated, and damage to the neighbouring crown is avoided. The cylindrical diamond point completes the box and cuts open the fissures destined to receive the retentive preparation. The round head fissure bur (fig. 74a) cuts two channels along the axio-labial and axio-lingual line angle and a channel inside of the margin of the gingival shoulder. The axial channels are slightly prolonged so that two pits on either side of the shoulder channel result. Margin trimmers (fig. 50h–k) shape the bevel of the gingival shoulder, sandpaper discs and fine stones smoothen and bevel all other margins. For increased retention pits or pinholes, not interfering with the pulp, may be prepared in the corners of the occlusal fissures.

Class C-Preparations:

Incisor and cuspid teeth:

Pinledge and three-quarter crown preparations without preparation of the incisal angle.

Bicuspids and molars:

mod-inlay preparations.

INCISOR AND CUSPID TEETH

The preparation is confined to the mesial, the distal and the lingual (palatal) surfaces of the crown. Thus, a pinledge or three-quarter crown without or with incisal coverage is distinguished by Class C or D. The newer concepts of preparation have fortunately abolished the hideous three-quarter crown which involves the peripheral parts of the labial surface, which would make it a class E-crown.

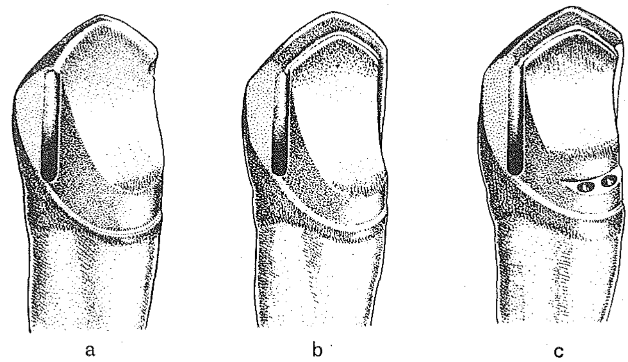


Fig. 53 Three-quarter crown preparations.
a = preparation with two axial grooves
b = two axial grooves with occlusal groove
c = axial and occlusal grooves with pin-ledge retention at the cervical step

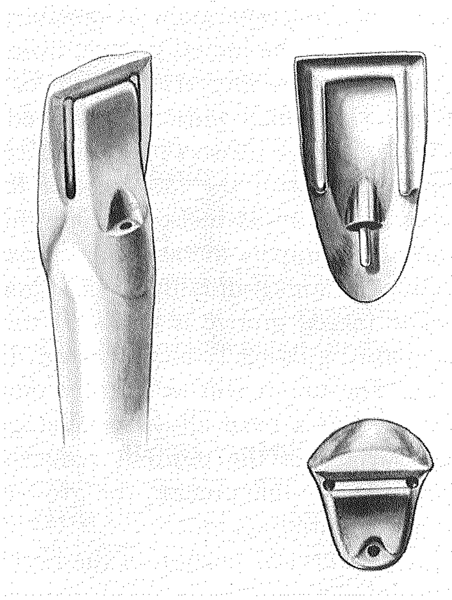


Fig. 54 Preparation and casting of a three-quarter crown with pin retention on a lower incisor tooth. This preparation gives maximum retention with a minimum of gold visible towards the labial.

The technic of preparation is basically the same for class C- and D-crowns, because the cutting of the incisal edge is just an additional final step to the preparation of a C-crown. Fig. 53 shows schematically the variable preparation of such abutments. The simplest design (a) shows two axial grooves, the next step to increase retention is the addition of a transversal groove and finally of a cervical ledge and pinhole (b, c).

A modification of the two axial grooves consists of two horizontal grooves which serve to lock the seated crown with two horizontal pins. Half of their diameter lies in the casting, while the other half lies in the body of the natural crown (fig. 55c).

Pinledge preparations (fig. 55a, b) may include three or four parallel pins. Two cervical pins instead of one may be of advantage in better avoidance of pulp neighbourhood. A hollow ledge or a sharp groove will increase the retention against separation towards the lingual side.

Preparation of the three-quarter crown

The first step is always to cut the incisal groove. The more a tooth is slender and its incisal wedge is thin, the finer this groove must be. Also, a thin incisal portion will force the operator to cut his groove where the bulky part of the crown begins. On teeth with a thicker incisal portion, the groove is cut as nearly behind the incisal edge as possible. On abraded teeth, as we often find them in the lower incisor region, the groove is cut on the incisal plane, where the dentin shows. The tendency must always be to obtain as much retentive height of the preparation as possible, and the retentive height is determined by the site of the incisal groove, from which the mesial and distal grooves are started. Another important factor for the location of the groove is the amount of material which must be removed from the lingual surface of the tooth. While on lower incisors it is not strictly necessary to remove a thickness which corresponds with the thickness of the casting, this will be most frequently necessary on upper incisors, where the occlusion of the lowers with the lingual wall of the uppers dictates the preparation. Sometimes, it will be possible to reduce the antagonists by a small amount.

The incisal groove is cut with the smallest diamond wheel (fig. 49a) by cautiously guiding it mesially and distally on the oral incline of the incisal edge. The depth will be slightly more than the anticipated thickness of the casting. For a hard alloy, an average thickness of 0.3 mm is sufficient. The oral surface of the tooth is reduced with a barrel shaped diamond point (fig. 49l). By this process, the groove may partly disappear and will have to be accentuated again.

In the cervical portion of the oral surface, a ledge is cut as a "sleeve" for the pinholes. For upper central incisors and cuspids, two pinholes are cut; for lateral and lower incisor, the small space will only allow one. The ledge is cut with the cylindrical diamond point (fig. 49c, d). The pinholes are marked with the small round bur (fig. 49o) and cut with the Spirec drill (fig. 74b, c).

Overhanging enamel portions above the gingival line are reduced with a tapered cylinder diamond point (fig. 49e). On adjacent incisors requiring preparation this lateral enamel reduction can be carried forward interproximally to the site of the lateral channels, but by no means further, since no gold is to show labially.

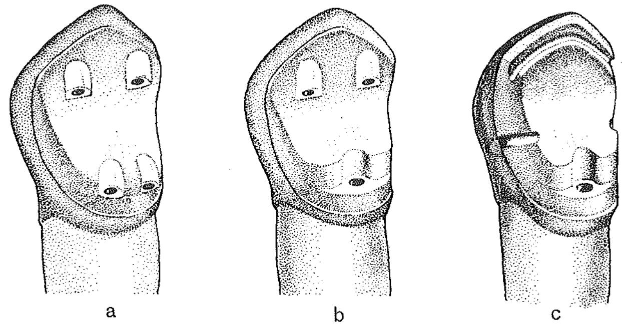


Fig. 55 Bilateral pinledge preparations, lock preparation.

a = pinledge with four pins;
b = pinledge with three pins;
c = three-quarter crown with occlusal groove, cervical pin and bilateral lock groove

The lateral grooves are cut with the round head fissure bur (fig. 74a). This is a delicate procedure and no attempt should be made to start the groove preparation with the bur held in an axial direction. The result would be that the bur would escape orally on one side and labially, which is still worse, on the other side of the tooth. The bur is therefore held at 45° angle to the incisal groove and thus finds guidance there. Gradually, the bur is tipped into an axial position. A guidance pin inserted into one of the pinholes gives the proper direction to be followed in the cutting of the axial grooves. The depth of the grooves will be a minimum of half the diameter of the bur, it is carried to the enamel-cementum line and terminates there in a pit which is cut by the head of the round head fissure bur.

For Class D-preparations, the incisal edge is tapered toward the oral side, and finally, the mesial and distal margins which, by the preparation of the grooves have right angles are tapered towards the labial in order to get the extension necessary for caries prevention. However, great care must be taken that this measure does not touch visible portions of the labial surface. The tapering of the mesial and distal margins can be done with steel discs which are very thin. A slight separation of the teeth for this measure may be advisable.

A modification of the above described preparation of the axial grooves is possible. When the enamel-dentin limit is established by the incisal groove, a 0.7 mm bur penetrates at this limit mesially and distally until it reappears at the gingival. With the tapered cylinder diamond instrument, the enamel coat is removed on the lateral walls until the depth of the above mentioned perforation is reached. This method avoids the difficulty of preparing a groove into the enamel surface.

The preparation should approximate parallelism as much as possible, because parallelism is the foremost factor in the retentive quality of an abutment preparation. Parallelism may be obtained by various devices permitting to guide the handpiece in the mouth, on the other hand, parallelism is obtained in free preparation by the skilled operator.

The preparation of pinledges on incisor and cuspid teeth.

Pinledges are most indicated on slender upper incisor and cuspid teeth, because their preparation involves the removal of only a minimum of tooth substance, just sufficient to allow for the proper thickness of cast metal. Teeth with large mesial or distal fillings are unsuited for pinledges, because they can be adequately prepared only if the pinholes can be sunk into healthy and unweakened dentin.

Preparation: First, the ledges are cut with the diamond wheel (fig. 49 a), one in the incisal third of the oral surface of the tooth, the other in the cervical region, just above of the largest convexity. The ledges are levelled off by the cylindric diamond point (fig. 49 d). At the chosen sites for the three or four pins, the same diamond point will cut the sleeves for the pinholes, and will remove the convexity of the cervical portion of the crown. The pinholes, in the center of the sleeves, are marked with the small round bur (fig. 49 o) and drilled with the 0.7 mm Spirec drill. The ideal direction of the pins is parallel to the labial surface of the tooth. However, a splint of several abutments may dictate another direction which will approximate the axial direction of the tooth. All pinholes should be drilled laterally or orally from the pulp chamber. The extent of the pulp chamber towards the mesial and distal can be accurately measured on the X-ray picture, while the dimensions towards the lingual must be guessed.

The final step of preparation is the cut on the mesial and distal, with the diamond disc (fig. 49 i, j) in order to remove undercut portions of the mesial and distal enamel. This cut should not show anywhere labially, it will only allow for soldering contact of the adjacent abutments.

BICUSPIDS AND MOLARS

On bicuspids and molars, the only three-surface preparation used for abutments is the *mod* preparation. The technic for this preparation is the same as for the already described Class B (*mo*, *od*) preparations (fig. 56 a).

Class D-Preparations:

Incisor and cuspid teeth:
Three-quarter crowns and pinledges with incisal coverage.

Bicuspids and molars:
Three-quarter crowns involving four crown surfaces.

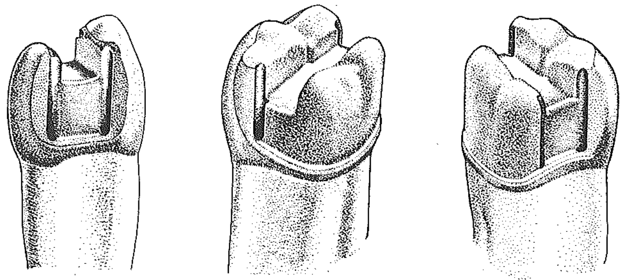


Fig. 56 a = *mod*-preparation on a bicuspid. Box preparation with channels and hollow, bevelled gingival step. The channels terminate in a shallow pit on the gingival step. b, c = three-quarter crown-preparation on a molar. On one side a single channel terminating gingivally with a pit, on the other side, box preparation with two channels with pits and hollow, bevelled step.

INCISOR AND CUSPID TEETH

The preparation of Class C-three-quarter crowns and pinledges have already been described. The only supplementary step to make a Class D-preparation is to cut, preferably with a diamond disc, the incisal edge at an angle of 45° towards the oral side. Mesially and distally, the cuts are prolonged towards the mesial and distal incisal angle, but still "in the shadow" of the mesio- and distolabial angle, so the cut, and later on the abutment casting, is invisible in the labial aspect. The mesial and distal incisal angles are orally rounded off with sandpaper discs.

BICUSPIDS AND MOLARS

The preparation begins with a cutting wheel which works along the mesio-distal main fissure of the crown, and to the depth of the dentin-enamel junction or slightly deeper. With a larger grinding wheel (fig. 49k) and the cylindric point (fig. 49d) the lingual cusps and the lingual incline of the buccal cusps are reduced by the thickness required for the casting. On the mesial and the distal of the crown, the box is cut similarly to the box of an inlay, as described earlier. On a healthy undecayed tooth, this box may be substituted by a small shoulder, cut with a diamond disc (fig. 49i, j) and the cylindric diamond point (fig. 49c), and an axial channel each on the mesial and the distal surface, cut with the round end fissure bur. The channel ends in the shoulder with a pit. The oral surface of the crown is then reduced with the cylindric diamond point, the linguo-mesial and linguo-distal angles with the conical diamond instrument (fig. 49g, h). The mesio- and distobuccal angles are shaped with diamond- and sandpaper discs (fig. 49i, j, v). The gingivo-lingual margin may be formed by a shoulder or simply a shallow rabbet. Both shoulder or rabbet allow for sufficient thickness of the marginal gold of the casting.

With the platinum band technic (see p. 109) neither shoulder nor rabbet are necessary, because platinum remains resistant even in featherend thickness.

For increased retention, especially on short teeth, pinholes may be prepared into the region of the buccal cusps. These pinholes, again provided with a sleeve, should be placed as far mesially and distally as possible, in order to avoid pulp damage.

Slice and slot preparations for abutment constructions are not recommended, because their retentive value is inferior to that of box preparations. Moreover, slice preparations often remove an unnecessary amount of tooth substance, especially in the buccal region. It is indicated only where the inclination of the crown axis (f.inst. tipped second lower molars) would make a box preparation difficult.

Class E-Preparations:

Incisor and cuspid teeth:

The gold veneer crown in its numerous variations, with labial porcelain or acrylic veneer.

The thimble crown, as a basis for porcelain or acrylic jacket crowns.

Biscuspids and molars:

The full crown.

The full crown with porcelain or acrylic veneer.

INCISOR AND CUSPID TEETH

The veneer crown used as a bridge- or splint abutment may be prepared with or without a labial shoulder. First, the incisal enamel is reduced with the wheel (fig. 49k), after which with the same instrument, the labial enamel is removed. With diamond discs, the mesial and distal enamel portion is removed, the barrel shaped diamond (fig. 49l) grinds away the lingual portion of the enamel. The cylindric diamond point removes the angles of the preparation and the gingival enamel, aided by the conical cutters (fig. 49g, h) and the remainder of the enamel may be removed with a sharp scaler. If a gingival shoulder is desired, it is cut with the cylindric diamond point and finished with chisels.

On short teeth or teeth with a round cross section, two lateral grooves cut with the round end fissure bur (fig. 74a) will increase the retention and unmistakeable seat of the casting.

For the thimble crown, the preparation is the same, only the construction will differ, because it serves to build full porcelain or acrylic veneer crowns, while the gold veneer crown only has a labial porcelain or acrylic veneer.

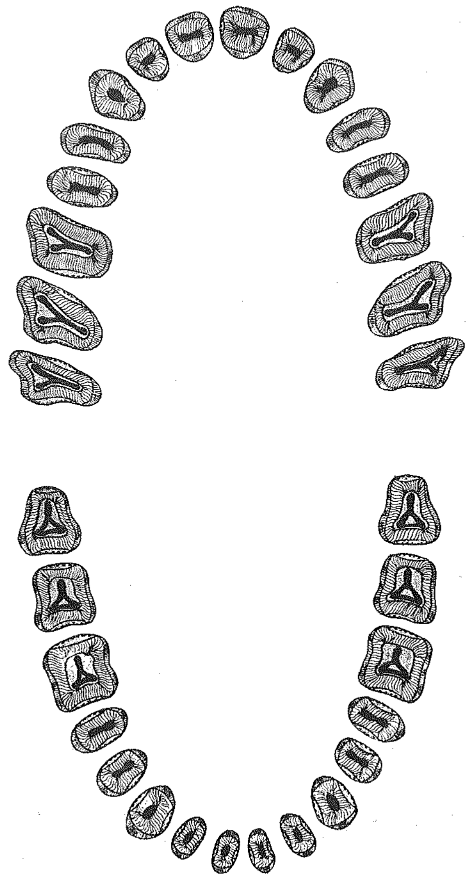


Fig. 57 Cross sections of a set of human teeth at the gingival plane (from: S. TYLMAN: Crown and bridge prosthesis, 2nd ed).

Naturally, the bite will determine how much more of the lingual tooth substance must be removed, if in addition to the thimble casting, a thickness of porcelain or acrylic is required.

BICUSPIDS AND MOLARS

Usually full gold crowns are admissible aesthetically on molars, while a labial veneer is often desirable on bicuspids. The knowledge of the various cross sections of bicuspid and molar teeth in the cervical region is a basis for good abutment preparation of crowns (fig. 57). The basic knowledge of the average contour will determine proper cuts, and once the main cuts are made, the individual variations of contour are distinguishable. The depth of height of crown preparations depends on the height of the gingival line. While in a young individual the preparation may not have to go to the enamel-cementum limit, elongated teeth with denuded cementum may require a greater length of crown. With well fitting crowns, however, it will not always be necessary to cover all the tooth substance above the gingival line, especially not if the root bifurcations are already visible. Some authorities on the subject even

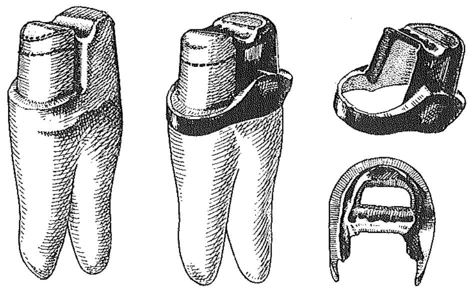


Fig. 58 Jacket crown preparation for an abutment tooth (bicuspid). The casting represents a modified thimble open towards the buccal surface. The advantage over full coverage is the absence of gold towards the buccal with sufficient retention by the two approximal and the occlusal grooves. The subgingival buccal part of the band is removed after the porcelain crown is finished and the slight porcelain excess is rounded off and glazed. Thus the porcelain crown meets on the buccal side with the natural tooth as in a conventional jacket crown preparation, while on the $\frac{3}{4}$ of the circumference the shoulder is formed by the casting. The dotted line indicates a variation for extent the casting.

claim that in most cases, the margins of a crown may be above the gingival line. It seems, however, that with individuals of low caries resistance, at least an attempt towards covering most of the tooth tissue above the gingival line should be made.

Preparation of a full crown

The grinding wheel reduces the cusps to dentin depth (fig. 49k) and then removes the enamel on the buccal and lingual surfaces. If necessary, the teeth are slightly separated in order to make the mesial and distal slices with the diamond discs (fig. 49i, j). The angles of the preparation are removed with the cylindric and slightly tapered diamond point and with the conical points (fig. 49d, g, h). The cylindric point then fashions the occlusal pattern and round off the angles around the occlusal surface. Also, the cylindric point will grind the recesses necessary on the mesial, distal or buccal sides, dictated by the morphology of the cervical region. Last, the surfaces are scaled and polished with sandpaper discs.

If a buccal porcelain or plastic veneer is desired, the buccal wall must be reduced more, and especially gingivally where the preparation should terminate in a shallow rabbet just above the gingival attachment. Thus, a shoulder can be built in gold which is concealed partly or totally by the gingivae.

Class F-Preparations, on non-vital, crownless teeth:

Incisor, cuspid and bicuspid teeth:

Post crown preparations.

Molar teeth:

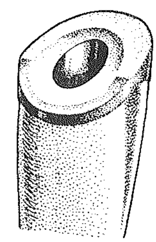
Anchorage of a cast or amalgam core.

INCISOR, CUSPID AND BICUSPID TEETH

The principle for the three categories of teeth is the same. Root canal work should preceed the final preparation, because rubberdam is difficult to apply on teeth prepared to receive post crowns.

With the grinding wheel, the crown or what is left of it is reduced to the height of the interproximal gingival papillae. With root facers, the remainder of the protruding material is reduced and two planes are cut, a plane at right angles, and lingually to the root canal, and an inclined plane from the root canal to the gingival margin. Mesial and distal sides of the root stump are freed of undercut areas with diamond discs, while the labial (buccal) and lingual undercuts are removed with the conical diamond points (fig. 49 g) and scalers. The labial (buccal) incline of the root surface should then be hollowed out with a large round bur or spherical diamond point. Thus, the porcelain facing and the gold or platinum base of the crown rests approximately at right angles on the buccal portion of the root and the dangers connected with an excessively pointed gingival angle of the facing is reduced (fig. 59).

Fig. 59 Post crown preparation.



MOLAR TEETH

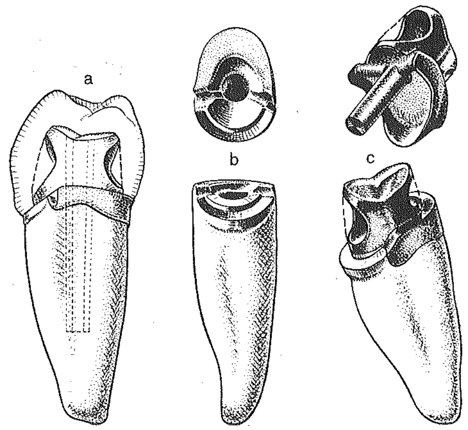
Restoration of crownless molar teeth belongs into the category of operative measures to restore the teeth for crown preparations. It is relatively seldom that post crowns are made for molar teeth. Usually they are built up by anchoring an amalgam restoration on screws, posts or tubes cemented into one or more root canals. The use of tubes may be welcome if access to the root canal at a later date seems desirable. The amalgam core is prepared to receive a crown just as if it were a vital tooth.

Fig. 60 Post crown preparation of a devitalized bicuspid as an abutment with acrylic or porcelain jacket crown.

a = the profile of the construction. For acrylic crowns, the core is hollowed out, while for porcelain crowns (dotted line) it is left massive or filled out with acrylic

b = preparation, with lateral grooves and buccal shoulder

c = the casting, hollowed out, or dotted line, massive. The soldering area corresponds with the reenforcement of the casting produced by the lateral grooves in the preparation
In principle the form is similar to that of the core shown in fig. 59.



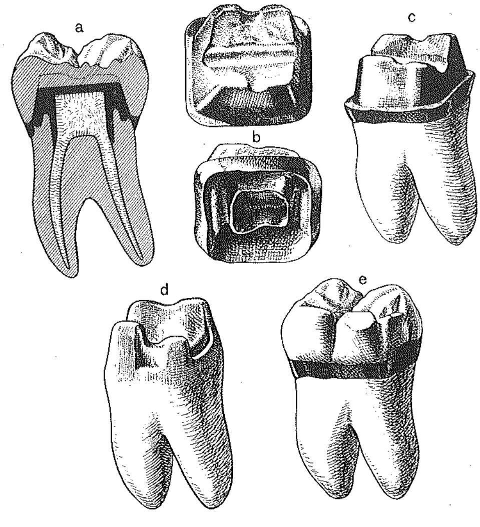


Fig. 61

a = cross section through devitalized molar with internal casting as matrix for jacket crown

b = casting

c = casting on tooth

d = abutment preparation

e = completed crown

Fig. 61 shows a variation to the above method, if a full veneer crown seems desirable. A casting is made over the remainder of the crown which is prepared shoulderless, and the shoulder and core is rebuilt in the casting. The interproximal part of the casting may be used as soldering surface for a bridge.

STUDY MODELS

For extensive reconstruction and in particular for CSP work, it is indispensable to have study models even before starting abutment preparation in the mouth. These study models should be accurate, with impressions taken by alginate, hydrocolloid or rubber materials in order to give a true picture of the details. A bad and distorted study model does not permit proper planning. After the establishment of the clinical picture of a case, aided by X-rays, intraoral examination and history of the patient, the necessary extractions will be decided on, root canal therapy will be given and the necessary abutment preparations planned according to design and purpose of the bridge or denture (page 175). Only when the dentist has reached a complete judgement of his case should he consult with his mechanic about the technical details. Consult he must, because his clinical and prognostic judgement must now help the technically skilled mechanic to find the optimal solution for his case. Often a tentative abutment preparation on the study models may eliminate any doubts about the practicability of one or the other design of a CSP attachment. It must never be forgotten that, however, skilled a mechanic may be, he must be allowed sufficient space to construct his attachments, otherwise his work will look bulky or it will fail to be strong enough.

Advice for planning a case will be found in Chapter IV, because the reader will wish to familiarize himself first with the technic before attempting to start planning.

MISCELLANEOUS INSTRUMENTS FOR CSP TECHNIC

The variety of dentists and the variety of patients are daily transforming the knowledge the practitioner has acquired from his university. This change is to the better or to the worse, according to the character and aptitude of the operator and to the personal attitude of each patient. The practice of dentistry does not follow too many strict formulas, but rather a chain of developments in medical and technical sciences. From these developments which we call progress, each practitioner profits according to his own interpretation and he thus forms his own methods of therapy. This explains the boundless variety of materials and instruments, of laboratory and office equipment, which often confuses the dentist who must choose the products best suited for his work. For the choice of instruments, a certain amount of basic engineering knowledge is indispensable; otherwise, the instruments are being chosen and used indiscriminately, without knowing their proper function, or whether they are efficient or inefficient in this function.

The instruments described in the following pages are all in some way or other connected with the technic of CSP attachments described in this book, and are therefore a specialized set, but most of them will be found useful also in the unspecialized daily work, or in other technics of the same branch of prosthetics.

INSTRUMENTS USED IN OPERATIVE PROCEDURES

Set of instruments described in the chapter on abutment preparation (fig. 49, 50)
Root facers
Circular saws (also for laboratory use)

INSTRUMENTS USED IN LABORATORY WORK

Measuring instruments: Wire gauge and calipers.

Burs and drills

the Helix wax bur
the Spirec drill
the round head fissure bur
the hollow cutter
the trepan bur
straight cutters
threading instruments

Root Facers

Root facers are instruments with cutting edges on the frontal face and a central trunnion in its axis (fig. 62). They were first described by OTTOLENGUI, BUTTNER, W. HERN a.o. and they serve to reduce the root stumps of teeth with one root. Two kinds are distinguishable, one type which also cuts on the periphery, and the other with only the frontal cutting surface. The former may be used if a ledge for a casting is to be prepared in the center of the root surface, around the root canal. The second type is liable to lacerate the surrounding gingival tissue, if the cutting edges reach to the periphery. Many years ago, such facers were made with a blunt peripheral margin. These facers are at the present used again, because they push the gingiva aside during preparation and do not damage it. The trunnion in the center serves as a guide and prevents slipping into the gingival tissue. It must be slender if it is to be used on teeth with not unduly enlarged canals. A mistake observed in all facers is that they have straight cutting blades instead of curved ones and thus have no proper cutting flow. The corners between the blades fill up with material and make the instrument inefficient after a short time. Moreover, the instrument should be free of blades in the center where the latter are inefficient and the spaces between them quickly filled up with shavings.

Technic: After the root canal has been filled, the root stump is reduced with a grinding wheel to the height of the interproximal gingival papilla. With the appropriate size root facer, the surface is given the classical shape for post crowns. However, this classical shape is strictly speaking incorrect

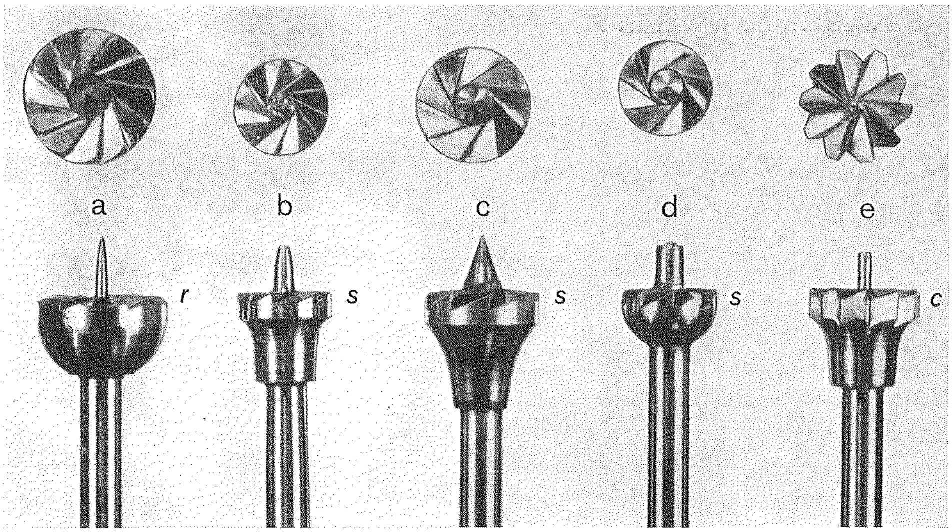


Fig. 62 Root facers: a = best design, with thin trunnion and non cutting center, the cutting edges are rounded off at the periphery; b, c, d = root facers with sharp peripheral cutting edges and partly excessively large trunnions; e = root facer with cutting side wall for root center preparations.

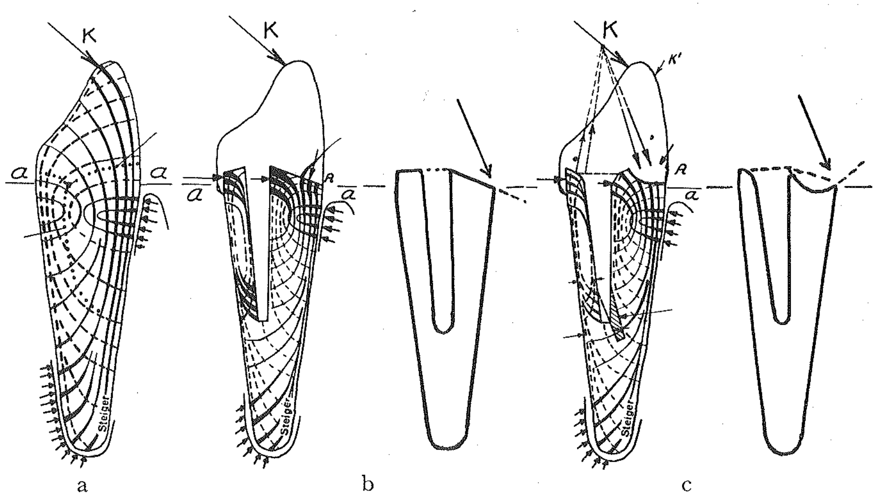


Fig. 63

a = Cut through an upper incisor with pressure trajectories (K, full lines) and traction trajectories (dotted lines).

b = The classical form of root preparation for a post crown with porcelain facing. The diagram shows that pressure and trajectories meet on an oblique plane.

c = Modification of preparation labially from the canal. The stress from the facing is directed onto base and labial surface of the root at right angles.

insomuch as the porcelain facing thus meets the cast base at a sharp instead of a right angle. The labial or buccal incline should be hollowed out, so the pressure trajectories will meet the base at a right angle (fig. 63). This is obtained by hollowing out the labial portion of the root surface with a spherical stone or a large round bur.

The Circular Saw

The circular saw is a cutting instrument (fig. 64). Its cutting head consists of a miniature steel disc with parallel walls, standing at right angles to the shaft. Its periphery carries fine acute angled teeth with straight cutting edges. Unfortunately the miniature size does not allow to produce the saw with teeth alternately bent outward or with cross cut blades. This is what makes them comparatively dangerous for use in the mouth. A saw with straight teeth is likely to jam against the walls of the cut when shavings wedge themselves between blade and working material. This either stops the instrument or, worse, lets it jump out of the cut.

Use of the circular saw: (a) in operative procedures: The saw may be used to cut crowns which have to be removed. Since the instrument only cuts when turning clockwise, care must be taken that the cut is always made from the occlusal toward the gingival, on the *left side* of the tooth—as seen from the operator—for mandibular crowns, on the right side for maxillary crowns. Thus the saw, should it jam, and jump out of the cut, will jump towards the occlusal instead of into the gingivae. Another purpose is the cutting of very slender incisal grooves, for instance in lower incisor teeth; (b) in technical procedures: Smallest bubbles in a casting, especially if they are located behind a ridge of the casting, may be removed with the saw. To increase retention of an abutment casting before cementation, the inner walls may be provided with smallest horizontal grooves which offer increased retention to the cement. In CSP attachment work, especially when constructing a CSP attachment on an abutment from a direct impression (see p. 130) the grooves are started by hand with a circular saw, so the fissure bur mounted in the parallelometer will more readily bite into the gold surface. The screwhead slots of a small screw can be cut with the saw.

When working in the mouth, the saw should always be well irrigated, while during laboratory work on gold, a lubricant (castor oil or eucalyptus oil) should be used.

Face Cutting Instruments

Face-cutting cutters or diamond grinders should not cut in the center (fig. 65). The very center of the instrument does not cut at all, because it only pivots on the same spot. The region immediately adjacent to the center

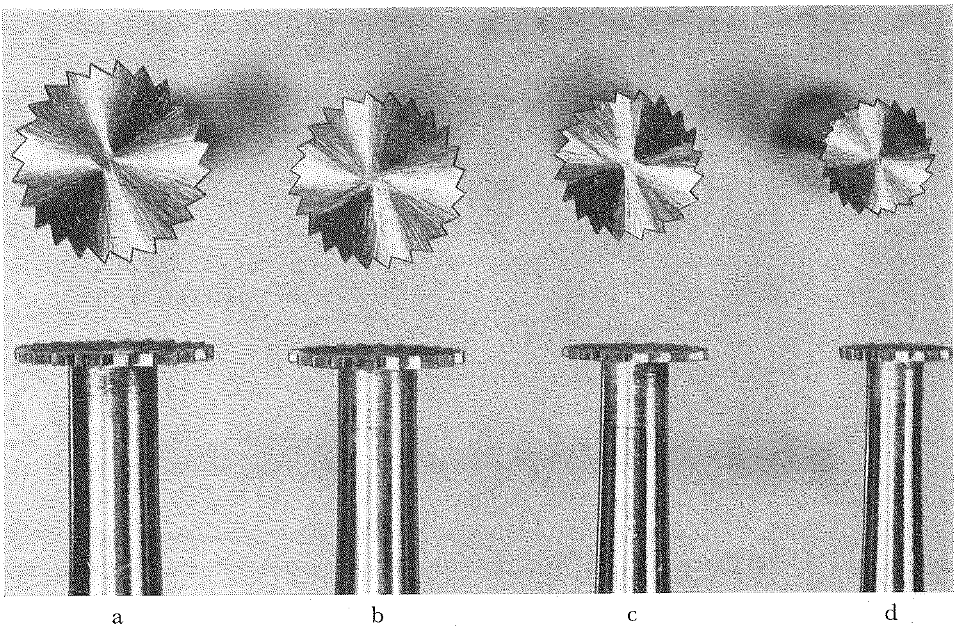


Fig. 64 Circular saw, different sizes.

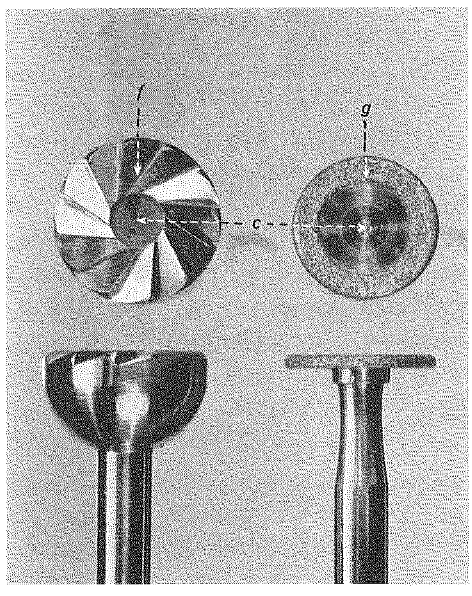


Fig. 65 Two examples of face cutters.

f ring shaped cutter face
g ring shaped grinder face
c free center

cuts very little, because the grinding surface travels around the center on a small radius and therefore travels a small way. The best cutting efficiency is at the periphery. Thus, with no cutting efficiency in the center and maximum efficiency on the periphery, the instrument will rotate on a dead center of unreduced substance which can only be removed by shifting the instrument and approximating peripheral portions to the uncut area. Therefore, face cutters should have a non cutting center portion which does not reach the level of the substance to be cut. This increases the efficiency of the instrument, and the movement of it on the working surface of the material is easier.

Measuring Instruments

Calipers (fig. 66a). Calipers are used in order to measure the thickness of a material. A slide gauge may only be used if the material is plane or convex. If it is concave, the slide gauge will not measure it. Calipers, also called "Dixième" allow to measure the thickness of a crown because the curved grabs reach into the concavity of the crown. The measured distance is enlarged ten times on the scale, so that one tenth of a millimeter may be read as one millimeter. This instrument is most valuable in CSP attachment work, because it permits to reduce the matrix to a minimum of bulk. In ordinary bridgework, it is handy to measure the occlusal thickness of crowns, especially if, after trying a crown in, the occlusion and articulation requires a certain amount of grinding. Very often, a perforation may be avoided by soldering the necessary thickness of gold to the inside of the crown before grinding a perforation.

Wire gauge. A wire gauge is necessary for all work where pins must correspond with the preparation of pinholes, or, where an exact measure of a wire is important to the purpose it will fulfil. In precision work, one fiftieth of a millimeter may be the criterion between fit and misfit. Therefore, a wire used for pinledge or CSP work must be checked for its required gauge, because it does happen that the tolerance of precision of the manufacturer is subject to errors. The wire gauge shown in fig. 66b measures wires of diameters from 52 to 126 hundredth millimeter, with two hundredth of a millimeter difference from one hole of the gauge to the other.

The Helix Wax Bur

Many a decade has elapsed since SOLBRIG, JAMESON and TAGGART have tried to obtain satisfactory cast replica of a wax pattern by the method of "cire perdue" (lost wax). The untiring work of scientists has meanwhile eliminated many sources of mistakes by proper investing and casting technics, but it took considerable time until the natural state of aggregation of the different materials involved and at different temperatures was recognized. With physical properties

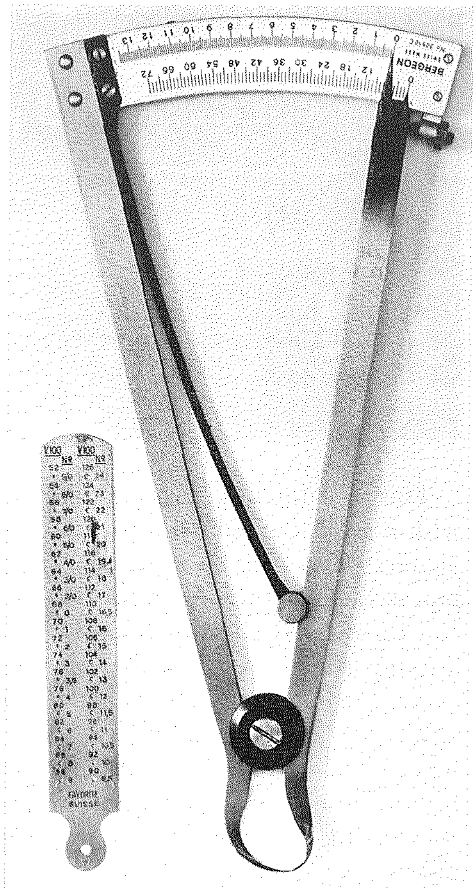


Fig. 66 Left: wire gauge for wires of 52 to 90 hundredth of a millimeter ∅. Right: "Dixième", also called calipers, to measure the thickness of a casting.

of each material changing at different temperatures, the technical sciences were to find the proper waxes, investments and alloys in which the properties were reciprocally tuned in such a manner that the casting was in fact a replica of the wax pattern. Even to date research is still working on the improvement of casting technics.

An important source of mistakes is the change of volume of the casting material during it's change from liquid to solid state of aggregation, and from the point of solidification to room temperature. Experience showed that this mistake can be considerably reduced by reducing the volume of the body to be cast. This knowledge therefore requires that the patterns be of thin walls with appropriate reenforcement ledges (see p. 77). Adequately reenforced hollow bodies have proven to be just as resistant as massive clumps of metal, a fact proven thousandfold in all branches of technical sciences, in particular in airplane and ship building. With the reduction of mass in a gold casting not only is there a considerable economy of gold, but the vital tooth benefits from it by improved pulp protection against thermal irritation.

Preceding the Helix wax bur, the process of wax reduction was effectuated by sharp spoons of small size, a most delicate procedure. F. E. ROACH invented an ingenious instrument: The Suction Wax Carver (fig. 67).

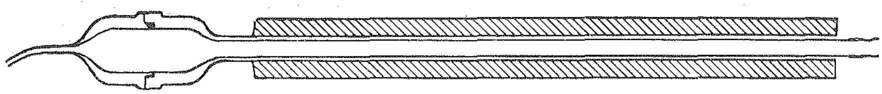


Fig. 67 Roach's suction wax carver.

This instrument consists of a hollow copper bulb which is fitted on one side with a small curved cannula, on the other side with a thicker tube, insulated against heat. This tube which serves as a handle, is connected to a rubber pipe which in turn fits a suction pump or a mouthpiece. The copper bulb can be screwed apart, is filled with cotton and closed again. It is heated over a flame until blowing or suction produces smoke. With the tip of the curved cannula against the wax and simultaneous suction, the wax is liquefied on a small area and sucked back into the cotton. The walls of the casting can thus be reduced to a thickness of 0.5 to 0.3 mm (from: H. W. C. BOEDECKER: Das Metalleinlageverfahren, Meusser, Berlin 1909). The danger in the use of this instrument lies in overheating the wax and in wax lesions adjacent to the desired places of reduction.

The Helix wax bur (fig. 68) eliminates such a danger because no heat is produced. The shape of this bur as the name indicates is similar to a ships screw. The spoonlike cutting wings with the projecting cutting angles are placed at an angle of 50° to the bur shaft. They pass into the shaft with an open groove. This facilitates the removal of the wax shavings. The most important parts of the bur are the cutting edges which have a cutting angle of 30° (see fig. 46 on the cutting angles for different materials). On the slightest touch of the rotating bur on the wax surface, and without heat production the wax shavings fly off and no clogging occurs. The bur does not escape laterally, because of the conic recess between the two blades. This recess always forms a little cone in the wax which guides the instrument.

The wax pattern is removed from the tooth or model with a V-shaped sprue. The double sprue protects the pattern from distortion. The pattern is mounted on the crucible former and is ready to be hollowed out. The parts which must not be touched by the reducing process are: All marginal portions of the pattern, all the inner surfaces serving as anchorage (fig. 69, 70). The remaining portions may be reduced to a thickness of 0.5 mm except where

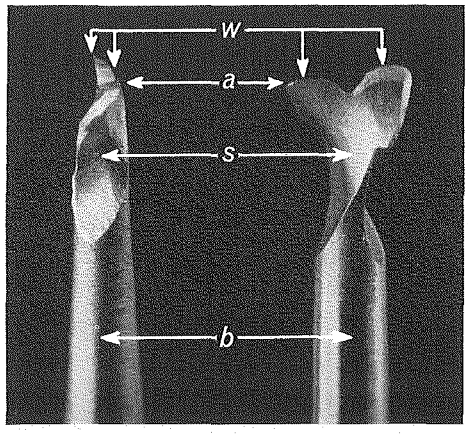


Fig. 68 The Helix wax bur.
w spoonlike wings
a cutting angles
s chip-slots
b bur shaft

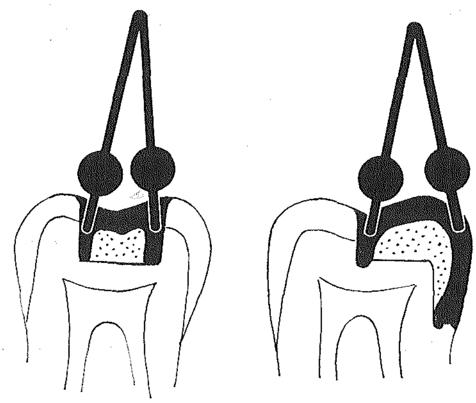


Fig. 69 Hollow wax patterns with sprues. Note the location of sprues.

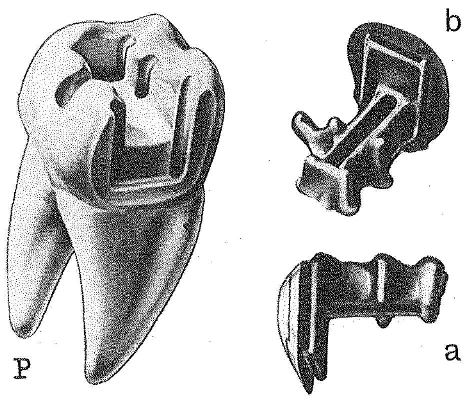


Fig. 70 *mo*-inlay, hollowed out by the Helix-technic. The pattern shows how only the unimportant bulk of the wax has been removed, while all portions important for marginal fit and all retentional elements of the pattern surface are left intact. The inlay contains a CSP attachment as shown in fig. 6.

heavy abrasion must be anticipated. In blue or green casting wax a definite transparency on transmitted light is noticeable.

Further use of the Helix bur is found in the wax reduction on Richmond crowns and pontics with their sometimes considerable volume, especially on bicuspid teeth (fig. 72). Pontics with platinum-pin porcelain facings are reduced from the labial side, leaving the portion with the pinholes and all margins and retention walls intact. Pontics with Steele's facings may be hollowed out completely, because the backing of the facing is soldered to the casting. The casting investment thus penetrates into the hollowed out spaces.

Another technic for platinum long pin facings has been described by Corrodi (Cobe-System). The whole body of the pattern is hollowed out. A tube is placed over each pin of the facing. This tube touches the inner surface of the facing while on the other end, it is pointed and serrated (fig. 73). After heating the serrated ends, the facing is placed into the correct position in the wax pattern, while the heated ends of the tubes penetrate into and through the back wall of the pattern. There they are properly sealed, the facing is removed and the pattern is ready for casting. The tubes, cast into the back wall of the crown or pontic thus entirely replace the pinholes of a massive casting.

Full gold pontics are hollowed out from the interproximal surfaces. Such full gold pontics, just as pontics or post crowns with Steele's backings, present a special problem in the soldering process. If a hollow body of a casting is closed by soldering, the air inside of this body considerably expands in high temperatures. After cooling, it contracts again. This force of contraction can be of such an extent that strong walls or backings may show deformations. Also, this phenomenon may render the soldering process most difficult and may prevent a hermetic seal. It is advisable therefore, to create a small opening as an air vent. This opening may be in the backing and will be closed by cementation of the facing, or, for gold pontics, in the lingual wall, closed by a conical peg or a small screw.

Screwholes and screws can be made in very short working time with the proper equipment. Fig. 80 shows an assortment of screw and screwhole threaders which find the most various use: (1) Screws for the above mentioned purpose of an air vent; (2) screws for fixed-removable bridgework; (3) screws for repairs of large fixed bridges or splints, where abutment teeth or roots have to be removed and replaced by pontics.

The dimension used most currently is 1 mm ∅. First, the screw is made by threading a 1 mm wire. Then the screwhole is started with a 0.8 mm bore. The screwhole threaders of each size are assorted in 3 sizes for depth of cut. First, the small size is used. If the screw fits too tightly, the next size follows and cuts the thread a slight bit deeper, until the screw enters the screwhole with still a certain amount of resistance.

Both screw and screwhole threaders have their holders. When threading a wire, it should be fastened in a vise which, however, must not deform or scratch it. The end of the wire must be well rounded (hollow cutter, fig. 76). The proper length of screw is cut off with a small saw and levelled with a disc. The screw slot is cut with a circular saw (fig. 64) or a small handsaw. Always, a screwdriver of proper size should be used in order not to foul the slots.

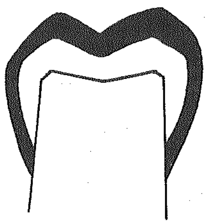


Fig. 71 Cross section of a molar crown where the cusps have been hollowed out.

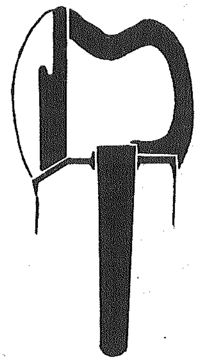


Fig. 72 Cross section through a Richmond crown with Steele's facing and hollowed out body of the crown.

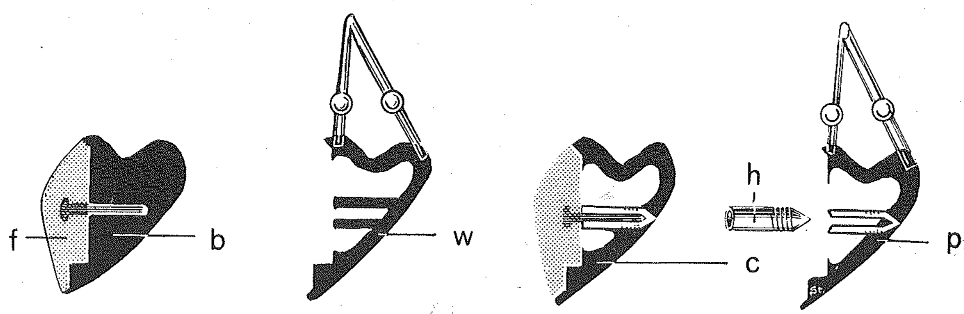


Fig. 73 Cobe-System for platinum long pin facings. Left: Conventional casting of pontic with facing; the whole bulk of wax is cast. Left centre: Reduction of bulk with Helix wax bur, leaving a sheath for the pins. Right centre: Placement of Cobe tubes over the pins and into the wax pattern. Right: Cobe tube and pattern ready for investment. *f* facing; *b* bulk of wax; *w* wall thickness necessary; *c* Cobe tube sunk into the wall; *h* cobe tube; *p* pattern with cobe tube ready for investing.

The Helix wax bur comes in three sizes, the small size for reducing inlays, the larger sizes for crowns or pontics.

The advantages are: Reduction of casting shrinkage, pulp protection, and considerable gold economy.

The Round Head Fissure Bur

The round head fissure bur (fig. 74a) combines a straight head fissure bur and a round bur. It has cross cut blades with a helicoidal twist. For operative procedures, it is being used to cut the channels and pits of box preparations for inlays (see p. 58) and to round off the corners of an angled preparation. In laboratory work, the 0.7 mm ⌀ size is used to drill channels of a CSP attachment matrix which was obtained by the direct impression method (see p. 130).

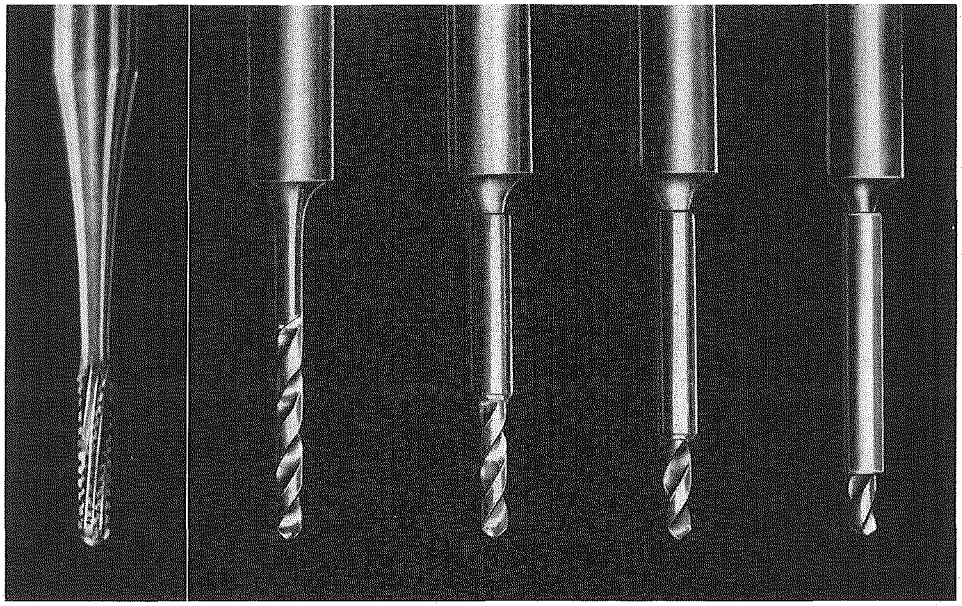
The Spirec Drill

The Spirec drill (fig. 74b) is a drill internationally known as type No. 5 drill. It is used in the industry to cut the softer metal group like soft aluminum and copper. These metals have cutting qualities similar to those of our conventionally used gold alloys. In metal, it cuts a curling chip and should always be used with a lubricant. With two cutting edges at its end which meet at an angle, it requires a starting mark on the material which, for dental purposes, is done with a small round bur. The size used in this technic is 0.7 mm ⌀, but it is available in various sizes. For operative procedures, it may be used to drill pinholes for pinledges and three-quarter crowns, for laboratory use, it serves to drill the channels through the shoulder of CSP attachments.

The conventional types of dental burs are unsuited for drilling a straight cylindrical bore. They are made for surface work and their main disadvantages in drillwork are directional aberrations and inadequate removal of chips. Spirec drills cut axially and very efficiently. When used on dentin, very little or no pain is felt by the patient. Therefore, such drills must be used very cautiously and with little pressure. The length of the shaft is of 19 mm, thus the drill may be used for operative aswell as for technical purposes. In operative work, i.e. used on dentin, it is advisable to limit the depth of bore in order to avoid pulp exposure, while in technical work, a limitation may prevent uncalled for perforations. To this end, tubes of german silver with an inner diameter of 0.7 mm and an outer diameter of 1.1 mm and of a given length are used to limit the depth of bore of the drills (fig. 74b, c).

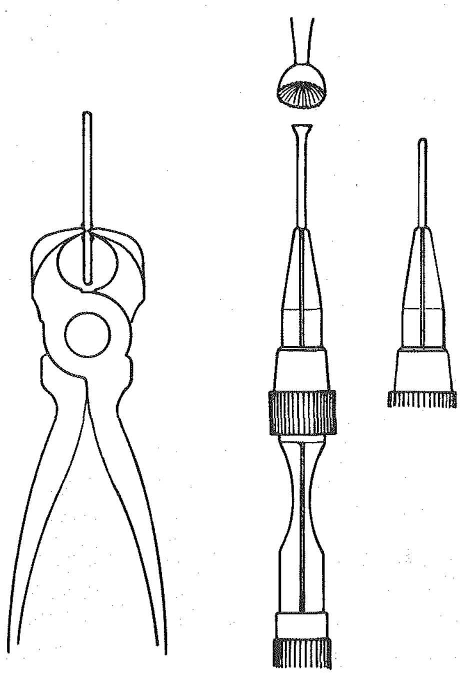
The Semispheric Hollow Cutter

Precision work must be carried out with the utmost precision from the first to the last step. Thus, the cutting of pins, either for CSP work or for pinledge or three-quarter crown technic, or the adjustment of a post for a post crown is not finished after clipping it off to the proper length. Wire clippers deform the material: The two wedges compress the wire and the molecular structure of the compressed area changes. The particles flow in all directions and the



2,5 mm 2,0 mm 1,5 mm

Fig. 74 a round end fissure bur — b Spirec drill — c Spirec drills with tubes of different length to limit depth of bore



a b c

Fig. 75 Illustration for the use of the hollow cutter on pins or rootcanal posts.

last thickness is sheared by the pressure of the blades. The cross section of the wire is no more round. The length of the wire has been increased by a few hundredth of a millimeter and the lateral parts of the end are upset (fig. 75a, b).

The technically correct method for rounding such wire ends would be to cut with a saw or a grinding disc, and to round off on the lathe, but since a lathe does not belong to the ordinary equipment of the dentist, the semispheric hollow cutter is a good substitute (fig. 76).

It fits into the dental handpiece. The wire is fixed into a holder (fig. 75c) and is held axially against the hollow cutter. Thus, a spheric end without asymmetry is obtained.

If this instrument is not available to a dental office, another technic may be used. With a diamond instrument, a groove is cut into the surface of a carborundum wheel. The wire or post is fixed into the holder as in the previous technic. By slowly turning the holder, while the end of the wire is held against the groove of the rotating wheel, the end of the wire is rounded (fig. 75b, c).

The Trepan Bur

The trepan bur (fig. 77b) is a cutting instrument of cylindrical and hollow shape, mounted on the conventional dental burshaft of ⌀ 2.34 mm. This instrument was known already to the old Egyptians as a means of trepanating the human skull. For dental purposes, and in particular for the technic described in this book, the dimensions of the trepan bur are: ⌀ outside: 1.5 mm, ⌀ inside: 0.7 mm, according to the pins used in CSP attachments or as retentional pins of pinlays and three-quarter crowns. The thickness of the cylinder jacket is of 0.4 mm. This thickness is in relation to the material on which the instrument is used. The depth of bore of the trepan head is of 4.5 mm, a measure sufficient for all work related to this instrument.

The trepan bur is used to clean the base of pins where they are soldered or cast into a casting. The pins of CSP attachments are always soldered into the patrix of the attachment, while the pins of pinlays or three-quarter crowns are cast in. In both instances, either solder or smallest irregularities in the casting may prevent complete insertion. The trepan bur, lubricated by a drop of eucalyptus or castor oil, cleans the base of such a pin very neatly and at right angles to the pin. A round bur would not reach the angle between pin and casting, while an inverted cone bur undercuts into the pin. Only a meticulous engraving technic could reach the same result.

The trepan bur is also being used with a center rod (fig. 77a). This is used for a purpose reversed from the one described above, i.e. to ream the opening of pinholes, if the casting should have slight irregularities (small bubbles). The center rod is guiding and centering the bur in the opening, and the margins of the hole may thus be planed.

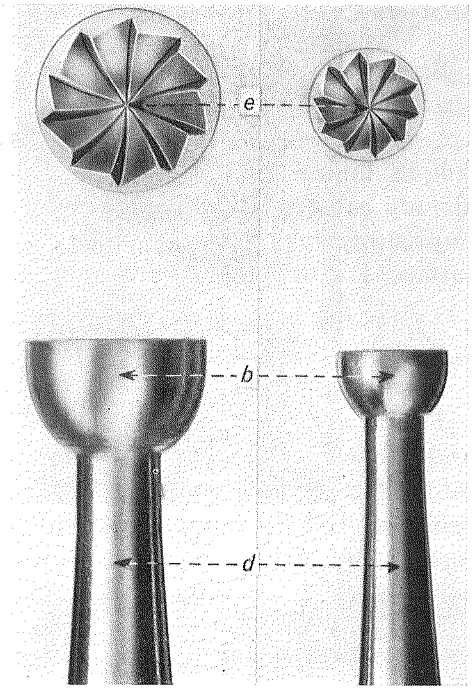


Fig. 76 The semispheric hollow cutter.
e cutting blades
b crown
d shaft

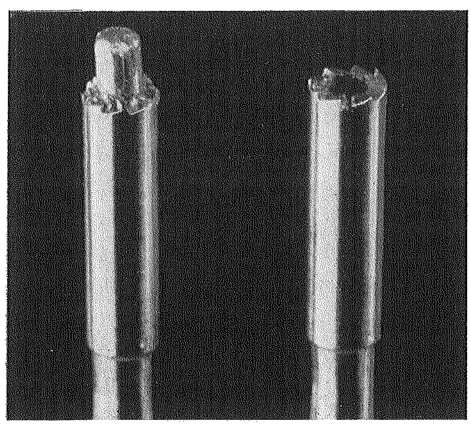


Fig. 77 Left: Trepan bur with center rod. Right: Trepan bur with center bore.

Straight Cutters

Straight cutters (fig. 78) are instruments used for the milling process which leads to the parallelization of the walls of CSP attachment matrices. They are used on the parallelometer only. Milling cutters are obtainable in different lengths and sizes, with straight or twisted blades. For reasons mentioned already earlier, blades with a twist provide for smoother running. A cutter must always be well cutting, if the result of milling must be a shiny, unscratched surface. For the technic of milling, see p. 123.

Polishing Material

Fig. 79 shows the most frequently used polishing materials. Rubber wheels and rubber cups, discs, bristle discs and felt points are well known and need no further explanation. Other instruments may be known less, such as the split mandrel for sandpaper strips which serves to give a surface a coarse finish. The hickory point, used with a polishing powder serves to polish surfaces which are difficult to reach with other instruments. A simple piece of string, drawn through interproximal spaces between soldered crowns or pontics with pumice, allows to polish those portions without endangering the gingival margins of the crowns. The pipe cleaner used with a fine polishing material gives a glossy finish to such surfaces.

Various polishing materials are used, such as pummice powder, chalk powder, Zinc oxyde powder, Trupolish, Paris red and others.

The art of polishing is very personal to every dental mechanic. Long experience and a careful technic may lead to similar results with different methods.

Polishing means the elimination of surface roughness of a casting. Although modern investing technics and casting may yield results of almost polished surfaces, the latter still need a certain amount of polishing in order to get a high gloss. A polished surface is more resistant to chemical or electrochemical corrosion and staining better than an unpolished surface. Ground or milled surfaces also need polishing because a cutting instrument, applied by hand to a metal surface, never yields a polished and completely even surface.

Coarse surface finishing of a casting is done with rubber wheels and cups aswell as with strips of emery paper mounted on a split mandrel (fig. 79a, b, c). Fine sandpaper discs (fig. 79d) give a fine finish to convex surfaces, while concavities and fissures are best reached with small rubber cups filled with wet pummice powder, or small felt cones (fig. 79c, g). Interproximal portions between soldered abutments are often difficult to polish without damaging the gingival margins. Rubber wheels aswell as sandpaper discs will damage these margins. A simple piece of string, preferably braided string, dipped into wet pummice can be drawn back and forth in such interproximal spaces

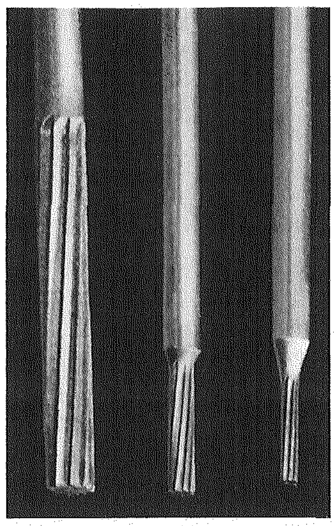


Fig. 78 Straight cutters.

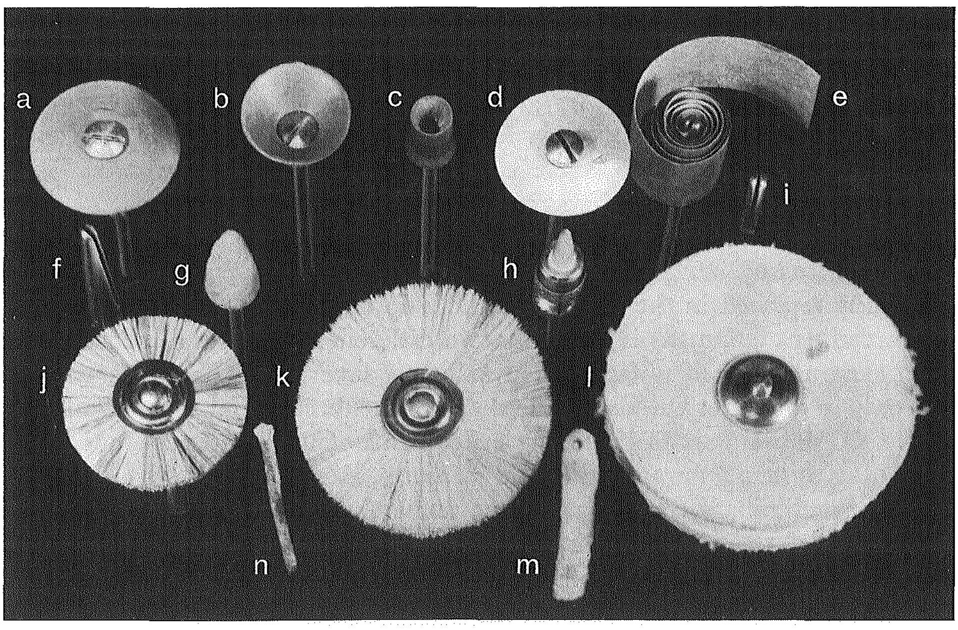


Fig. 79 Polishing instruments

a = rubber wheel
b = large polishing cup, rubber
c = small polishing cup, rubber
d = sand paper disc
e = split mandrel with emery paper strip
f = split post mandrel
g = felt cone
h = hickory wood point
i = small split mandrel for sandpaper strips
j = goat's hair brush wheel
k = goat's hair brush wheel
l = linen wheel
m = pipe cleaner
n = piece of string

without any damage to the margins of the castings (fig. 79n). Pipe cleaners (fig. 79m) will do equally well. For little pits and fissures, openings of pinholes, etc. the hickory wood point, mounted on a mandrel, used with a polishing paste, renders most valuable services (fig. 79h).

The final gloss is given with coarse, then fine brushes and polishing paste (fig. 79j, k) and finally with the linen or chamois wheel and rouge of Paris. After washing the polished casting, it is shaken in a box filled with fine sawdust and wiped with a jeweller's cloth.

In CSP work, polishing requires more skill than for ordinary crown- and bridgework, especially the polishing of the primary part of the attachment, the matrix. If the parallel walls of the matrix are being polished uncarefully, and unevenly, slightest undercuts are created, a mistake which will appear either when the pattern of the patrix will not draw readily, or if the casting of this pattern will not fit the matrix. It is difficult to give a recipe against such failures. The better the parallel surfaces can be finished in the milling process, the less polishing is required and all polishing instruments applied to these surfaces should be led over the whole height of the surface in one stroke.

Threading Instruments

Every modern dental laboratory should be equipped with an assortment of threading instruments. Screws are used for the most various purposes. Fixed-removable bridgework may be screwed onto the abutments, so the dentist may remove it for cleaning purposes or repairs. Various repairs in the mouth may be effectuated on bridgework with the help of screws. Lost screws of any size are easily replaced in the office with the help of proper equipment.

Threading equipment is made for two different systems, the metric or the inch system. Tool manufacturers usually produce both. The systems differ not only in measures but also in the shape of the threads and their angulation.

Fig. 80 shows a set of threading instruments of the "International metric threading System" for special dental purposes, sizes 1.0–3.0 mm.

A few preliminary considerations may serve for better understanding of the properties of the threading instruments. Ignorance of these facts lead to immediate damage of the instruments, and also of the work at hand, from which a broken screw tap must be removed. A definite tolerance is observed by the manufacturer in order to have screw taps and screw plates corresponding with each other. These tools are made of the best alloyed tool steel or of high-speed steel and heavy duty high speed steel. High speed steel instruments have the advantage of better quality and durability for dental purposes. Since the screw taps may be used in the mouth and may thus come into contact with saliva, chromium plated instruments are useful. By the process of chromium plating, the instruments get surface-hardened. The cutting angle

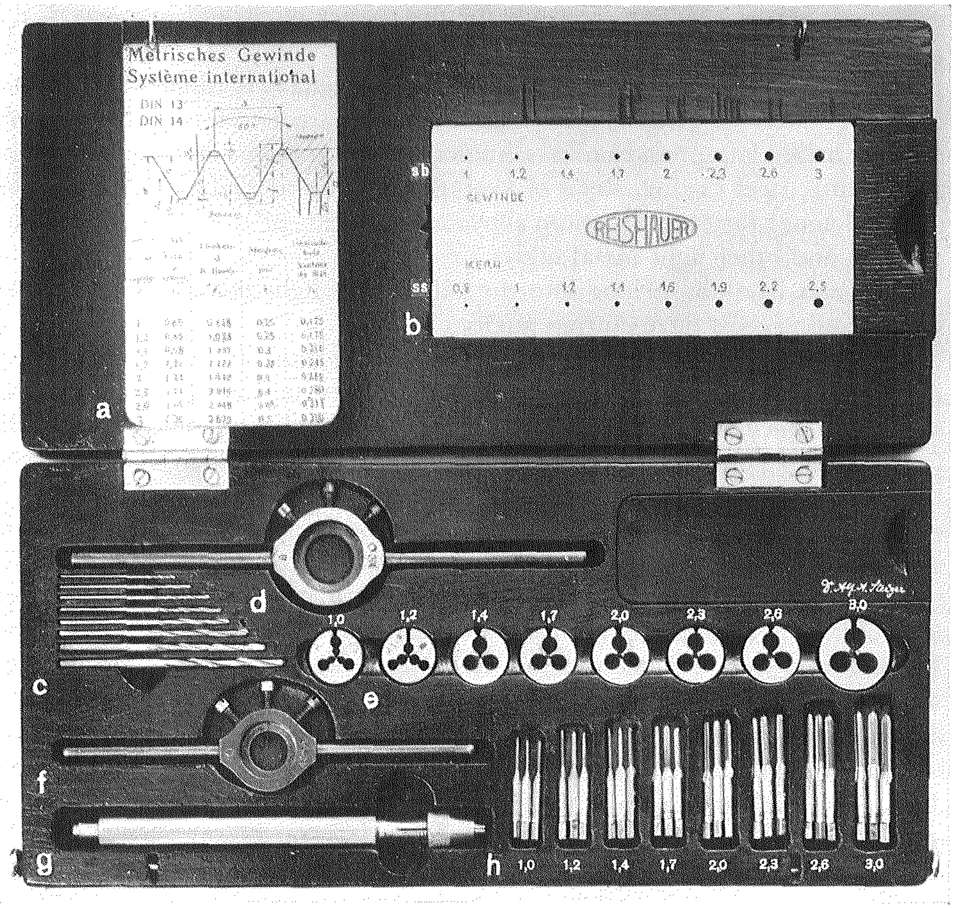


Fig. 80 Screw threading instruments.

a = index for metrical thread gauge "International System". *d* outer diameter of screw bolt; d_1 diameter of screw spindle; d_2 diameter of screw flank; h_3 pitch of thread; t_1 depth of thread.

b = internal gauge: *sb* for screw bolt; *ss* for screw spindle = diameter of core boring.

c = assorted drills for core borings.

d, f = clamps, holders for screw plates with three adjusting screws.

e = adjustable screw plates from 1.0 to 3.0 mm.

g = holder for screw taps.

h = assorted screw taps corresponding to the screw plates and the thread gauge.

The box with the slide lid contains screws.

Bolt *Thread* ∅	*Core* ∅	*Flanks* ∅	*Pitch*	*Depth of thread*
1	0,65	0,838	0,25	0,175
1,2	0,85	1,038	0,25	0,175
1,4	0,98	1,205	0,3	0,210
1,7	1,21	1,473	0,35	0,245
2	1,44	1,740	0,4	0,280
2,3	1,74	2,040	0,4	0,280
2,6	1,97	2,308	0,45	0,315
3	2,30	2,675	0,5	0,350

of a screw tap is widely responsible for the proper pitch and neatness of the thread and for the amount of force necessary to cut it. As screw taps and plates are cutting tools, their cutting angle will also have to differ when cutting different materials. Thus angles between 0 and 2° are used for hard steel, hard casting, brittle latten, and bronze. Angles of 2–8° apply to malleable castings, soft casting, steel casting, steels of average strength, angles of 8–20° for iron, soft steel, tough latten, magnesium alloys, angles of 20–40° to copper, aluminum, electron and other light metal alloys.

Gold and its alloys belong into the category of light metals, and therefore the threading tools have cutting angles of 20–40°.

The choice of the size of the core boring is the most important factor in a rational threading operation. Most fractures of screw taps are due to excessively small core borings. Therefore, the manufacturer indicates the sizes of drills for each size of thread (fig. 80a). The cutting speed does not matter in hand threading, while for lathe threading, a certain speed in meters per minute is prescribed. On the other hand, lathe threading eliminates the danger of misdirection, while in hand threading, misdirection of the screw tap during the operation may lead to breakage. Finally, it is important to use a proper lubricant. This again depends on the working material which is to be threaded. For steel and iron, oils like rape oil, lard oil, whale oil, boring oil, sulfuretted mineral oils and pigs fat are preferably used. For gold work, eucalyptus oil is used with good results. It can be used without harm to the patient for work in the mouth.

Procedure for Threading

The location for the screwhole is marked on the metal by tracing a cross. The intersection is marked with a tool called the center. Thus, the drill cannot "walk away" but is guided in the depression left by the center. According to plate b in fig. 80 a bore of 1 mm is required for a thread diameter of 1.2 mm. The 1-mm drill, well lubricated, is pressed against the metal with the proper direction. Intermittently it is removed and reinserted in order to control the operation. The danger of breakage, apart from misdirection of the instrument starts on the point of perforation. As the surface of dental work pieces may be irregular, the blades of the drill, on perforating the material may cease to cut at different times and the resulting torque may lead to breakage. Therefore, the pressure must be decreased considerably, as soon as the perforation is imminent. Just ahead of the perforation a slight protuberance is noticeable on the surface of the metal. A screwhole which does not perforate the material is done with much less risk. After completion of the bore, the screw tap of ⌀ 1.2 mm is fastened in the holder. For each size there are three taps marked 1, 2 and 3. Work is started with No. 1 tap, well lubricated. The tip of the tap is without thread, so it may be inserted into the boring in proper axial

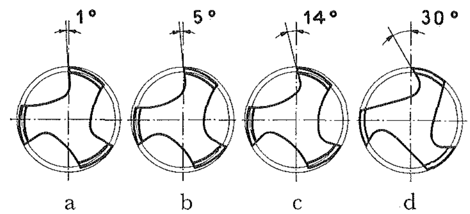


Fig. 81 Angles of threading taps.

a = 0°– 2°: for hard steels, hard cast iron, brittle brass, and bronze.
b = 2°– 8°: for malleable pig iron, soft cast iron, cast steel, steels of average hardness.
c = 8°–20°: for iron, soft steel, tough brass, and magnesium alloys.
d = 20°–40°: for copper, aluminum, electron and other light metal alloys.

In principle, a comparison cannot be drawn between the angles on the cutting edges of a cutter and those of taps because the cutting principle is different. Taps cut along the profile edges (Reishauer).

alignment. Cautiously, it is turned clockwise, and after a few turns, turned back and cleaned. It is again lubricated and reinserted for a few more turns. As soon as the thread is finished to its full length, No. 2, then No. 3 are used.

To make a screw, a piece of wire ⌀ 1.2 mm, rounded at the end, is immobilized in a vise, mandrel or bench chuck. The M 1.2 screw plate is fastened in the plate holder (fig. 80d). Held at right angles to the wire, it is screwed onto the wire, with appropriate lubrication. For proper correlation between the diameter of screwhole and screw, the screw plates may be adjusted with the screws on the outside of the plate holder. By tightening the two lateral screws, the plate is compressed and the screw becomes slightly thinner. Tightening of the central screw pries the plate apart, which makes the screw slightly larger. Thus, the fit of the screw in the screwhole can be adjusted.

One side of the screwplate has a conical opening which is to receive the tip of the wire which is to be threaded. The first thread fillets of the plate are very shallow, they serve to grip the end of the wire and to feed the wire into the subsequently deeper fillets which cut the thread to proper depth. Before threading all the way through, a first part is tried in the threadhole or nut in order to check the proper dimension. If the screw is loose, it is too thin, the plate must be pried apart with the central adjusting screw and a new piece of wire must be threaded. If the screw is too tight, the plate is compressed by the two lateral adjusting screws and the same wire is rethreaded.

If the screw should receive a head, cylindrical or conically countersunk, a tube with a bore corresponding to the outer diameter of the screw is placed over one end of the screw and soldered at the top. The top is then flattened or rounded and with a jigsaw for metal, the slit is cut. If the head of the screw must be countersunk in the work piece, the entrance of the nut thread is milled out cylindrically or conically. The proper fit of the screwhead is given on the lathe, by turning off the proper amount with the turning steel.

With some training and proper care all sizes of screws of the international system may thus be easily made, which is a great help in the planning and construction of fixed-removable bridgework.

The Planostat Steiger

This small instrument is very handy for determining the direction of the future working axis. For practical purposes, the perpendicular to the occlusal plane formed by the central incisors and the occlusal surfaces of the first molars will always do very well as a working axis (fig. 82–85). This assumed plane has nothing to do with occlusion or articulation, it is meant only for the technical process of obtaining an axis of insertion for the removable appliance. It has been suggested that this axis should not coincide with the opening axis of the mandible for the reason that sticky foods could loosen the removable appliance. In CSP work, such occurrences have rarely been reported by patients nor observed by the dentist. If it happens, activation of the pins will eliminate such risks.

The Planostat consists of two beams (fig. 84). The end of one beam is joined to the middle of the other by a hinge with a central bore fitting the axis rod, and a fixation screw to immobilize the rod. Supports with supporting posts can be slipped onto either of the free ends of the beams. These supports serve to give artificial support to one or more beam ends if teeth are missing. The support is then adjusted in such a way that the beam rests at the supposed height of the missing tooth crown.

Once the proper plane is found, the axis rod is dropped through the hole in the hinge. Where it hits the model, a hole is made into the plaster, large enough to receive the nipple. With the nipple in place on the end of the rod, and with the hole in the plaster filled with cement, the axis rod is lowered into the cement, having the upper end of the nipple flush with the model surface. When the cement has set, the planostat is removed and the model is ready for mounting on the parallelometer.

This procedure is already advisable on the study models, because it gives the operator an idea of the approximate direction of his preparations in the mouth (see also pp. 99, 100).

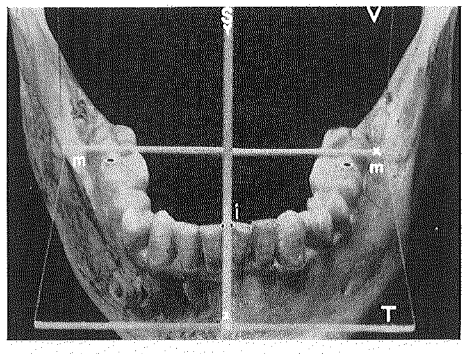


Fig. 82 A mandible in frontal aspect. The transversal (working) plane is formed by the incisal point *i* and the tips of the distobuccal cusps of the first molars. At right angles to the transversal plane are the sagittal *S* and the frontal *V* planes. Their intersecting line represents the working axis.

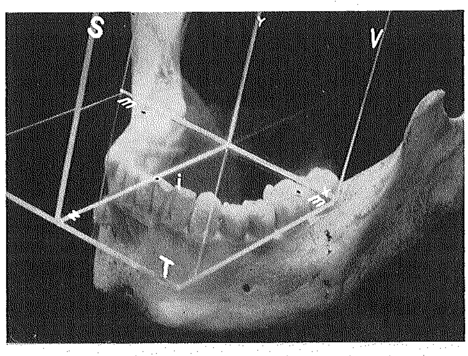


Fig. 83 The above described planes are viewed from the cuspid area and the intersecting line of the sagittal *S* and the frontal *V* plane *y* represents the working axis. *x* = intersecting line of frontal and transversal planes, *z* = intersecting line of sagittal and transversal planes.

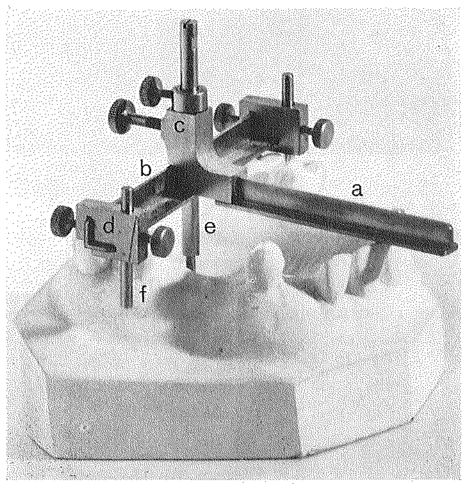


Fig. 84 The working axis established with the Planostat Steiger. The Planostat with its sagittal and transverse beam is placed on the model, the transverse beam resting on the molars, the sagittal beam on the central incisors. If any of these teeth are missing, supporting pins can be adjusted to place either of the three ends of the beams in the appropriate position of the supposed occlusal surface of the missing tooth or teeth. The supporting pins are also used if the hole in the model for cementing the axis would interfere with the palatal plate of a denture and therefore must be placed distal to the soft palate line on the model.

a = sagittal beam
b = transversal beam
c = joint
d = supports
e = axis rod
f = supporting pins

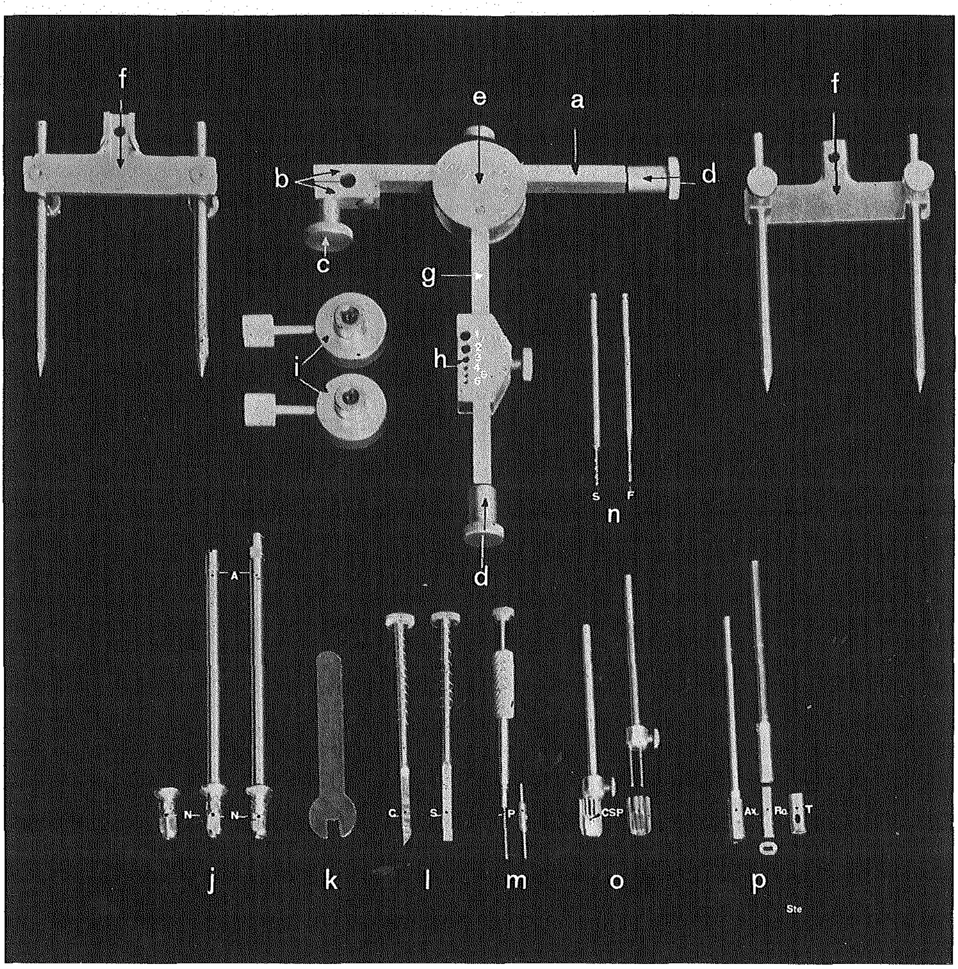


Fig. 85 Parallelofor with accessories.

a = main beam of the Parallelofor
b = screwclip for fastening the beam on the axis rod
c = fastening screw for screwclip
d = fastening screw for supports (f)
e = toggle joint for Pantostat beam (g)
f = supports for stabilization of instrument
g = beam to the Pantostat
h = slide with fastening screw and perforations for different size bur- and drill-shafts

1 = for dental burs ⌀ 2,34 mm
2 = for bur shaft ⌀ 2,00 mm
3 = for bur shaft ⌀ 1,5 mm
4 = for bur shaft ⌀ 1,0 mm
5 = for bur shaft ⌀ 0,7 mm
6 = for bur shaft ⌀ 0,6 mm

i = supporting discs for the main beam (a) on the axis rod
j = axis rod (*A*) with nipple (*N*) in two sizes of rod length
k = wrench for tightening axis in nipple
l = wax carvers
m = pin seater with straight and sleeved pin (*P*)
n = spirec drill ⌀ 0.7 mm (*S*) and round head fissure bur (*F*) ⌀ 0.7 mm
o = holder for parallelizing ready made CSP attachments (see fig. 30)
p = holder for parallelizing AxRo and Ro-stress breaker joints (see p. 95)

The Parallelofor Steiger

The Parallelofor was designed in order to obtain a small, inexpensive instrument for laboratories where several mechanics have the use of only one large parallelometer. The Parallelofor replaces the parallelometer for certain steps in the technique of CSP attachments:

(a) parallelizing the waxed up matrix,
(b) seating the stainless steel pins,
(c) cleaning the channels in the raw casting of the matrix,
(d) seating the stressbreaker joints of resilient partial dentures in their correct soldering position. For the practitioner who does not use precision attachments but prefers clasp work, the Parallelofor serves as a surveyor and as a means of correctly positioning stressbreaker joints to continuous clasps. Parts of the Parallelofor (fig. 85):

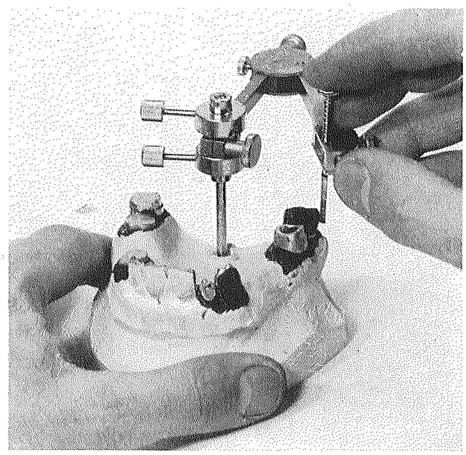


Fig. 86 Use of Parallelofor for carving up CSP matrix with wax knives.

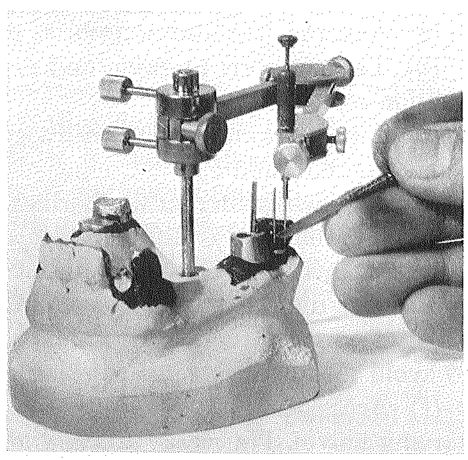


Fig. 87 Use of Parallelofor for seating stainless steel pins into waxed up CSP matrix.

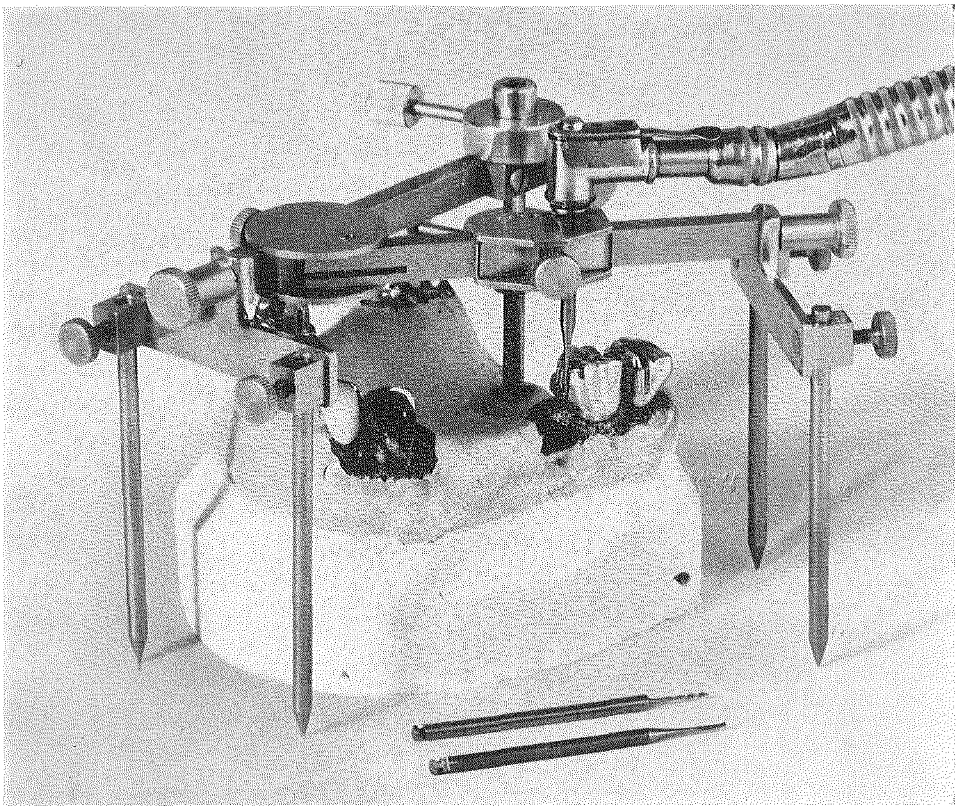


Fig. 88 Use of Parallelofor for cleaning and smoothening channels on cast CSP matrix. Note the contrangle handpiece with special length round end fissure bur.

(a) Axis rod (see also accessories parallelometer, fig. 85j).
(b) Two supports to guide and support the horizontal beam, each with a fixation screw (fig. 85f).
(c) Two horizontal beams with toggle joint fitting the axis rod, with fixation screw (fig. 85a and g).
(d) Slide with different size borings (fig. 85h). This slide is the working head of the Parallelofor. 6 different size drills, burs, holders, pinseaters may be inserted. Drills are driven by a contra-angle handpiece, and drills of other dimensions than dental drill shafts must be fastened with a chuck mandrel.
(e) Two supports may be fastened to the end of the outer beams, in order to avoid torque during the working procedure (fig. 85f).
(f) Accessories: Spirec drills for contra-angle, burs, mills. Set of wax carving knives. Pin seater (fig. 85 l, m, n).

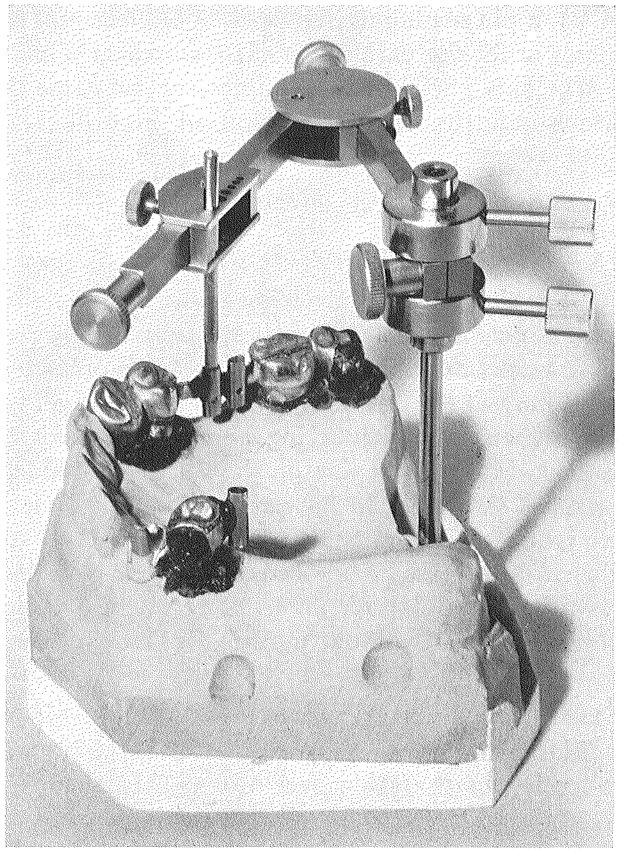


Fig. 89 This illustration actually belongs into the chapter of resilient partial dentures, pp. 143 to 174, but is shown here to demonstrate the working range of the Parallelofor Steiger. Note the joint holder onto which the joint-female is slipped and fastened in its proper position with sticky wax.

The Parallelometer "Bachmann" *

The name parallelometer is not quite descriptive or correct for this instrument, because "meter" would imply a measuring device which it only partly is. The parallelometer should be defined as a multipurpose parallelizing machine. It combines the following devices in one instrument:

(a) the isodrome, i.e. a drilling and milling machine, driven by any laboratory motor with flexible driving axle or Doriot type attachment;

(b) a pantostat, i.e. a lever with two parallel hinge joints, conventionally called a surveyer in prosthetics;

* The "Bachmann" was chosen for this publication because it was and is being used by the authors. It was found to be a sturdy, precise and practical instrument. This should not minimize the quality of other construction of similar type.

(c) a pin seating device for the parallelism of frictional pins in CSP attachments or for the parallelism of stressbreaker joints of resilient partial dentures.

The only part which would deserve the name "meter" is a millimeter scale which indicates the boring depth of the drill.

PARTS OF THE PARALLELOMETER (fig. 90)

1 *a* Base with adjustable working table

Loosening of the knob *a* allows the table to be turned around a perpendicular axis. Loosening of knob *b* allows any oblique position desired for surveying clasp work or establishing the correct axis of insertion for precision work. With both lines at the front of the table in alignment, the table is horizontal, i.e. perpendicular to the boring and working axis of the instruments. Lever *c* inserted into the opening on the side of the table serves to activate a magnet inside of the table. In forward position of the lever, the magnet is active, in backward position, inactive. The magnet serves to immobilize a model—with a special steel disc incorporated in its base—on the working table. With lever *c* held firmly, and both knobs loosened, the table can be brought into any oblique position without rotating, by moving knob *a* backwards or forwards.

2 Vertical beam with rack

The vertical beam supports all the working parts of the instrument with the exception of the table and serves to raise and lower the horizontal beam which is attached to its top. Knob *e* moves the beam up and down, knob *d* is the fixation screw against this movement. The cogwheel which drives the vertical beam is concealed in the base shaft.

3 Horizontal beam

The horizontal beam serves to move the working instruments in a horizontal plane. *e1* is the knob for horizontal movement. A cogwheel allows a linear displacement which is arrested by fixation screw *f*. The joint *g* allows a rotation of the horizontal beam around a vertical axis in order to place the different working parts into working position over the table. Fixation screw *h* arrests the rotational movement.

4 Drillhead

The drillhead serves to drive drills, milling instruments. The top *i* is a slip joint connection for the laboratory motor. Certain laboratory motors require a slip joint adapter (fig. 84) manufactured by SSW or KAVO. Drillhead chucks for different size drill shafts fit into the drillhead and are tightened by a screwwrench (Accessories fig. 92j). Lever *k* serves to move the bur, drill or mill in a vertical direction and scale *l* indicates the boring depth in millimeters.

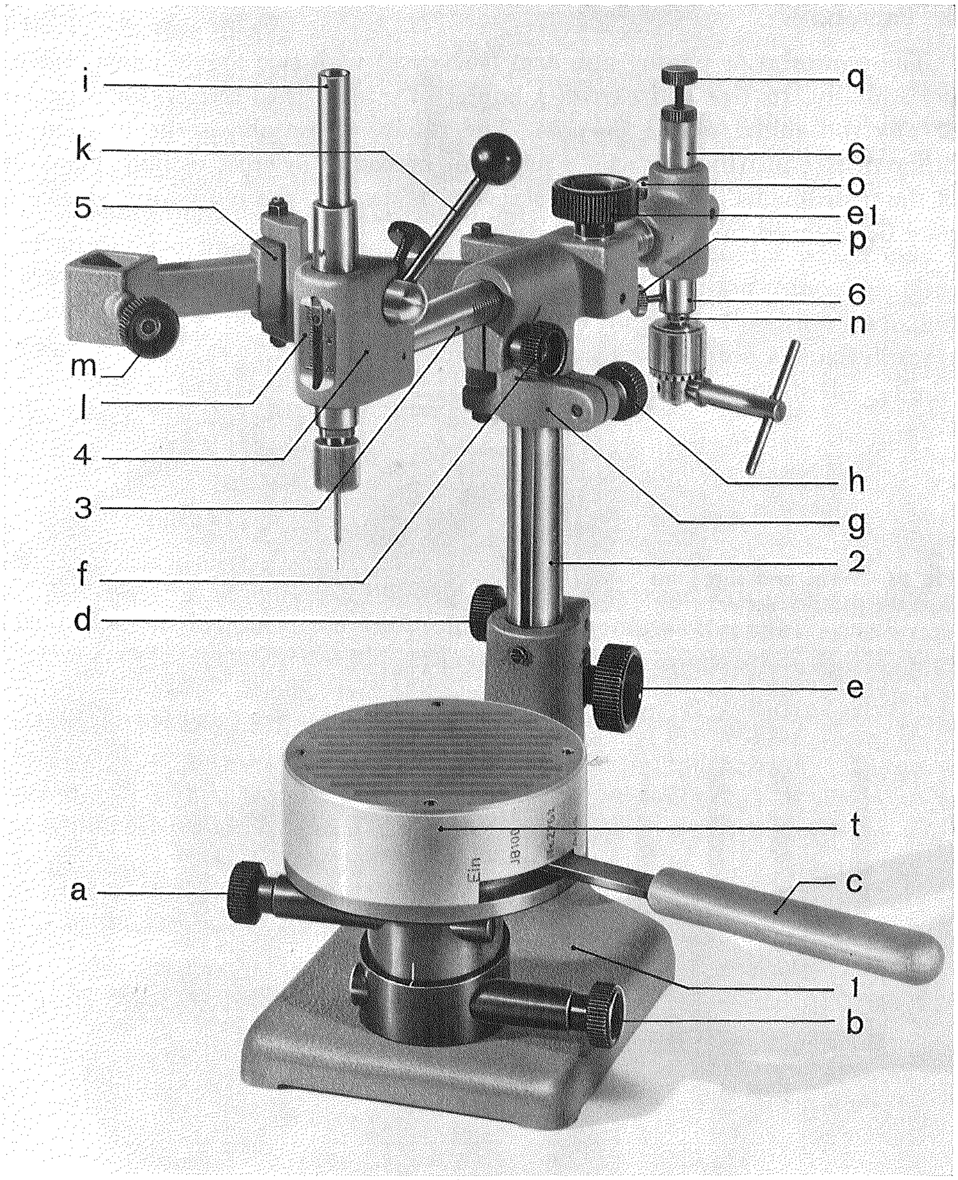


Fig. 90 The Parallelometer 1 Base of instrument 2 Vertical beam 3 Horizontal beam 4 Working head with slip joint for laboratory motor 5 Pantostat 6 Pin seating device *a*, *b* Knobs for table adjustments *c* Magnet lever *d* Fixation screw for vertical movement *e* Knob for vertical movement *e1* Knob for horizontal movement *f* Fixation screw for horizontal movement *g* Joint for rotation of horizontal beam on vertical beam *h* Fixation screw *i* Slip joint connection *k* Lever for vertical movement of drill *l* scale for boring depth *m* Fixation screw of pantostat *n* inner cylinder of pin seating device *o* Fixation screw for pinseating device *p* fixation screw of outer cylinder against the inner cylinder *q* adjusting screw for accurate height adjustment *t* Working table.

5 Pantostat

The pantostat or pantograph arm (surveyor) with two toggle joints, moves horizontally. Its free end carries a holder of square cross section for a pencil or any rod suited to the purpose. The square shape allows the fixation of different size instruments which need not be round in cross section. Fixation of the instruments is obtained by screw *m*. If desired, the pin seating device *6* may be fastened in the pantostat arm.

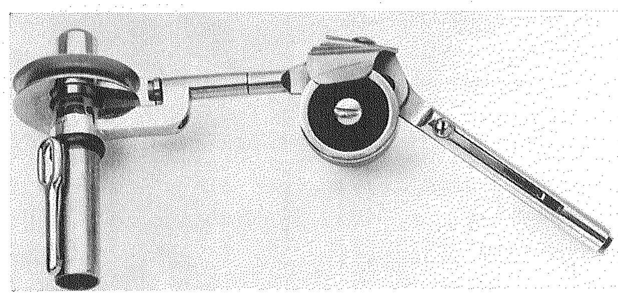


Fig. 91 Wrist and slip joint used for parallelometer.

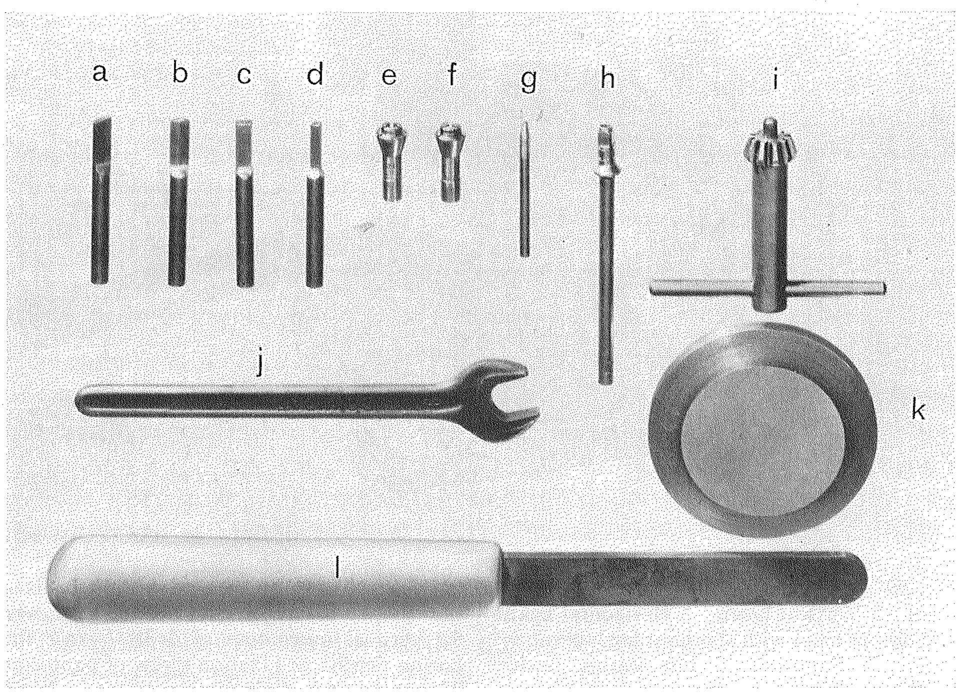


Fig. 92 Accessories to parallelometer: a–d = Set of four wax knives for carving up CSP matrix e,f = Two chucks for drillhead g = Pinholder for 0.7 mm pins h = Axis post with nipple for establishing the working axis i = Key for pinseater chuck j = Key for drillhead chuck k = Steel disc for model base l = Lever for magnet in working table.

6 Pin seating device

The pin seating device serves to seat the frictional pins of CSP attachments into the waxed up restorations (p. 120). The rod is removable from its shaft by loosening fixation screw *o*. The lower end of the pin seater carries an adjustable chuck for shafts of different sizes. In this chuck, the pin holder or the joint holder (for stressbreaker joints) is fastened. The pin seater consists of an outer cylinder held by a shaft *6* and an inner piston *n* which may be lowered by manual traction into the exact desired position. Since the piston is retained by a spring, it must be fastened into the desired position by fixation screw *p*. Adjustment screw *q* serves to lower the fixed piston a small distance. Loosening of fixation screw *p* causes the release of the spring inside the cylinder, the piston retracts into the cylinder.

THE WORKING AXIS

The working axis largely depends upon the average axis of the abutment teeth. For single abutments—not soldered into groups—this working axis must *approximately* determine the axis of preparation. For group abutments, it must nearly coincide with the axis of preparation. This is why it is important to establish this axis on the study models *before* starting preparation of the teeth. In cases of doubt, it may be worthwhile to make preliminary preparations on the model on an assumed axis, which will show immediately whether the conditions become favourable for the abutment construction. At the same time, it must be decided which of the abutments shall be soldered into splinted groups, because naturally splinted abutment must all have the same axis of insertion while single abutments may slightly vary in their preparation axis, provided the space allows for CSP attachments of a different axis (fig. 93).

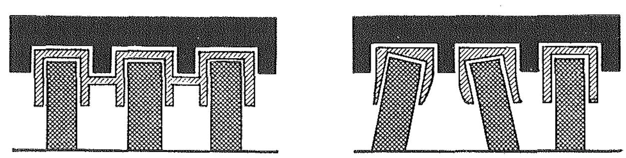


Fig. 93

▩ = abutment teeth
▨ = abutment construction
■ = removable part

The study model (or, later the master model) is placed upon the working table of the parallelometer. The axis rod is fastened in the chuck of the pin seater, or of the drillhead, whichever seems more convenient. The nipple of the rod is lowered into approximation of the centre of the model. The table is now moved into the oblique position which places the axis rod at the desired angle which will constitute the working axis of the model. A hole is then cut into the model at a place in the lingual or palatal region where no bar or plate is planned. (In cases where full coverage of the palate is planned, the site of the nipple may be behind the soft palate line.) The hole is then filled with dental cement, and the axis rod lowered so the nipple stands in the cement filled hole*. When the cement has set, the horizontal beam of the parallelometer is raised, thus suspending the model by the axis rod. The table is brought into horizontal position (for the master model, the steel disc is placed underneath the model) and a plaster base is poured on the table into which the model is again lowered. Thus, once and for all the plane perpendicular to the working axis is established, *provided the position of the working table is left horizontal* (fig. 107). The axis rod may now be unscrewed from the model and is needed no more for further work.

* If the Planostat Steiger was used to establish the axis, the model at this point is suspended into the parallelometer (see p. 116).

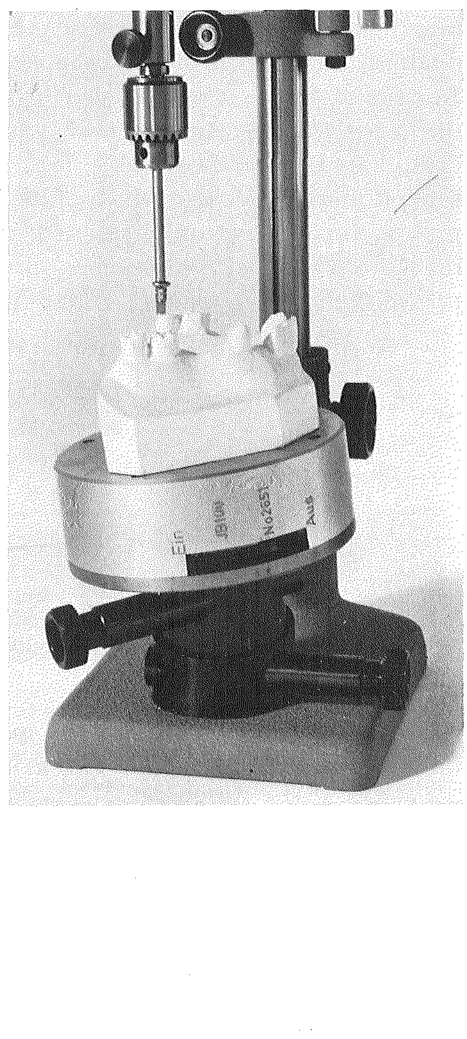


Fig. 94 Study model on parallelometer table. Table at proper angulation for the fixation of the axis rod. Immediately after fastening the nipple in the model, the latter, suspended by the axis rod, should be raised by moving the drive wheel on the vertical beam. The table is then fixed into horizontal position, plaster poured onto the table, and the model lowered into the plaster. Thus the model obtains a base which is exactly perpendicular to the working axis.

PREPARATION OF OPERATIVE PROCEDURES

In preparing the abutments, care must be taken to create sufficient space occlusally and interproximally to build the attachments, and this is precisely why it is so important to have a well established plan and study models on the basis of which to discuss with the dental mechanic. X-rays are of help to avoid any pulp damages resulting from abutment preparation, because the degree of secondary dentin formation may determine the admissible depth of preparation and the type of CSP attachment to be used. It must always be born in mind that a bipartite gold casting on a tooth requires more room than a simple casting.

In every kind of extensive reconstruction work, abutment preparations and the taking of impressions should be done within the shortest possible time in order to reduce the more or less uncomfortable time the patient spends in the dental chair. A patient dragging through innumerable short appointments each time arriving with the prospect of having another tooth cut down, of having another needle stuck into his gingivae, a patient wearing temporary replacements interminably will be discouraged and tired of treatment. He will be reluctant to put in a few extra sittings. It will make the period of adaptation more difficult for him, because he may not be looking forward to his reconstructed set of teeth anymore. Rationalized work in the mouth is the answer to all these problems: Long appointments, the preparation of at least one quadrant in one sitting and preparation under good anesthesia. This will help both patient and operator to bear patience with each other. Individual impressions of the prepared abutments should be taken immediately following preparation. Temporary replacements—preferably of cold curing acrylic—, will enable the patient to chew and look well following his dental appointments and preceding the insertion of the finished prosthetic work. For large edentulous areas an immediate partial clasp denture may be indicated.

TEMPORARY REPLACEMENTS

Quicksetting acrylic has not proven entirely satisfactory for permanent fillings. On the other hand, its value for temporary crowns and bridges cannot be underestimated. For devitalized teeth, a temporary crown can be made in less than 10 minutes. With a temporary post of german silver adapted into the root canal, a crown form shell is cut to proper gingival fit, filled with self-curing acrylic and seated on the root in proper position. After the necessary time of setting, the crown is removed, the shell peeled off and the excess acrylic trimmed away. The same procedure is adopted for full crowns. For inlays and three-quarter crowns, a copper band is adapted the same way as for an indirect impression. It is properly contoured, and after coating the abutment tooth with vaseline, the band is filled with the acrylic of doe-like consistency, inserted and the patient asked to close into centric occlusion. Before the acrylic has *completely* hardened, the filled band is removed and the acrylic left to set. This will avoid difficulties of removal, and damage to the vital tooth from the heat of polymerization. The band is then cut away from the acrylic, excess acrylic trimmed and proper contour given to the temporary replacement. In such a way it is possible to even make a temporary splint, by simply roughening the contacting surfaces of the temporary replacements and filling the spaces with selfcuring acrylic. When bridges are made this way, it is advisable to reenforce the pontic part of the bridge by a wire laid into the lingual face of the acrylic pontics. An old question has always been the fixation of temporary replacements. Any temporary cement will cause difficulties on removal, especially if the temporary replacements fit well. Zinc oxyde eugenol is inadmissible in conjunction with acrylic, because it softens it. Guttapercha easily breaks the seal and cannot be used with well fitting crowns, inlays or three-quarter crowns. STEIGER has developed a new fixation material which eliminates all the inconveniencies of the conventional temporary filling materials. "Profix" is a wax compound which stays soft, can be squeezed into a thin layer, seals perfectly, has sufficient adhesion, and does not acquire any disagreable odour. "Profix" is slightly heated and applied either to the surface of the abutments or to the inside of the temporary replacements.

IMPRESSIONS

The method of impression taking is immaterial to this technique provided it gives accurate results. The authors believe that the direct impression method whenever applicable, is still the method which includes the least amount of possible errors. A wax pattern, as well finished as possible on the abutment tooth and withdrawn from the mouth, may be reinserted and checked for possible distortion. Which of the indirect impressions can be accurately rechecked? With indirect impressions, only the casting tells about inaccuracies and distortions which may have happened during the intermediary work from impression to casting. The longer an abutment tooth is and the deeper the preparation, the greater the difficulties become for accurate indirect impressions. The indirect method should therefore be limited to simpler impressions such as for Richmond crown, thimble crown, full crown and Jacket crown preparations. For indirect impressions, only materials which may be metal plated should be used, since no plaster or cement models have yet proven to be superior or even equal to metal plated dies.

Taking direct impressions is an art which requires skill, practice and above all, patience and endurance until the proper result is obtained. It is not within the scope of this work to dwell at length on the correct method of

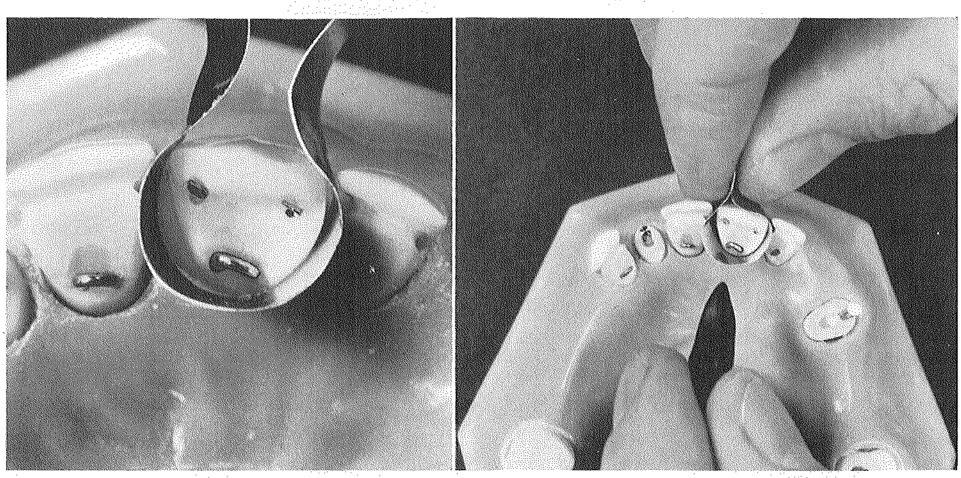


Fig. 95 A 0,02 mm soft brass or copper band adjusted for direct impression of pinlay or three-quarter crown for incisor tooth. The two platinum-iridium pins towards the occlusal are squashed flat at their occlusal end to have retention in the wax. The two pins above the gingival have been adjusted as a U-shaped loop, and the wax retention is given by the loop. The wax is inserted into the loosely held band, after which, under wax pressure, the band is drawn towards the palatal face of the tooth. On three-quarter crowns, this movement draws the wax into the lateral channels.

direct impressions. This method is taught at most schools and is individual to each practitioner. However, it seems useful to show some of the direct impressions which create most difficulties: Three-quarter crowns, the most widely used abutment construction on vital teeth (fig. 95).

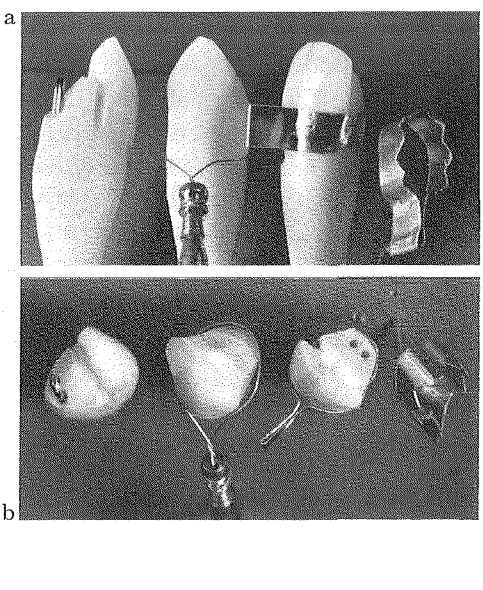
The tooth is dried and remoistened with a moist cotton pellet. Never use oil or vaseline on a preparation.) A band of soft copper or brass is adapted to proper contour and width. The inside of the band is oiled. If pins are used for anchorage, platinum pins with bent or flattened ends are placed into the pinholes. The band is held with two fingers of one hand while the other hand presses the softened wax between band and abutment preparation. The most current mistake is made by using too much wax, thus creating a large bulk of excess wax which may prove difficult to remove. While the wax is still soft, the band is strongly drawn towards the lingual surface of the abutment tooth, and immediately the impression is chilled with tepid water (not cold water). Excess is trimmed away from the band until it is possible to remove it.—In many instances it will be possible to have the patient bite into centric occlusion while the wax is still soft. This should be done wherever three-quarter crowns are made for premolar and molar teeth.

This is equally practicable on upper front and cuspid teeth although on these abutments with their flat lingual surface it is easier to check occlusal interference during the finishing process of the impression. On lower front and cuspid teeth an occlusal check is unnecessary because there is no interference. In order to obtain an even and minimal thickness, the casting itself can be reduced by grinding and by checking with the calliper (see p. 75).

Finishing of the impression is done with warmed instruments: sickle shaped probe, spatula, carvers. Interproximal portions are smoothened by linen strips. Finally, the whole impression surface is smoothened by carefully rubbing it with a wet, heated cotton pellet. The impression is withdrawn with a loop of thin wire, preferably gold wire. This makes it possible to attach an adequate sprue at the appropriate location.

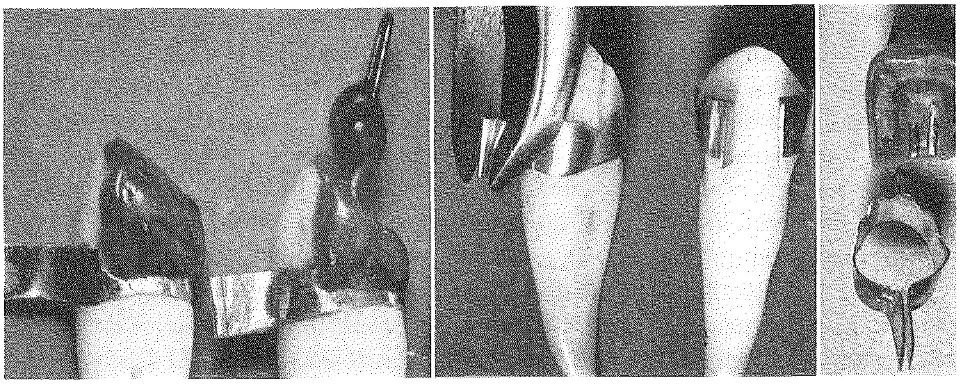
A variation to the above technique is the platinum band impression (STEIGER) (fig. 96–99). A strip of soft platinum band (0,14 mm thickness) is soldered into a ring which is about twice as large as the circumference of the abutment. The band is cut to fit the gingival contour of the abutment tooth. On the occlusal margin of the band, a series of notches is cut out. The band is then squeezed on the buccal of the tooth with a pair of pliers. Thus it is closely adapted to the gingival margin of the tooth. The band is slightly oiled, the tooth dried and remoistened and the impression taken as described above: Adapt soft copper or brass band, insert wax, tighten band, chill and carve up impression. After removal of the impression, the platinum band still stays in place, but on the inside of the impression, the notches of the band have left their key im-

a



b

Fig. 96 Direct impression for a three-quarter crown with platinum band.—Left: Prepared tooth with retention pins in place.—Middle: Measure of band with wire.—Right: Platinum band adapted to the tooth and squeezed labially. The band has been given a serrated margin towards the occlusal, while the gingival margin has be cut to follow the gingival sulcus.



a b c

Fig. 97a The direct impression has been taken, it is removed with a sprue, while the platinum band stays in place on the tooth.

Fig. 97b With crown shears, the band is cut open and can thus be removed over the broadest portion of the crown. If it does not go back entirely into the original position, it is held with tweezers and annealed which will make it stay in the former position.

Fig. 97c It is then placed back into the wax pattern with the serrations as an exact guidance.

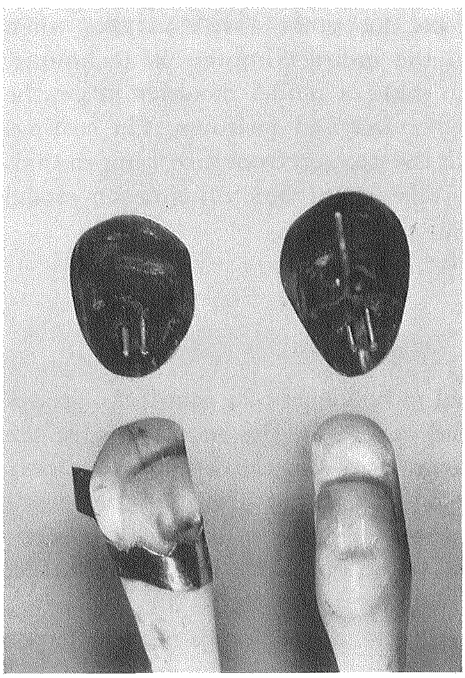


Fig. 98a Left: Removal of impression with band in place.—Right: Reposition of the band into the wax pattern. The band is fastened to the pattern on the outside with impression wax.

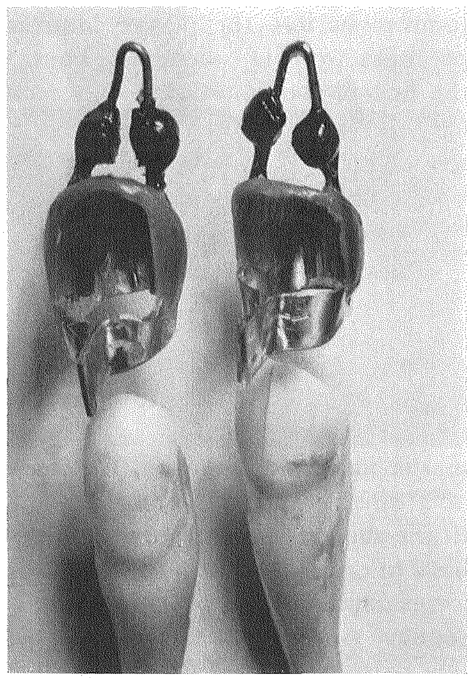


Fig. 98b Bands repositioned in the impressions.

pressions. The platinum band is then cut with scissors as shown in fig. 97b. Carefully the band is removed over the broadest portion of the abutment tooth. The elasticity of the platinum will prevent distortion of the band by this procedure. The band is then reseated into the impression according to the key notches and fastened with wax to it. After casting, the excess band is cut away before trying the three-quarter crown in the mouth. The purpose of this technique is twofold: On long incisor teeth it is often difficult to get proper interproximal adaptation at the gingival. With the platinum band technique this is made easy. Even if the band should slightly open during the try-in, it may be accurately tightened during the cementing procedure. The second reason is that platinum at the gingival margin is better tolerated by the soft tissues than gold, and the tough alloy allows for a finer marginal edge than in a gold casting.

Before beginning laboratory work on the abutment castings, these castings should be checked for fit in the mouth. If direct impressions have been taken, this is easy, but for indirect impressions, the try-in of the castings must be preceded by a rough wax-up of the CSP attachment matrix. It is inadmissible to make a master model by taking a plaster impression over the copper band impressions, because the possible errors in repositioning the copperplated impressions into the plaster impression are too great a risk to take when precision work is concerned. Thus, with the indirect impression technique, the first plaster impression only serves to make a model in order to get the abutment castings into proper alignment, contour and occlusion. The castings are then tried in the mouth—together with the castings from direct impressions—and a second plaster impression is then taken from which the master model is poured.

SPLINTING

If several abutment castings are planned to be joined to a splint, the groups to be splinted must first be soldered and retried in the mouth before the master impression is taken. It is recommended to solder two abutments only at a time, i.e. one soldering. Soldering several areas in one step often leads to the slightest displacement of one abutment against the other. This fact is hard to explain, but it undeniably happens sometimes. In a five element splint for example, a plaster key is taken over two abutments each. After soldering, we have two pairs of abutments and a single one. A new key is taken over the two pairs, which, after soldering makes a splint of four elements. The last single element is then soldered to the completed splint. Another advantage of this method of soldering splints is that the parallelity of abutment preparations can be gradually checked, while in trying a completed splint in the mouth, the places of interference are difficult to check.

THE OPERATIVE AND LABORATORY WORK OF AN ASSUMED CASE

For better comprehension, a specific but simple model case has been chosen to illustrate all the steps necessary to complete a removable partial denture with CSP attachments. This case has not been chosen, because of its typical indication for CSP work, but because a large variety of design and methods can be shown in one single case.

The critical reader will no doubt soon notice that the problem of occlusion and articulation is given very little, if any attention in this book. This chapter is one which belongs to the basic equipment of every dentist. Also, the variety of methods used in the professional world is so great that describing one method would neither suffice for all cases nor would it meet with the approval of more than a portion of the readers, who prefer their method. Since the authors have nothing new to offer in this field, and since the method of constructing CSP attachments does not in any way influence or determine the use of one or the other method or articulator, the whole problem of articulation is left out of these pages. Let it be emphasized that it must not be left out in practice.

For the sake of simplicity, it will be assumed that the mandibular teeth have already been rebuilt to a proper occlusal plane.

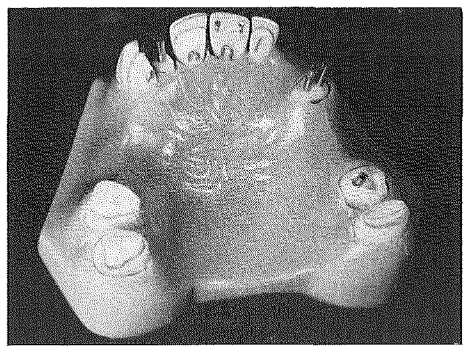


Fig. 99 Model case for the step-by-step demonstration of the technique for making CSP attachments.

Status	1.	8+	vital	Full crown
	2.	7+	vital	Full crown
	3.	3+	vital	$\frac{3}{4}$-crown
	4.	2+	nonvital	Richmond crown
	5.	1+	vital	$\frac{3}{4}$-crown
	6.	+1	vital	Pinlay
	7.	+2	vital	$\frac{3}{4}$-crown
	8.	+4	nonvital	Richmond crown
	9.	+7	nonvital	Buoy (cap with post)
	10.	+8	vital	Full crown

Nos. 3, 5, 6 and 7 impressions will be taken after the direct method as shown above (p. 103). IMPRESSIONS

Nos. 4, 8 and 9 are devitalized but healthy teeth with proper previous root canal work performed. The post for such crowns must be at least the length of the crown, and has a taper of 2 degrees. It is made of a platinum-iridium alloy. Notches are made in the portion of the post protruding from the canal so as to give retention to the impression compound. The copper band is adapted, filled with compound and carefully placed over the root. Whatever textbooks on indirect impressions may have to say, experience tells that no excessive pressure should be applied to the compound when taking the impression. The well heated compound will readily adapt itself to the surfaces, and overpressure will only result in internal tensions which are apt to cause distortion *after* removal of the impression. The impression is checked for possible flaws. The most frequent mistake made is overextension towards the gingival, i.e. beyond the abutment preparation. Naturally, such an overextension of the band would cause the compound to flow into sometimes only slightly undercut areas hardly detectable on the impression. However, the casting will not fit at its gingival margin, a mistake which, alas, is seldom found to be corrected and which accounts for the innumerable ill-fitting crowns found in X-rays and on extracted teeth. Overextensions of the band therefore must be corrected and the impression retaken.

The other method for making Richmond bases is of older origin than the cast base, but, if correctly done, not less accurate. It has been experienced that gold bands—for crowns or Richmond bases—are not resistant enough to withstand the technical process of building a Richmond crown without at least slight deformation. In bridgework, even the cementing process may, at the last moment, distort the band. This drawback is overcome if a more resistant material, platinum, is used. POST CROWNS

A wire measure is taken of the tooth, and the corresponding length of 0.19 platinum band is cut. The ends of the band are filed to corresponding flashes so the soldering surfaces are just *overlapping.* 24 karat gold is used for soldering. The ring is then properly cut and adapted to the tooth, its occlusal rim ground flush with the tooth surface. A piece of platinum band slightly larger than the surface of the tooth is then carefully adapted to the ring and soldered. The excess, except for a small rim, is cut away, and the base tried in. A hole is cut at the proper location and widened to almost the size of the post. The post is forced down into the canal through the base, a drop of sticky wax applied to the joint of base and post and the base removed for soldering. The little rim left will greatly help in prying the base loose (fig. 101).

Nos. 1, 2 and 10 are vital molars prepared to receive full crowns. Copper bands are adapted and indirect compound impressions are taken. If band

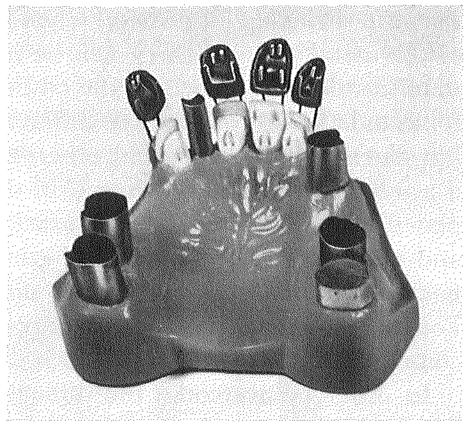


Fig. 100a Impressions for primary abutments: 3, 1 +2 are direct impressions of three-quarter crowns with two or one cervical pins, +1 is a direct impression of a pinledge with four pins, 2 +4 are indirect, copper band-compound impressions of Richmond crown preparations, 8,7 +7 are indirect impressions for full crowns, and +8 is a platinum band, adapted in the mouth and filled with self-curing acrylic, for a full crown.
All preparations on vital front teeth are carried out in such a way that a minimum of gold will show on the incisal edge only.

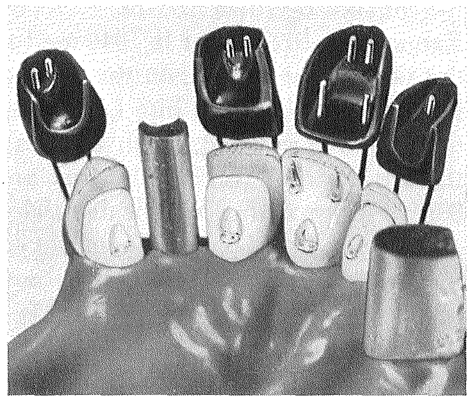


Fig. 100b Direct impressions enlarged.

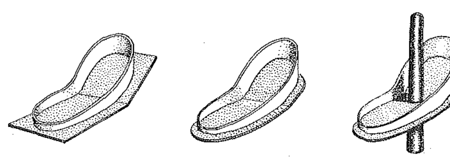


Fig. 101 Platinum band Richmond crown base with platinum-iridium post. The excess margin is useful for removing the base from the tooth without damaging the margin of the band. It is reduced after casting the backing and soldering it to the base.

crowns are preferred to full cast crowns, platinum bands are again preferable to gold bands, and again, both methods, if correctly practized, give satisfactory results, and may be used in connection with CSP attachment work. Nos. 1 and 2 in our model will therefore be done as a full cast crown, No. 10 as a band crown.

THE FULL CAST CROWN

The full cast crown has, beside its incontestable advantages, some disadvantages which sometimes make its use problematic. It is a wellknown fact that the shrinkage of a metal when solidifying is proportional to the volume of the metal. Hence, there will be more shrinkage in places of thick casting than in other places where the casting is thin. Every crown, especially when it has to be built up in an axis different from the axis of the root (tipped teeth), has places of large bulk and others of small bulk. It is therefore not unusual if a full cast crown, on trying it in the mouth, or, on trying it on the copper plated model, shows a certain measure of poor fit to the discriminating eye, and needs a certain amount of grinding into occlusion. With a reasonably parallel preparation of the stump no fault in gingival fit must be discovered. For simple crowns without precision attachments this may not be of any consequence, but for CSP work, it definitely is.

OPEN THIMBLE CROWN

In order to overcome the difficulties described, and for further purposes which will become clear during the technical procedure, BOITEL has modified the full cast crown to the "Open thimble crown" (zweiteilig gegossene Krone) (fig. 102). [GILL in 1946 used a gold coping (or thimble), but articulated the wax in the mouth, on the coping]. The metal plated die is isolated with Microfilm and dipped into liquid impression wax so the prepared area of the tooth is well covered. With a *warm* damp cloth, the wax is pressed against the die in order to chill the wax and to prevent it from retracting from its base. This procedure is repeated twice or three times, according to the fluidity of the wax. Its thickness should not exceed 0.3 mm. The excess at the gingival line is then trimmed away with a sharp knife, and so is the center of the occlusal portion. On the occlusal such an amount of wax is cut away as to leave just a slight grip over the occlusal borderline. Four sprues are attached to the wax thimble which is then carefully pried loose. If the wax breaks somewhere along the gingival line, this is a sign for an undercut area, and a sign that, alas, the preparation has a flaw that *must* be corrected, or it is a sign that the gingival extension is, as described above, excessive. This thimble, with its occlusal hole, is of such even thickness, that the casting process will reproduce the most accurately fitting crown base obtainable. Since the thimble is open at the occlusal, the fit on model or tooth may be checked on the occlusal, and checking such a thin thimble at the gingival is of course also much easier, especially interproximally, than in a bulky crown. The thimble, the part of the future crown which contacts the tooth surface, may therefore be used in the master impression.

It was previously stated that in CSP work only castings, never copper band impressions, should be included in the master impression, because copper band impressions may be damaged (a) by the heat of the setting plaster, (b) by the removal of plaster impressions, (c) by the process of grinding the die material into shape after copper plating the impression, and (c) by incorrectly repositioning a but slightly damaged band with its die into the plaster impression. It follows that a preliminary impression must be taken over such copperband impressions in order to allow a proper wax up of CSP matrices and to obtain correct contours of the crowns. For full crowns, this is not necessary if the open thimble can be incorporated in the master impression.

To complete a simple cast crown after the "open thimble crown"-method, the contour of the crown is waxed up over the thimble, carved to proper anatomy and occlusion. The wax is then sprued and removed from the thimble for casting. The casting is adapted to the thimble and soldered. In order to facilitate soldering, a slight groove is made along the gingival border of the casting which scratches the thimble (fig. 102d). Thus the solder will shoot along this line without smearing the gingival margin of the thimble.

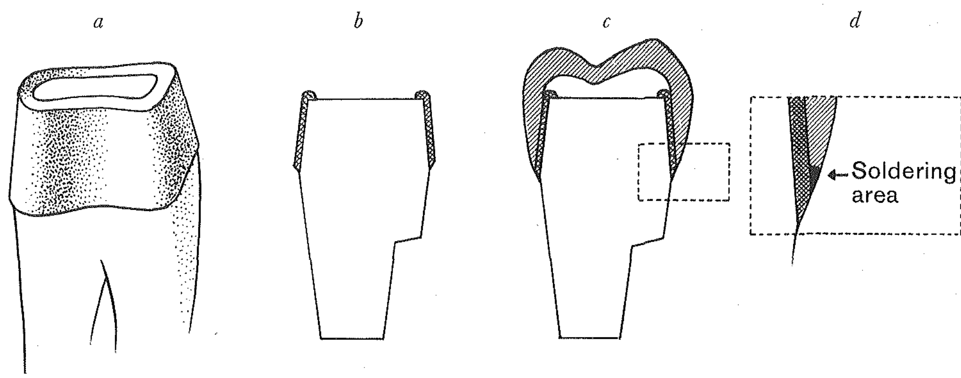


Fig. 102 Construction of an "Open thimble crown". *a* open thimble on molar abutment. *b* cross section of molar die with open thimble. *c* modeled crown on thimble, excess thickness of crown has been removed, hollowed out in the wax with Helix wax burs. Separate casting of crown is adjusted on the thimble and soldered along the margin. *d* detail of soldering area with soldering cut.

In CSP work, the matrix of the CSP attachment is waxed up over the thimble, cast and also soldered to it. However, this may prove to be difficult, where little space is available occlusally aswell as in lateral bulk of the crown. In such cases, the thimble is only used (a) to prove the accuracy of the indirect impression by its correct fit on the tooth, (b) as a means of correctly repositioning the die in the master impression, (c) to take the proper bite when establishing centric occlusion. It may then be discarded, and the CSP matrix may be waxed up directly on the model, instead of over the thimble.

BAND CROWNS

0.19 mm platinum band is used. After wire measuring the prepared tooth, the appropriate length of band is cut, and with the ends of the band tapered, the ring is soldered "overlapping", the same way as described for the platinum base of a Richmond crown. The band is adapted in the mouth and cut and filed to proper gingival fit. Then, the tooth is painted with vaseline, the ring placed on it, and selfcuring acrylic in doe consistency pressed into the occlusal opening. An excess of acrylic is used occlusally, to cover the margins of the ring. Before the polymerizing heat sets in, the band is removed with the acrylic which is left to set. A recheck in the mouth will make sure that no distortion has occurred. The acrylic is then trimmed and a notch cut into the occlusal rim of the band. Thus, the band may be used for the master impression. On the master cast, the band is removed and cut to a height of 3 mm. The stump on the model is covered with a thickness of tin foil which covers all areas except the one contacted by the platinum band at the gingival. The tinfoil facilitates removal of the waxed-up crown together with the platinum band.

Phase 2

INDIRECT MODELS DIES

In our assumed model case, all individual impressions, direct and indirect, have been completed. From the direct impressions, the castings are immediately obtained, while the indirect impressions require copper plating and the making of dies, on the basis of which the bases for the future crowns (open thimbles, post crown bases), will be waxed up. With the platinum band technic for full crowns, the bands are set aside for further use in the master impression.

Since this manual represents a study of advanced operative and laboratory technic rather than a textbook on well established school methods, it would seem unnecessary to go into details on the technics of copper plating impressions, assembling plaster impressions, pouring models and articulating them, on the waxing up of post crown bases and about the investing and casting process It may suffice to say that skill and adequate equipment must give first class results. Vacuum or pressure investing along with proper measurements of the water powder ratio of the investing material, correct preheating of the invested patterns and a good casting technic will yield satisfactory results as far as the mechanic's work is concerned.

Posts for post crowns should never be cast, but should be of a tough platinum iridium alloy. They should be turned round and conical by 2° from the axis, on the lathe. The bases should not be cast to the posts, they should be cast separately and soldered to the posts. Casting to a post involves overheating of the investment. With a perfectly round post, it may be repositioned without mistake or difficulty into the cast base. The amount of conicity mentioned, 2°, is ideal for the purpose. With more than two degrees, the post can be removed too easily, with less conicity, the depth of seat cannot be accurately determined because of the approximation to parallelism. Also a parallel post in an accurately congruent root canal will not let the cement escape unless a groove is made along the post.

CASTINGS

All castings are now tried in the mouth and checked for accurate fit (fig. 103). Occlusal interferences are ground in, and if necessary, a bite is taken. Wax bites have proven much too inaccurate for extensive work. In particular if one or both ends of the dental arch is cut down, out of occlusion, for the purpose of abutment preparation, a wax bite is completely unsatisfactory. The

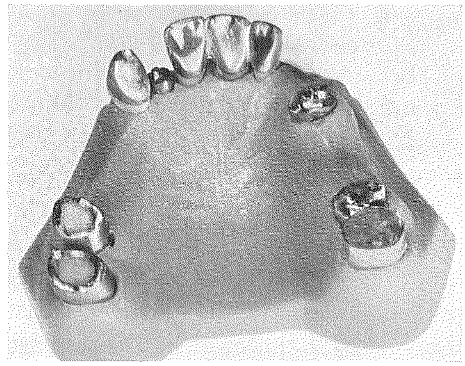


Fig. 103 Castings of the direct impression patterns, open thimbles for full crowns and post bases for the devitalized teeth have been adapted in the patients mouth and checked for accurate fit. The three adjacent castings on the front teeth have been already soldered. The platinum band with acrylic impression is re-seated into the mouth (+8). Everything is ready for the master impression.

most accurate results are obtained by bites of cold curing acrylic at different locations.

With the abutments in place, their surfaces and the surface of the opposing teeth are covered with vaseline. Cold curing acrylic is mixed to a heavy consistency, so it will not adhere to the fingers. Small lumps of acrylic are placed on the lower teeth opposing the abutments and the patient is asked to close. With large edentulous areas, the patient may not be able to find his proper centric. In such cases, a regular wax bite should preceed the acrylic bites. After chilling the wax bite, the wax is removed from the regions where the individual bites should follow. With the guidance of the wax bite, the patient will close on the acrylic bites and will be asked to open again only after the acrylic has set. The acrylic bites show a perfect detail of the occlusal pattern of both abutment and antagonist tooth.

BITE

MASTER IMPRESSION

The taking of the bite is followed by the master impression with impression plaster. Plaster is still the material of choice for master impressions where castings must be repositioned. The impression of the antagonistic dental arch may be taken with any of the conventional alginate, hydrocolloid or elastic rubber impression materials, which do not show distortion on removal.

Impressions, castings and bite then go back to the laboratory and the patient, with his temporary appliances in place, may be dismissed for the more or less long period which the technical procedure now will require. Before completion of the case, it may be advisable in certain cases to try in the facings of post crowns mounted on a plate of shellac or quicksetting acrylic.

Phase 3

The assembly of a plaster impression for a master model must be a most minute procedure (fig. 104). The impression plaster, covered by a damp cloth, should be left to harden completely before an attempt is made to assemble it. Then, every piece of plaster is carefully freed of debris by slightly scraping the surfaces contacting the tray, and by brushing the fragment surfaces with a stiff little brush. The assembly is first made without the castings in order to check if every interference has been removed. Then the impression is reassembled with the castings. Sticky wax fuses the impression to the tray and the casting to the plaster. The castings should be covered with vaseline on the inside, to facilitate removal. Pins of pinledges and three-quarter crowns are covered with tubes of german silver (fig. 105). The impression is then painted with a separating fluid and is ready to be poured. The areas which contain the CSP abutments are packed with quicksetting acrylic. This makes the model more resistant against breakage in the portions which will be subjected to drilling and milling on the parallelometer. While the acrylic is still soft, bent pins are stuck into it. These pins serve as retention for the stone plaster from which the bulk of the model is poured (fig. 106). MASTER MODEL

After removal of the impression plaster, the master model is trimmed. The first step on this model is to re-establish the working axis. A proper location for a hole in the model is selected, bearing in mind that this hole should not interfere with a palatal plate or bar. With the Planostat, the axis post with the nipple at its lower end is correctly positioned over the hole in the model. Cement is poured into the hole, and the axis is lowered into it. After the cement has set, the Planostat is removed, leaving the axis on the model.

This starts the use of the parallelometer, and if desired the Parallelofor, two instruments designed for the technique of CSP attachments (see p. 97, 93 resp.). PARALLELOMETER

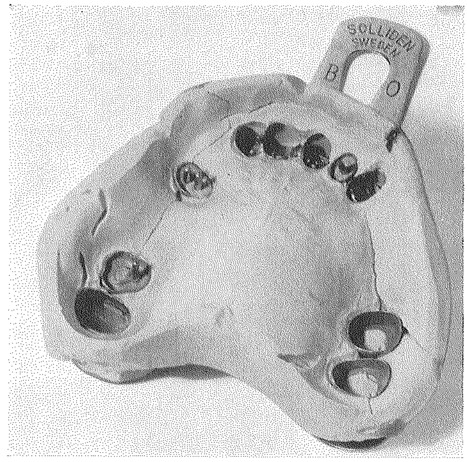


Fig. 104 Assembled plaster impression of abutments.

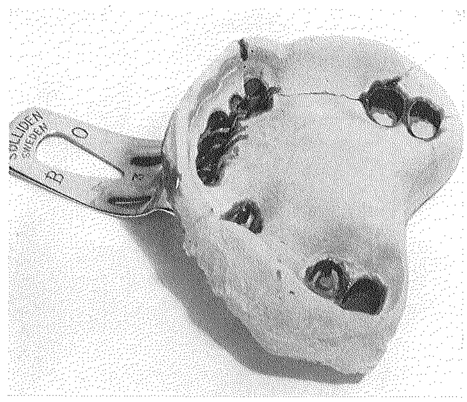


Fig. 105 The platinum iridium pins of the pinlay and the three-quarter crowns are fitted with corresponding tubes of German silver which are flattened and bent over at the end, for better retention in the plaster of the master model. The German silver tubes have an outer diameter of 1.0 mm, an inner diameter of 0.7 mm.

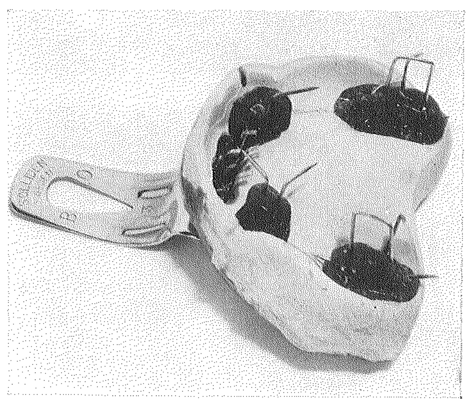
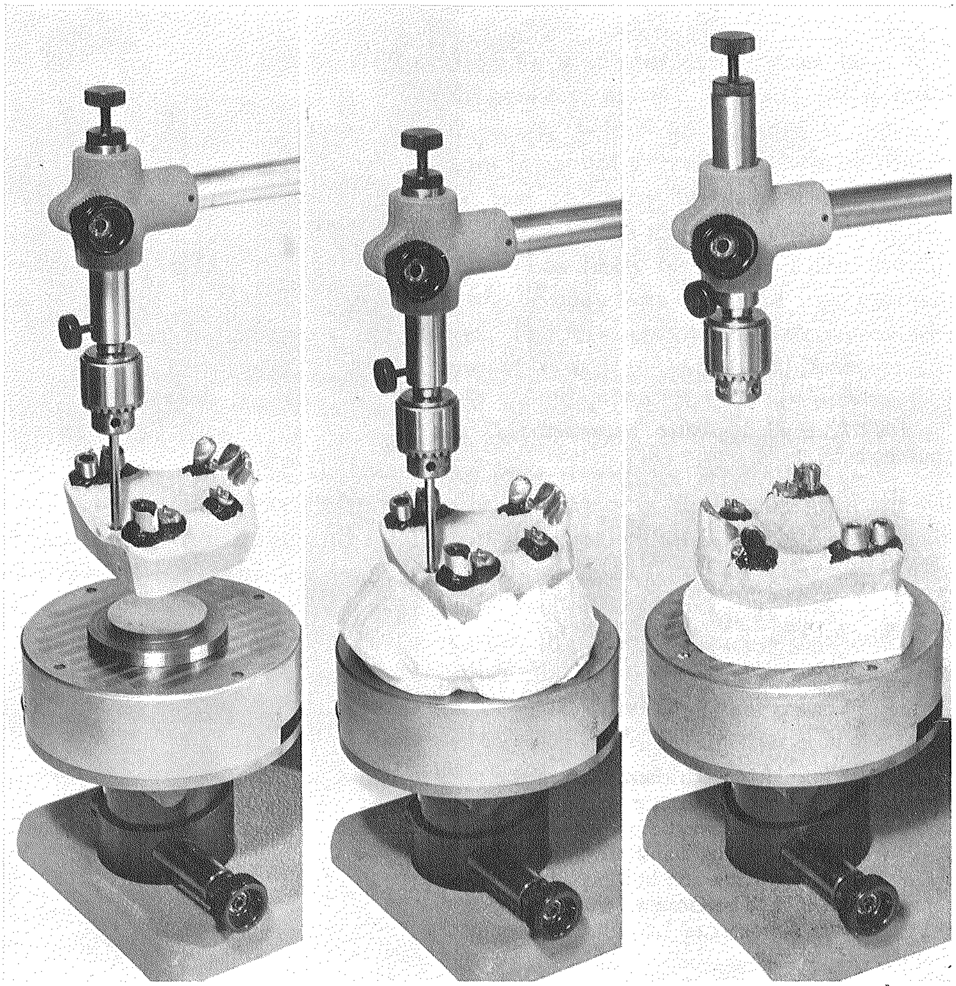


Fig. 106 The abutment areas are packed with a quicksetting acrylic suited to the purpose. Paper pins or nails bent over at both ends or shaped into U's are stuck into the still soft acrylic. When the acrylic has set, the remainder of the impression is poured in stone.



a b c

Fig. 107 a = after cementing the axis as shown in fig. 94 and described on p. 100, the master model is suspended in the parallelometer by the axis post. *The parallelometer table must at this point be absolutely horizontal and stay this way throughout the whole construction work.* The steel disc is placed below the model on the table.

b = a little mound of plaster has been placed over the disc, the master model has been lowered into the plaster which is left to set.

c = the new base is trimmed, the axis post is discarded and the model is ready for construction of the attachments.

Phase 4

THE CSP ATTACHMENT, CONSTRUCTION OF THE MATRIX

The axis post is screwed into the cemented nipple, and is then fastened in the chuck of the working head of the parallelometer. Thus, the model is suspended above the working table (fig. 107a). A steel disc is placed on the working table beneath the model, and a little mound of plaster is placed over the disc. The model is then lowered into the soft plaster by lowering the vertical beam of the parallelometer, and the plaster is left to set (fig. 107b). After trimming off the excess plaster, the axis is released from the chuck and removed from the nipple. With the base of the model perpendicular to the axis, and with the table in horizontal position, the master model is always perpendicular to the axis from now on, and the axis post may be discarded (fig. 107c). It is most important to check the working table for horizontal adjustment, before pouring the base for the model.

THE CSP ATTACHMENT ON THE FULL CROWN

The method for both kinds of crowns, cast (open thimble) crowns and for platinum band crowns will be described.

The platinum band of +8 is cut down to 3 mm from the gingival margin. The stump of the model is covered with tinfoil. Then, the crown may be waxed up. 8 7 + have been fitted with an open thimble as described previously, and the crowns are also waxed up to full contour (fig. 109). For easier carving,

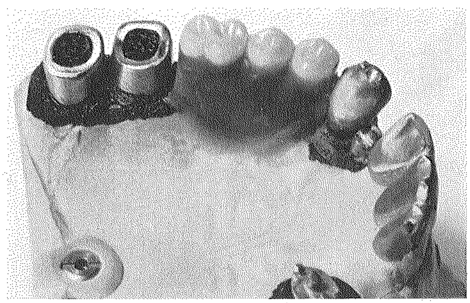


Fig. 108 Set-up of the missing teeth after having taken the bite on the patient.

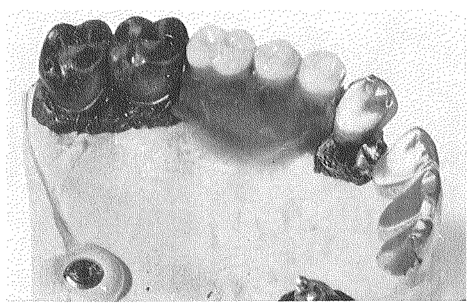


Fig. 109 Wax-up of the crowns to full contour.

each abutment may be transferred to a separate working model. The copper plated dies are used for this purpose. A special transfer holder, or a bur with a large, retentive head, such as a large circular saw, is fastened in the chuck of the parallelometer. The head of the bur is approximated to the casting and is fastened to it with sticky wax. After chilling of the wax, the casting is lifted off the master model by raising the parallelometer beam. The prepared die is inserted into the casting and is lowered into the plaster which has been poured on the separate disc on the working table (fig. 110, 111, 112).

Large or small models are now ready for the carving. The model is immobilized with the magnet, and a wax knife (fig. 113), fastened in the removable head of the parallelometer—the latter fixed in the pantostat—is carried over the surfaces of the wax crown, which require parallelization. On + 8 of our model, the entire lateral surfaces circling the crown, on 7 +, a surface from the mesial over the lingual to the distal or the crown require parallelization. For wax carving with the parallelofor, see p. 93.

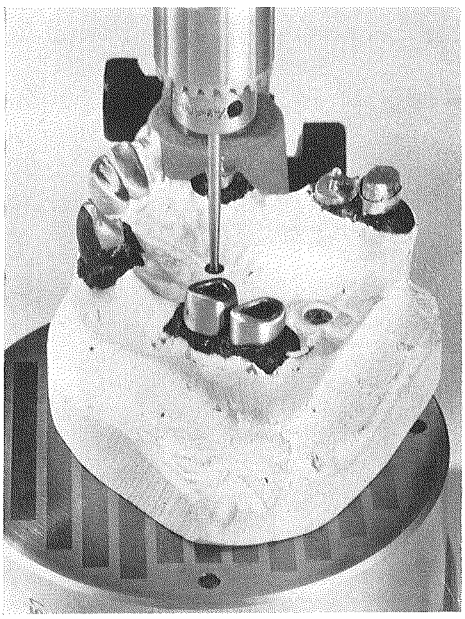


Fig. 110 and 111 Transfer of abutments to copper plated dies mounted on individual discs. This facilitates the waxing up of the CSP matrix and the drilling and milling procedures on the castings later on. The abutment is fastened with sticky wax on a large bur held in the chuck of the parallelometer. It is raised off the model, the die is inserted and lowered into the plaster on the disc.

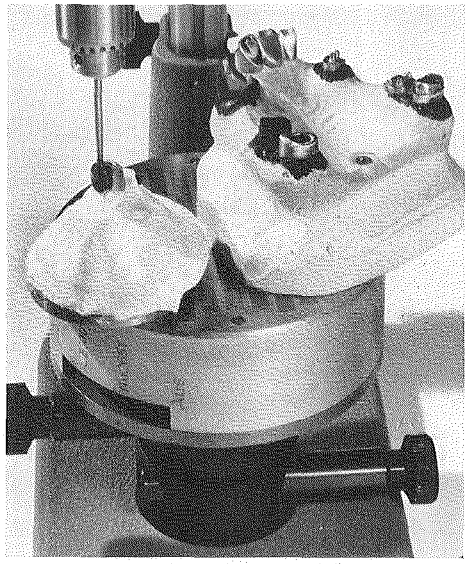


Fig. 112 When the plaster has set, the model is trimmed and ready for use.

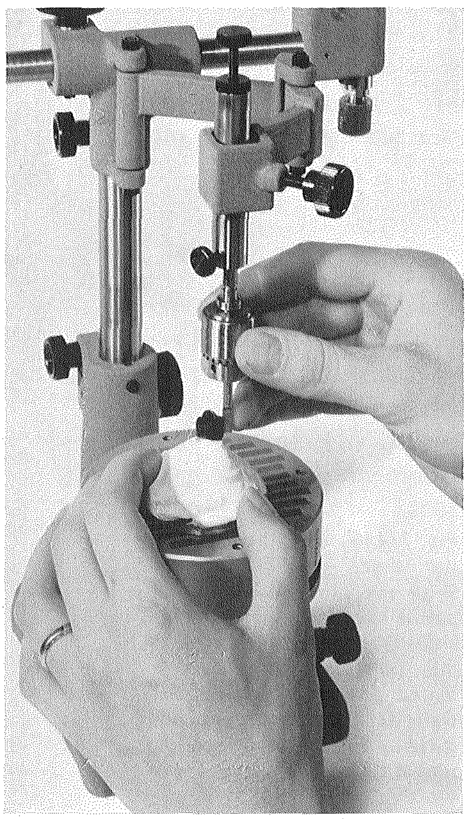


Fig. 113 With wax knives fastened in the large chuck of the parallelometer and through the use of the pantostat as shown here, the walls of the future CSP matrix are trimmed parallel. The best shaving angle must be tried out individually.

PIN SEATING

The next step is to seat the pins into the wax matrix. These pins of a special stainless steel (0.7 mm ⌀) will be left in the wax for casting and after removal of the casting, leave the guiding and pin channels in the surface of the matrix. Under "accessories to the parallelometer" the pin seater is listed (fig. 92g) which consists of a simple dental bur shaft with a bore of 0.7 mm at the forward end. The pin seater is fastened in the chuck of the pin seating head of the parallelometer.

The pin seating head is a telescope construction with a spring inside. This makes it possible to pull down the lower part, and the fixation screw immobilizes it in this position. By moving the pantostat and adjusting the desired height of the pin on the vertical tooth gear of the parallelometer, the pin is brought into the desired approximation with the waxed up crown. By rubbing the pin with a heated spatula on the outside, the pin gradually sinks into the wax of the crown (fig. 114). When it is almost flush with the wax wall, the

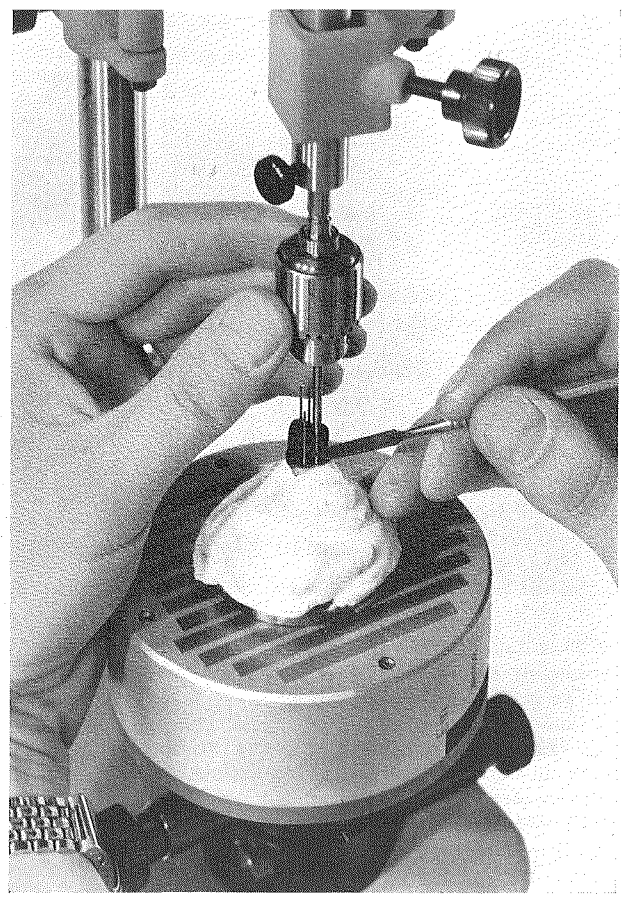


Fig. 114 Seating the pins into the waxed up CSP matrix. With the same set-up of the parallelometer, the pinholder is fastened in the chuck, and one pin after the other is seated into the parallelized walls at their appropriate location. The heated spatula makes them sink into the wax surface. Make rubbing movements along the pin.

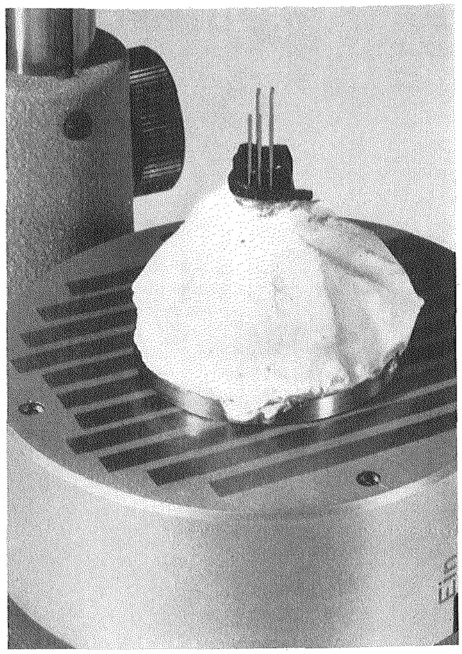


Fig. 115 At the chosen location for the shoulder, a semiround wax wire is adapted to the waxed up matrix and fused with the heated spatula. Fuse from lower side, leave upper side. Wax wire covers lower ends of pins.

fixation screw on top of the pin seating device is released and the head with the pinseater is retracted upward, away from the pin. The pin seating may also be performed with the Parallelofor (see fig. 87).

Thus, all pins are seated in their proper place.

WAX UP OF THE SHOULDER

Next, the shoulder is waxed up. A round wax wire is adjusted on the whole length of the parallelized walls. A small amount of wax flown into the gingival recess between wax wire and crown fuses the wire safely to the crown (fig. 115).

Nothing as yet is done to shape the concave rabbet towards the occlusal as described on p. 38. This will be prepared only in the casting. The pattern of the fully waxed up CSP matrix is sprued (fig. 116), removed from the model, vacuum invested and cast.

Fig. 117 shows such an unretouched casting. With a pair of pliers, the stainless steel pins are removed from the casting, a procedure which is without difficulty provided the pins were absolutely straight with no flash on their ends. In case a pin should break, it is easily and quickly dissolved in 50% hydrochloric acid. The casting is then placed back on the model. On open thimble crowns, the matrix is adapted over the thimble and soldered. The soldering should not touch the gingival margin but should be kept $\frac{1}{2}$–1 mm above it. A little groove cut along the lower margin of the matrix will facilitate soldering.

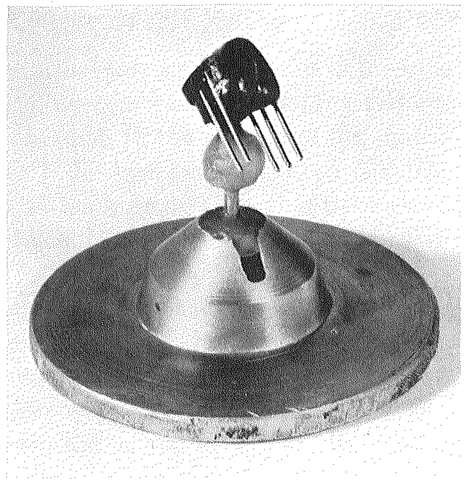


Fig. 116 Sprued pattern of CSP matrix with stainless steel pins.

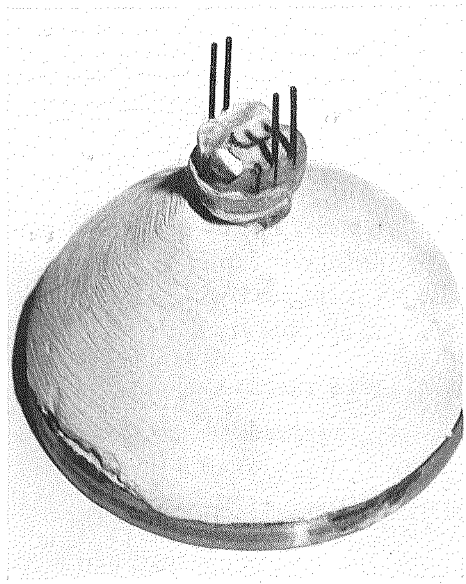
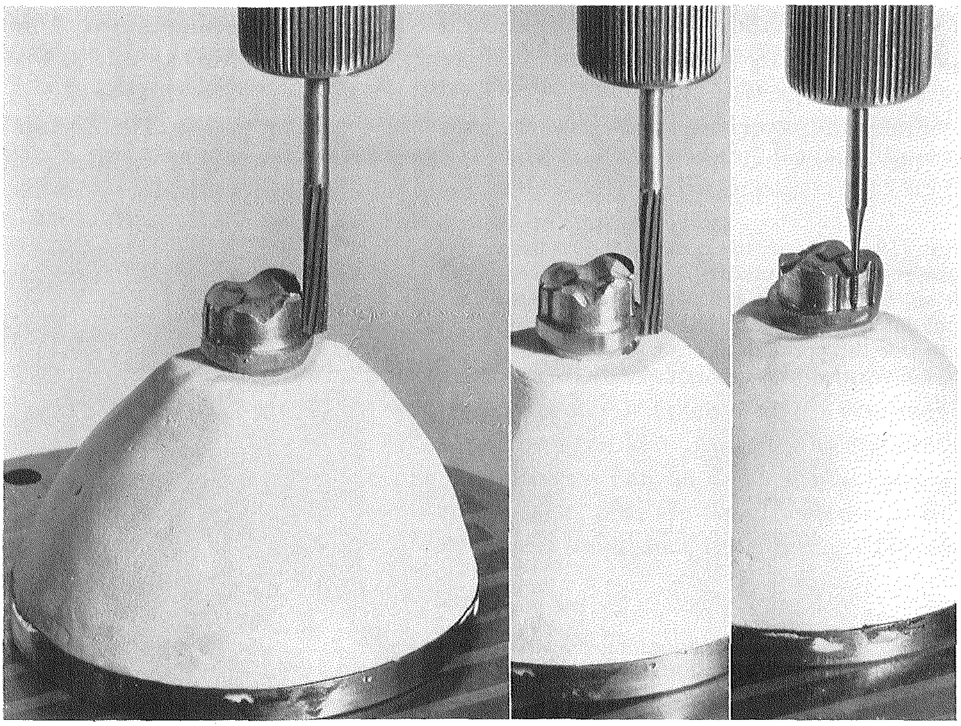


Fig. 117 Raw casting of CSP matrix. One of the stainless steel pins in the foreground has already been removed. The casting button is visible.

FINISHING OF THE MATRIX

With a mill as shown in fig. 118a the parallel walls are milled until there is an even surface. The proper technique for milling is to immobilize the working head of the parallelometer and to move the model in a direction opposite to the movement of the rotating mill. After the walls above the shoulder, the shoulder itself is milled on the outside. Thus, the "sealing wall" (fig. 118b) is obtained. The sealing wall is usually of a height of about 1 mm.

The channels are then cleaned with a 0.7 mm round end fissure bur and the sharp edges of the channels are broken into smooth roundings. The



a b c

Fig. 118 Milling of walls on the parallelometer: a = milling above the shoulder. b = milling of the sealing wall, outside of the shoulder and reduction of shoulder to proper width. c = cleaning of channels left by the stainless steel pins with a 0.7 mm ∅ round end fissure bur.

channels will now get their individual characteristics: The guiding channels, most frequently placed most buccally of the mesial and distal channels, end outside the shoulder at the gingival (fig. 118c). The pin channels, however, must perforate the shoulder as described on p. 36. If a straight perforation is possible, this is done with a 0.7 mm spirec drill on the parallelometer. If a straight perforation would perforate the matrix into the inside, the drill is only carried as far as it is safe without matrix perforation, and the remainder of the perforation is made at an angle from the outside into the pin channel fig. 33b, e.

For the beginner, probably the most difficult part is the finishing of the shoulder. As it must not be flat, but gutterlike, it takes some skill and practice to shape an even gutter. The round end fissure bur, mounted in the parallelometer will help to shape the shoulder, but the skilled mechanic will prefer to do this by hand. The best way to do it is to cut a wheel bur down to the proper thickness, and, with a mounted stone, grind the cutting profile to that of the shoulder (fig. 120).

Fine sandpaper discs will give the gutter the proper polish. The occlusal of the matrix has not been touched yet. If a CSP attachment on a crown,

Fig. 119 By hand, the depth of the occlusal groove has been precut, and on the parallelometer, its walls are parallelized. (Later polishing will make it just slightly tapering towards the occlusal.)

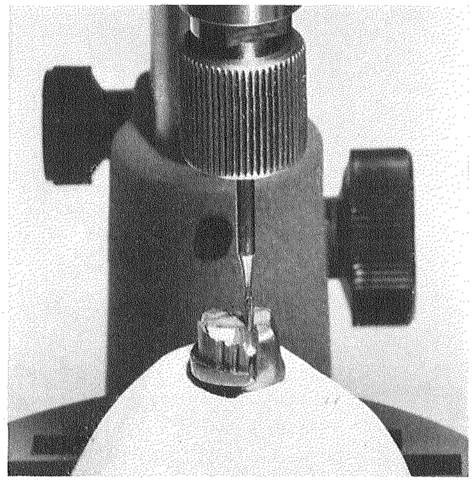
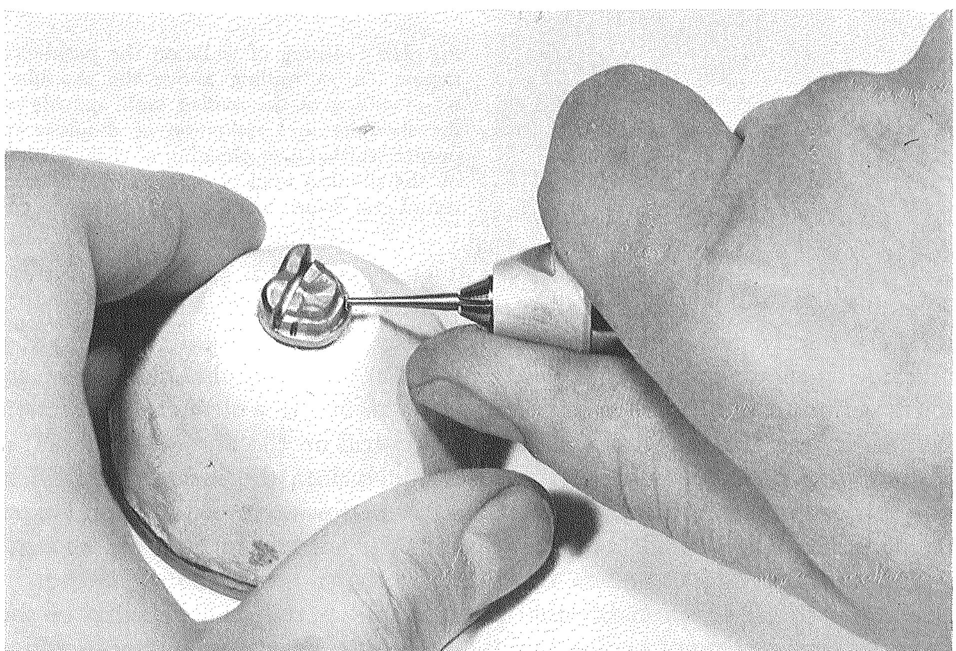


Fig. 120 The shoulder is fashioned with a wheel bur and rounded off with the round end fissure bur.



three-quarter crown or post crown is planned to receive an occlusal groove and bar, this groove is prepared into the gold of the matrix casting (fig. 119). It is roughly prepared by hand, then parallelized on the parallelometer. The last step is to prepare the shallow groove or rabbet which will give the CSP patrix the necessary bulk. It is prepared with a round head fissure bur and polished with discs (fig. 121). Finally, the whole patrix is polished to high finish with small felt wheels, brushes and polishing powder.

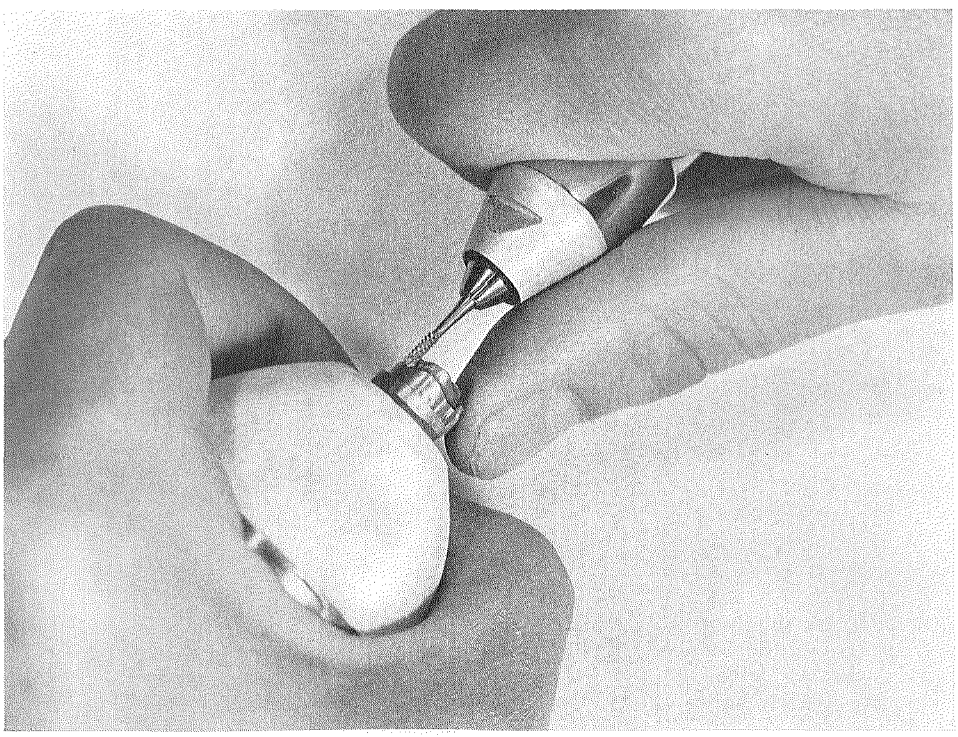
Phase 5

CONSTRUCTION OF THE CSP PATRIX

In cases where a cemented splint is planned, the matrices of adjoining CSP attachments must first be soldered. A plaster key is taken over the abutment constructions, these are removed, placed into the key, invested and soldered. In such cases, the patrix of several attachments can be done in one casting.

With the matrix on the model, stainless steel pins are again seated into the channels, but this time into the pin channels only, since the guiding channels

Fig. 121 The rabbet towards the occlusal of the parallelized wall is fashioned with a large round end fissure bur.



must be reproduced in the casting. They are but slightly waxed to the matrix (fig. 122). Instead of building up the patrix with wax, as it has been done until very recently, a new material most perfectly suited to the purpose (Dura Lay) is used (fig. 123). It is a quicksetting acrylic material which is being advertised for use in taking direct and indirect inlay patterns. As we shall see, it has most remarkable advantages over wax, as far as building up the CSP patrix is concerned.

The matrix, with the pins in place is coated with the special paste with a brush. With a little bit of Dura-Lay liquid in a dappen glass, and some powder in another, a small sable hair brush is dipped into the liquid, some powder taken up with it and applied to the surface of the CSP matrix. The material should be applied very wet. The crown is thus built up to its full contour, in fact, it is slightly overcontoured. Then Dura Lay is left to set to full hardness for half an hour. The pins can then easily be removed from the material, and with the model returned to the articulator, the occlusion is ground-in. Overcontour is reduced with sandpaper discs. This procedure of articulating is not possible with wax, because the removal of the pins would break the wax and without removal of the pins no articulation is possible (fig. 124).

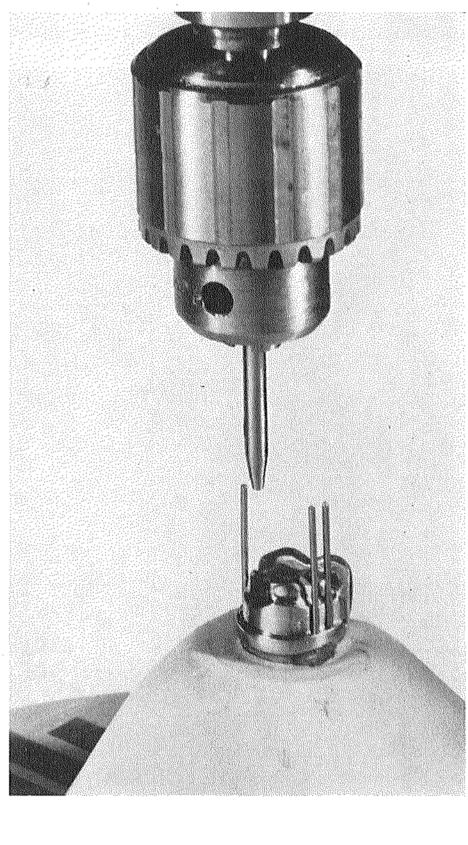


Fig. 122 New stainless steel pins are seated and waxed into the channels. Parallelism is merely checked with the parallelometer, since the channels are already supposed to be parallel.

Fig. 123 Material for the pattern of the CSP patrix: Brushes, Dura-Lay powder and liquid, a dappen glass for each, an eye dropper for the liquid, and lubricating paste for the matrix surface.

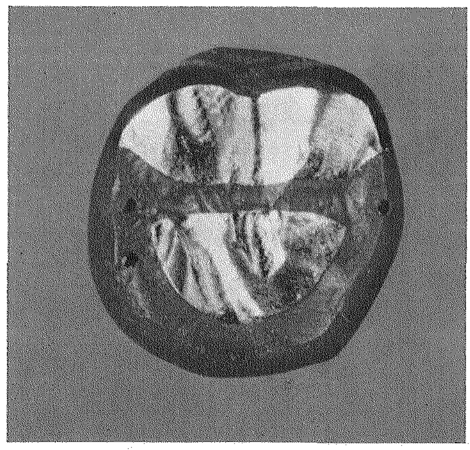


Fig. 124 Finished Dura-Lay pattern of patrix on finished matrix. Stainless steel pins have been temporarily removed from the pattern in order to grind the pattern into occlusion on the articulator. They are reseated into the pattern before investing for casting.

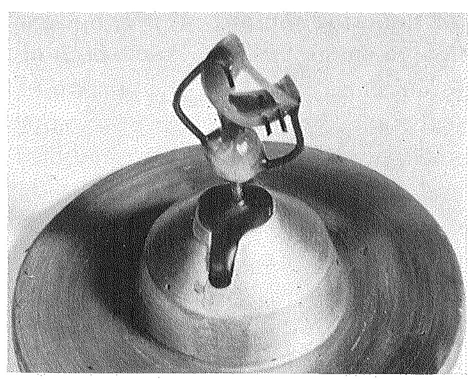


Fig. 125 Sprued patrix pattern, the pins are reinserted.

Since the Dura-Lay pattern is hard and rigid, there may be some difficulty in removing it. Preceding removal any undercut portions are cut away. The proper way to remove the pattern is to hold it with the fingers of both hands and have another person use a little wooden stick and hammer on different places along the gingival margin of the plastic material. After removal, a flaw less, shiny inside surface of the pattern is noticed. It is reinserted on the matrix the stainless steel pins are placed back into their holes and fastened with a drop of sticky wax. Again, the pattern, now with the pins in place, is removed and sprued (fig. 125). It may then be invested and cast.

Casting the patrix of a CSP attachment, especially a molar attachment, is a test for the investing and casting technique of the laboratory. With an improper technique, even if it seems to yield satisfactory inlay- and crown work, the CSP patrix will be difficult to fit to the matrix.

From the cleaned casting, the stainless steel pins are again removed and the patrix is carefully fitted to the matrix. Even with the best of technique, a fit without any small interference is not the rule. The casting techniques have improved considerably since Taggart first introduced it in dentistry, but the profession is still waiting for further improvement in accuracy. So, some small reliefs on the inside of the patrix are to be expected. Any excessive friction between patrix and matrix will prevent the complete assembly. The patrix is dipped into alcohol, heated to a dull red and left to cool (fig. 126). Dark oxides are formed on the surface. Any points of interference during insertion can be subsequently noticed as shiny spots which sometimes are detected only with a magnifying glass. Such spots are carefully and very slightly milled away, and the procedure is repeated until easy insertion and removal is possible. The outside of the patrix is polished, the pinholes left by the stainless steel pins are reamed with a jeweler's broach of proper dimension. The insider of the matrix is slightly polished with a brass wire brush on the handpiece.

The final pins of an elastic gold-platinum wire are cut to proper length and adapted into the pinholes until they slide in and out easily. One must make sure that they go all the way down to the end of the pin channel in the matrix. Their occlusal end is then bent over (fig. 127). Before investing the patrix for soldering the pins, it is again oxidized in order to prevent the solder from flow down along the whole length of the pin to the inner wall. With a 0.7 mm round end fissure bur, the portion of the pinhole which is to serve as soldering seat for the pin is freed of the oxide. After reinsertion of the pins, a drop of sticky wax on each will immobilize them for the removal from the matrix and for investing the patrix in soldering investment (fig. 128).

After well heating the whole soldering block, the soldering flame is directed to the head of each pin, so the solder will flow down to the desired depth. After cooling, the excess of the pins is snipped off from the patrix surface and levelled with a stone and sandpaper discs. With patrix and matrix assembled, the final polish is given to the whole CSP attachment crown.

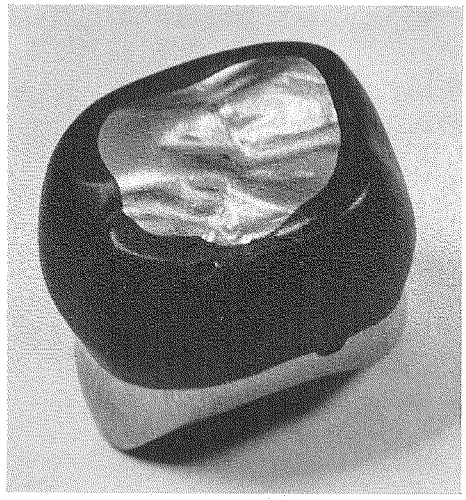


Fig. 126 Oxidized casting of patrix adapted to finished matrix.

Fig. 127 Pins of an elastic gold-platinum alloy have been inserted into the patrix, bent over at the top and fastened with sticky wax. The picture shows the patrix just slightly removed from the matrix with the permanent pins in place.

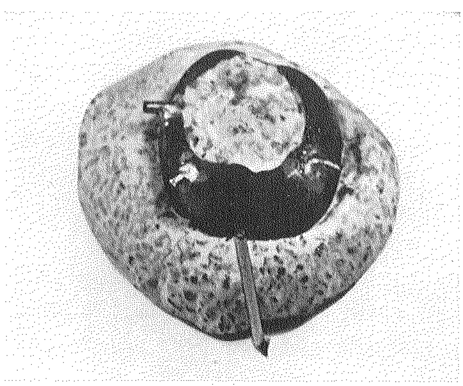


Fig. 128 Patrix shown in soldering investment with pins just soldered. On the oxidized patrix casting, only the surfaces to be soldered have been cleaned with a bur, so there is no danger of the solder shooting down along the pin and the inner wall of the patrix.

This method of construction for CSP attachments is applicable to all abutments from indirect impressions. It should be repeated, however, that before taking the impression for the master model, each abutment tooth should be fitted with its respective casting. For CSP abutments, this means that the matrices should be waxed up and cast on a tentative model, then be tried in the mouth, and then incorporated into the master impression. The exceptions from this rule are: (a) open thimble crowns, and any kind of post crown constructions, where thimbles or Richmond bases are tried in the mouth before the master impression is taken.

CONSTRUCTION OF CSP ATTACHMENTS ON CASTINGS FROM DIRECT IMPRESSIONS

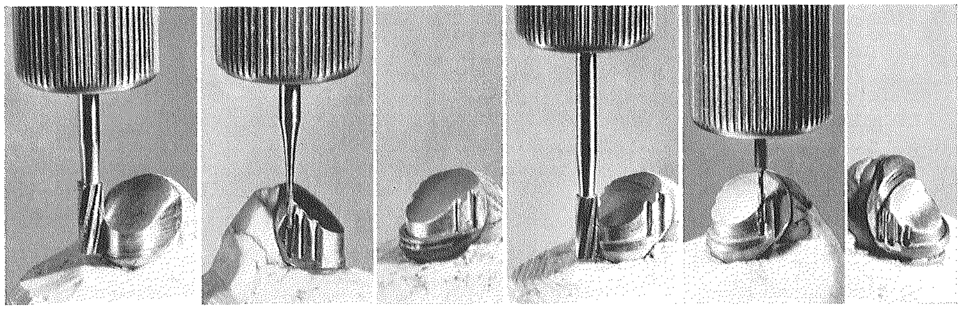
On our model case, there is one CSP attachment made on the base of a direct impression abutment, 3+. The method of taking direct impressions has been described on page 102.

On the master model, placed on the parallelometer table, the outside walls used for the attachment are milled parallel without paying attention to the shoulder (fig. 129a).

Into the parallelized wall, the channels are milled at their respective chosen locations. In order to do this and in order to prevent the bur from slipping all over the surface, a start for each channel should be done by hand before attempting to use the parallelometer. With this start made, the bur, when used in the parallelometer, will bite more readily without slipping off. The depth of the channels should be half of their diameter, or 0.35 mm. 0.7 mm round end fissure burs are used (fig. 129b). The shoulder is made from a round wire which is accurately adapted around the casting at the proper height. Free soldering will fasten it to the crown. The gingival recess between wire and casting is either filled with solder, or a thinner wire is laid into the recess and soldered (fig. 129c).

The shoulder thus obtained is finished as described earlier (p. 124) with the "sealing wall" milled on the outside of the wire (fig. 129d). On the parallelometer, the pinholes are drilled through or into the shoulder according to the anticipated opening (fig. 129e). On 3+ it should be noticed that the channels on the outside of the matrix correspond with the location of the channels in the abutment preparation, thus a minimum thickness of the matrix is required, something which will prevent overcontouring of the patrix.

It is a matter of experience to properly contour the direct impression patterns in order to allow for the proper design of the attachment. The beginner will feel safer if he rather overcontours his patterns, so he will have enough bulk to work on. The thickness of the matrix must constantly be checked with callipers during the drilling and milling process. Perforations, if not too large, can easily be soldered, but working without perforations most certainly is preferable and less time consuming! Callipers measure the thickness of the walls to $^{1}/_{10}$ mm close (fig. 66).



a b c d e f

Fig. 129 Fashioning of the matrix for a CSP attachment on a cuspid on a casting from direct impression pattern. (a) The wall of the matrix is milled on the parallelometer. (b) The channels are made with 0.7 mm round end fissure burs. (c) One or two wires are adapted to the matrix wall, then soldered, to form the shoulder. (d) The sealing wall on the outside of the shoulder is milled. (e) The pinholes through the shoulder are drilled with 0.7 mm Spirec drills. (f) The groove from mesial to distal is cut by hand.

The above procedures are the only ones which differ from the ones described earlier. Thus the remainder of the technique, after walls, shoulder and channels have been completed, will not be repeated.

For a continuous CSP attachment on front teeth, a comparatively rare construction, the whole splint is first soldered, and only then the attachments are milled into the gold (fig. 29).

Another method of incorporating the pins into the attachment is described by P. Frei: Instead of incorporating the stainless steel pins into the waxed up matrix of the CSP attachment, the latter is waxed up without any pins. After casting and finishing the matrix, now without pin channels, the patrix is completed, thus yielding a CSP attachment without pins, pin channels or pin holes through the shoulder. The location of the necessary pins is determined, the working model is placed on the parallelometer table in such a position that the spirec drill in the drill chuck points to the occlusal starting point of the future pin channel on the matrix. Since the pin channel will lie half in the matrix and half in the patrix, the relative position of drill and matrix must be established accordingly. Now, the magnet lever on the parallelometer table is pushed into On-position, and the model with the CSP matrix is thus immobilized in the chosen position. The patrix is inserted over the matrix and the drill lowered into working position. A center mark is made where the drill touches the patrix and now the pin channel may be drilled to the desired depth. The depth must be established on the matrix previous to the insertion of the patrix. The millimetre scale on the drillhead of the parallelometer serves this purpose. Drilling must never be done without proper lubrication of the spirec drill (eucalyptus oil) because an unlubricated drill factures easily. A fractured drill can usually only be removed by dissolving it in acid. After the pin channels have been completed to their desired depth, the platinum-gold pins are adjusted and soldered to the patrix as in the previously described technic.

This method may be time saving for the advanced and skilled technician, while for the beginner, it bears certain dangers: Fracture of drills, inaccurate position of the channel, either too much in the matrix (perforation) or too much in the patrix (poor guidance of the pin). In the hands of the accomplished mechanic, this technic is very rewarding.

In our model case, abutments with and without CSP attachments are now finished, the bridge between +1 and +3 completed (fig. 13o). For bilateral stabilization, a palatal bar can be made. After comparison of the model with the mouth, soft portions of the palate are scraped on the model, and hard portions slightly relieved (tin foil of appropriate thickness). The palatal bar is waxed up with sheet wax, and proper retention for the acrylic is secured. After casting, a plaster key is taken of the palatal bar and of all CSP attachments. By placing the bar and the attachment patrices into the plaster key, the proper position for soldering them is found. The replacing teeth are set up on the now completed structure of the removable partial, and the acrylic is processed in the usual manner (fig. 131, 132).

This model case has been chosen for the one and only purpose of demonstrating a working procedure on different kinds of abutment teeth and abutment constructions. This should be made clear, because naturally, there are a great variety of solutions for restoring this particular case, and the reader might be tempted to say: Why go to all this trouble to solve this case in this way, while a simpler solution would do equally well. This solution may be chosen for quite definite reasons derived from intraoral and X-ray examinations, from the standpoint of biostatics. The model case was, however, not chosen for these reasons, but for the sole purpose of *technical* description. The chapter on planning cases and the illustrations of completed cases will satisfy the reader on the indication of certain combinations of splints and attachments.

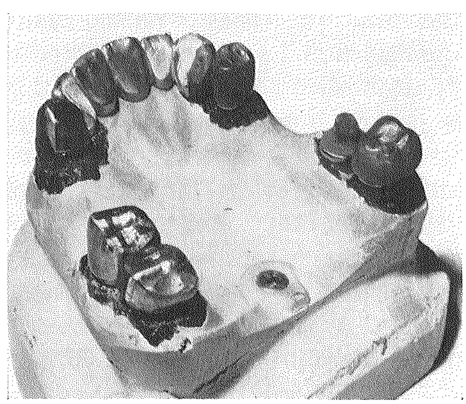


Fig. 130 All seven attachments are fitted. The patrices are made visible by the darker shade (oxidized).

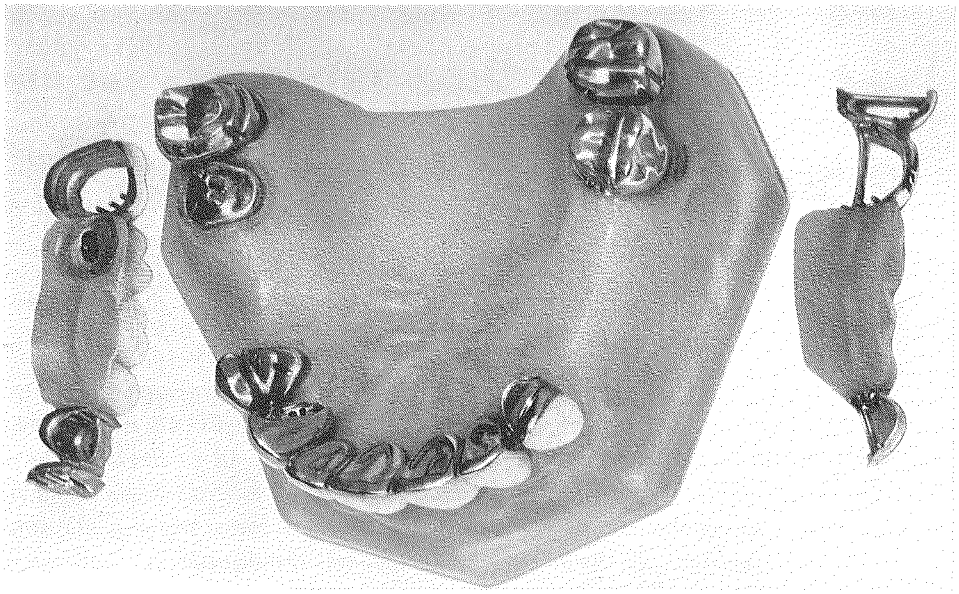


Fig. 131 Finished case with the two bridges removed.

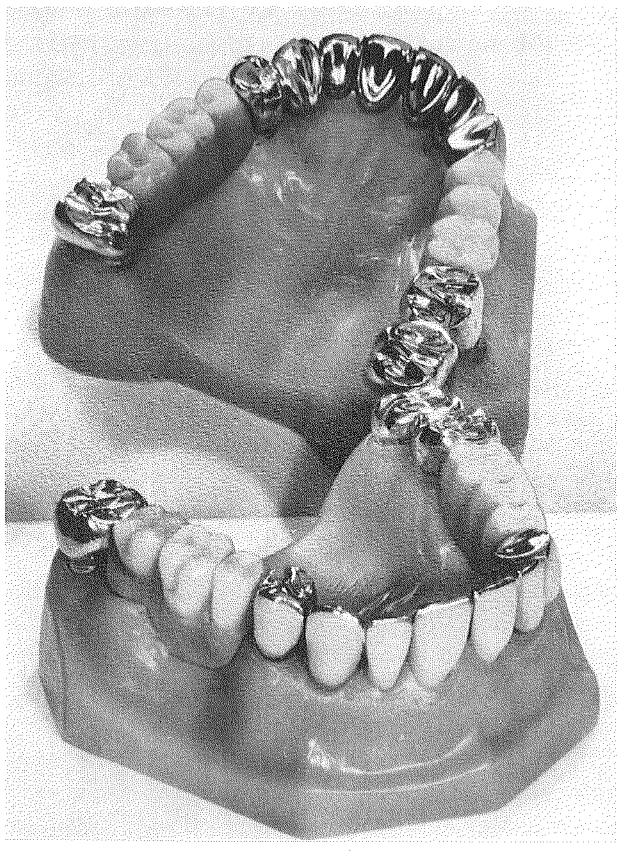
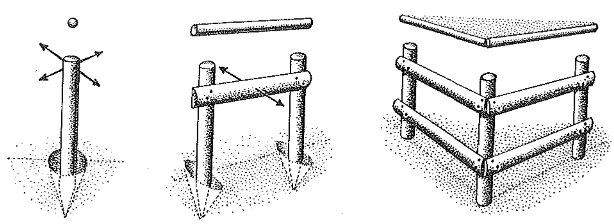


Fig. 132 Case finished and assembled. On special indication, the two bridges could be joined to one denture by a palatal bar or plate. Note the minimum of gold showing in the splinted incisor- and cuspid region.

CHAPTER IV

THE BAR ATTACHMENT

One of the main goals the dental profession seeks to reach in partial denture prosthesis is no doubt to increase the stability of the damaged tooth arches, to make them as fit as possible for the task of bearing an additional amount of masticatory stresses. The teeth most endangered by the conventional clasp methods are the ones immediately adjacent to an edentulous area and in particular the completely isolated teeth with no immediate neighbours on either side. Such denture supporting elements are usually doomed to premature extraction unless their stability is artificially increased by splinting them *permanently* into groups with other abutments. The best example for the principle of splinting is the simple fence (fig. 133).



a b c

Fig. 133 Principle of splinting. (a) A single fence post can easily be loosened by moving the top in all possible directions; (b) two fence posts joined by a crosspiece represent a linear anchorage, movement in one direction only; (c) three fence posts arranged at an angle and joined to each other represent an anchorage on a triangular plane, and loosening or displacement is almost impossible by horizontal movements.

A single fence post may easily be removed from the soil, if small movements are carried out in different directions. It will take considerably more effort to remove two fence posts joined by a cross bar. The fence will be even more, considerably more solid, if the fence posts are not standing in linear, but staggered alignment. In other words, if teeth are splinted in linear alignment, they will be more stabilized than if left unsplinted, but if there is a possibility to splint them into a supporting plane instead of a supporting line only, the stabilization will be at its optimum. This principle is applicable to the fixed bridge, but many cases in our daily practice prove to be out of the range of indications for fixed bridgework.

Contraindications for fixed bridgework are:

(1) Excessive width of the edentulous areas, in connection with an insufficient number and biostatic quality of abutments.
(2) Periodontal disturbances from bad mouth hygiene or inaccessibility of the soft tissues surrounding the abutment teeth.
(3) Excessive loss of bone and soft tissue, from operations, extractions or various forms of atrophy.
(4) Doubtful prognosis for certain abutments in connection with the periodontal condition or devital status of the roots.
(5) Esthetic reasons.

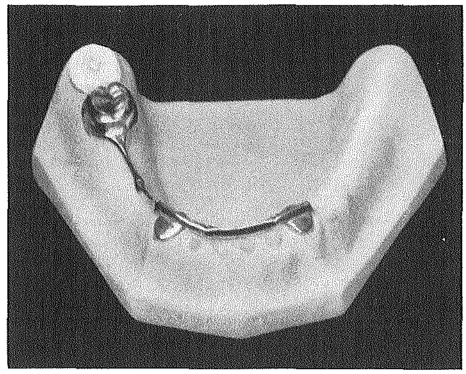
The Bar attachment is a splint which reaches across edentulous areas without being a food trap. It splints the abutments permanently. Experience has shown that the splinting action of the removable part alone is far inferior in effect than the splinting action of a permanent, cemented splint. It has been said earlier already that the small unphysiologic movements to which the abutments are subject when inserting and removing a partial denture, are harmful to the periodontal health of these teeth, especially if their number is limited to a few. The Bar attachment was inspired by earlier designs like the Fossume attachment, the Bennet blade and the Gilmore attachment (fig. 3).

It has been claimed that a minimum of 6 abutment teeth is needed for a durable partial denture. This general rule should be modified inasmuch as it may apply (with exceptions) to front teeth. If only front teeth are left, these are more or less in linear alignment or rather the supporting plane formed by the teeth is very small. Forces displacing such a splint of front teeth frontodorsally may eventually loosen them unless anchorage is found in a sufficient number of abutment teeth. If, however, the abutments are arranged so as to form a large supporting plane (fig. 134a) a lesser number of abutments will be required in order to give sufficient stability.

To make this point quite clear, the case shown in fig. 134 should be explained. The two cuspid abutments were more than doubtful when the case was started. They were abutments to a fixed lower anterior bridge, loosened to a certain degree by the masticatory forces from the upper front teeth. Unlike the model case, the patient had only one molar left. Beyond doubt the bar splint has brought about a stabilization of the cuspid abutments by joining them to the molar abutment. 6 years of use have not shown any damage, but, on the contrary, X-rays show evidence of improvement of the abutments and their periodontal tissues. During the 6 years, the hinge joint for the resilient saddle part of the denture was replaced twice because of lateral wear (a disadvantage of all stressbreaker joints which are not bilaterally stabilized.

The Bar attachment consists, the same as the CSP attachment, of a matrix and of a patrix. The matrix is a bar, approximately rectangular in cross section, which spans edentulous areas between bridge abutments. The patrix

a



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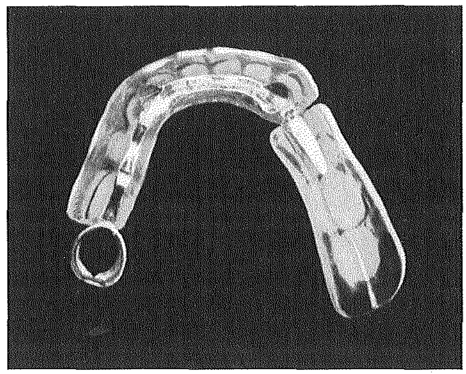

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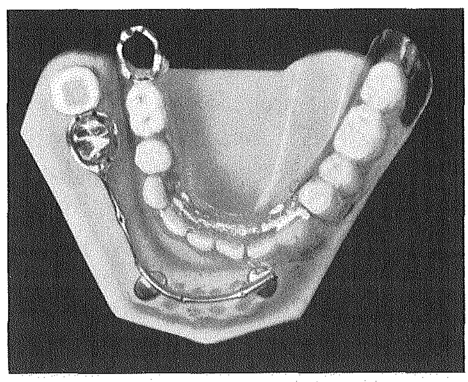


Fig. 134 Model of actual case now worn six years, with three abutment teeth, molar vital, two cuspids devitalized. Toothborn section supported by Bar attachment, mucosa born saddle stressbroken by hinge joint.

is a reversed U-shaped casting which fits over the bar, carries the acrylic and the teeth of the denture. The friction between matrix and patrix is given by frictional pins arranged in various ways and at certain intervals (fig. 135).

The Bar touches the gingival tissue of the alveolar crest; it follows its prominences and depressions, while the occlusal surface may be kept more or less straight between the abutments. It follows that the height of the Bar varies with the height of the alveolar crest. Both the buccal and the lingual (palatal) walls are parallel to each other. The Bar attachment may be used alone or in connection with CSP attachments. In the former case, the frictional retention of the denture will depend on the frictional pins of the Bar attachment alone, while in the latter case, the pins of the CSP attachment will complement whatever number of frictional pins are incorporated into the Bar attachment. They slide either into pinholes drilled through the bar, or along channels in either lateral wall of the bar (fig. 135b).

For teeth with an uncertain prognosis, the bar may be constructed removable from the base, so at any time that it would seem necessary to remove an abutment tooth, one might do so without having to destroy the cemented work (fig. 178, O. Staehelin).

CONSTRUCTION OF THE BAR ATTACHMENT

The Bar attachment may be used in connection with vital or with devitalized teeth. *The principle of keeping the vitality of abutment teeth should never yield to constructional motives for devitalizing them.*

First, the abutments are prepared and fitted with their primary abutments such as CSP matrices, cast caps with posts. Then the teeth are set up on the articulator and tried in for articulation and esthetics. A plaster key retains the position of the teeth on the model, the wax is removed and the bar may be planned within the limits given by the position of teeth, gingival tissue and the prospective bulk of the whole appliance. Porcelain or plastic teeth may be used. Where the space is ample, porcelain teeth are preferred because of their superior quality. Since the denture is removable, the replacement by acrylic teeth is admissible. If attrition wears them down, they can be easily replaced, and they offer the advantage of needing less space.

Often a compromise is made by using porcelain molars and premolars along with plastic front teeth. Thus, there is no danger of attritional loss of vertical dimension.

On the model, the region where the bar will touch the tissue is relieved in order to allow for polishing of the casting and in order to have the bar *just slightly* impinge on the tissue. At chosen intervals, holes are drilled—by means of the parallelometer—into the ridge of the alveolar process on the model (drills of 0.7 mm ⌀ are used). 0.7 mm stainless steel pins are seated into these holes, and subsequently the bar is being waxed up to its full extent.

The walls are parallelized with wax knives on the parallelometer, with re-enforcements around the pins. These re-enforcements compensate for the loss of material in the pinholes or pin channels. Several sprues are attached at

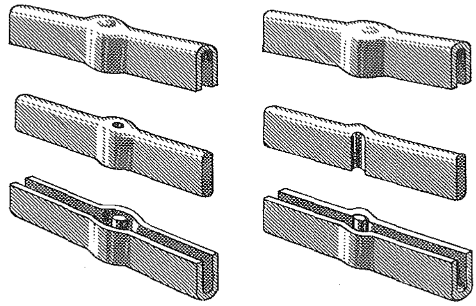


Fig. 135 Principle of Bar attachment: Left row: *a* patrix, *b* matrix, *c* patrix from below, Note the reenforcement of material around the pinholes. Right row: Modification of the frictional element. The pinholes are replaced by channels, and the pins stand close to one wall of the patrix instead of in the middle.

chosen intervals, and the bar removed together with the stainless steel pins. Investing and casting follows.

Without removing the pins, the casting is seated back into position on the model, which is facilitated by the pinholes in the plaster. A plaster key is taken over bar and adjacent abutments, the parts are removed from the model, reseated into the plaster key and invested for soldering. After soldering, the stainless steel pins are removed and the case is placed on the parallelometer table for finishing. With mills the walls of the bar are smoothed and perfectly parallelized, taking good care that the re-enforcements around the pinholes are not weakened. The edges of the pinhole openings are rounded and the pinholes may be checked for proper parallelity by means of 0.7 mm drills on the parallelometer. The pins must easily slide into the holes, so, for practical purposes, the pinhole diameter will be between 0.7 and 0.72 mm wide. The combined friction of all pins will then still be ample for proper retention. The bar with soldered abutment constructions is then removed from the model. Its gingival and occlusal surfaces are rounded at the edges, gingivally because we do not wish to have tissue irritation by sharp edges, occlusally because the patient, with his denture removed, should not feel sharp edges, and because rounded shapes are more easily cast. As discussed earlier in the chapter on cavity preparation, castings follow rounded contours better than sharp edges.

Finally, all surfaces are polished to a high finish.

Before waxing up the patrix, the removable part of the Bar attachment, the patrices of the adjoining abutments, if any, should be completed and polished.

The patrix of the Bar attachment may be made either in wax or in Dura Lay. In wax, a piece of sheet wax (thickness 0.4 mm) is adapted over the bar by slightly preheating it and pressing it on the bar surface with a warm damp cloth. Excess is trimmed away and the stainless steel pins are inserted into their respective location. The pins are fastened with a small drop of sticky wax, which will give the casting the re-enforcement necessary for sufficient soldering bulk. When, ultimately, the platinum-gold pins are soldered into the Bar attachment patrix, this slight bulk will give sufficient soldering retention. In sprueing, the sprues must form a splint which prevents distortion of the pattern during removal from the model and during investing.

If, instead of wax, Dura Lay is used for making the patrix pattern, the pins must be inserted first, and the material applied as previously described for the CSP-attachment patrix. Removal will be slightly more difficult, but on the other hand, breakage during removal is practically nonexistant.

After investing and casting, the stainless steel pins are removed with a pair of pliers and the casting is carefully adapted on the bar. On long bars, slight reliefs may be necessary where the friction is too strong. The outside of the casting is not finished, but only thinned out where the thickness is excessive in order to eliminate unnecessary bulk and weight. A finishing groove for the acrylic on the lingual (palatal) side is made if this has not already been done during the waxing up procedure. This finishing groove should be a retention for the acrylic, in order to prevent a flaring and unstable edge of the acrylic (fig. 136).

The labial (buccal) side of the casting is pricked with a jeweller's prick in order to create sufficient surface retention for the acrylic (fig. 137, 138).

(*Note:* A jeweller's prick must be of good steel and sharpened to an angle of 30 degrees. The dental mechanic should familiarize himself with the procedure on some piece of used gold. The pricklings should not be longer than 1 mm from base to tip, and not deeper than about 0.2 mm, and should have varying directions.)

If stressbreaker joints are indicated because of free end saddles, these are now placed into proper position and soldered to the patrix. A hinge does not require a lingual or palatal bar for contralateral stabilization, while all other designs do. The hinge on the other hand is subject to more wear than a bilaterally stabilized appliance (see also p. 211).

The casting is then soldered to the adjoining CSP patrices upon which the final step, the soldering of the platinum-gold alloyed pins follows. Before inserting the pins, all portions of the casting adjacent to the soldering area are painted with an antiflux (pencil). The pins are inserted, their occlusal ends bent over and fastened with sticky wax. These bent-over ends may afterwards be snipped off or used as additional retention for the acrylic, provided they do not interfere with the position of the teeth.

Matrix and patrix must be heat-treated.

Before setting up the teeth, it may be wise to try the splint in the mouth, so any parts of the castings impinging too much on the mucous tissue may be detected and removed. Relieving the model before waxing up the bar is done more or less arbitrarily and the amount of plaster scraped off does not always coincide with the amount of polishing and the degree of tissue resilience at every place of gingival contact.

The teeth, retained in their try-in position in the plaster key are then waxed up by flowing wax between teeth and Bar attachment, and the case is then processed in the conventional way.

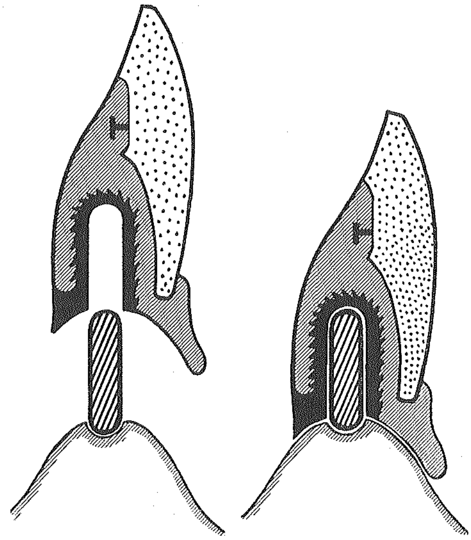


Fig. 136 Cross section through a removable Bar attachment case in the incisor region. The picture on the left shows the removable part placed above the bar and alveolar tissue. In black: The casting which fits over the bar. Shaded: The acrylic cured over the casting and retained by the pricklings in the gold surface. Dotted: Porcelain facing. To the right, the case in situ inserted.

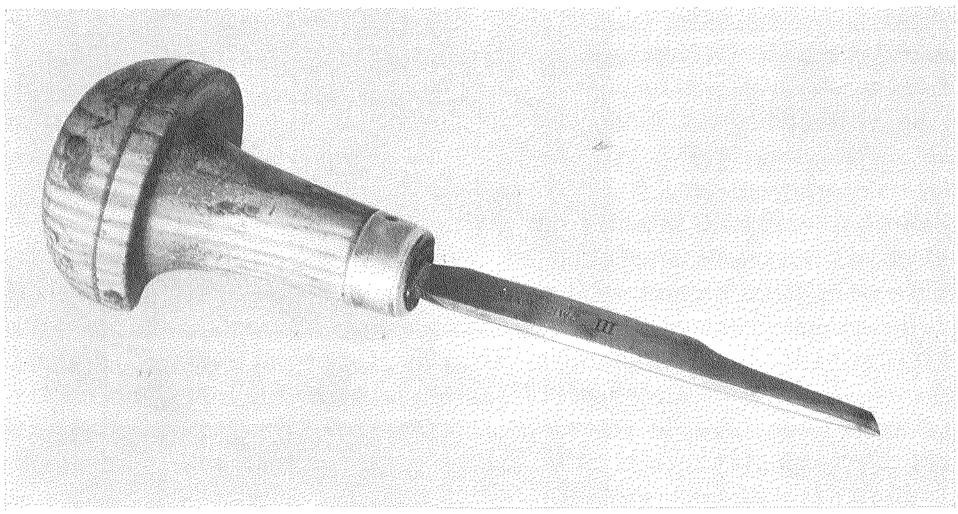


Fig. 137 Jeweler's prick to prick gold surfaces to make them retentive for acrylic resin.

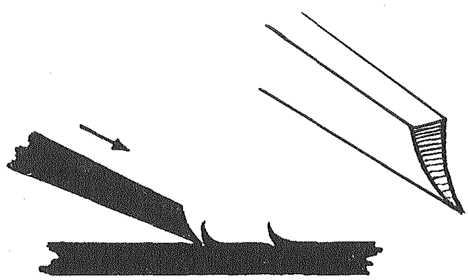
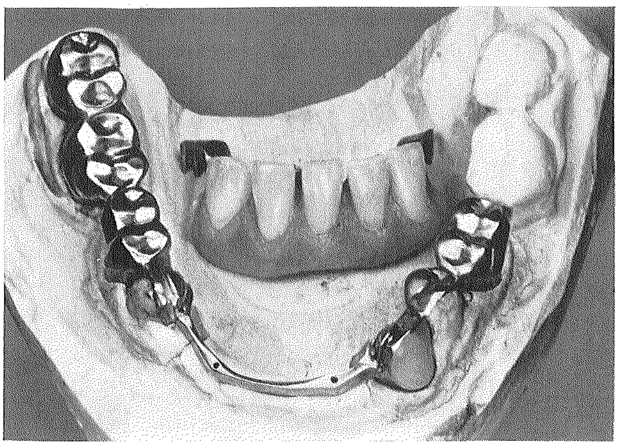


Fig. 138 Tip of jeweler's prick working on gold surface. Cut: Profile of prick tip.

a



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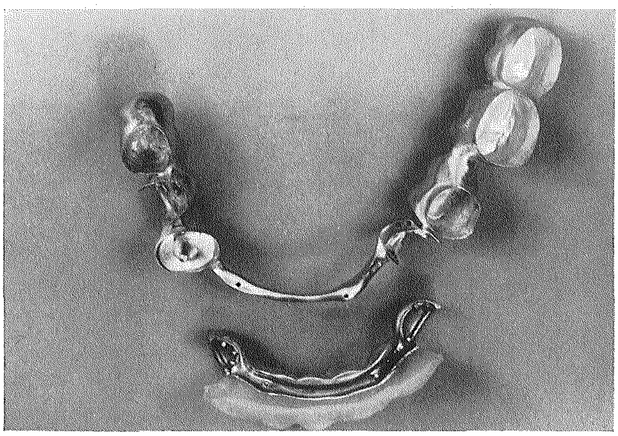

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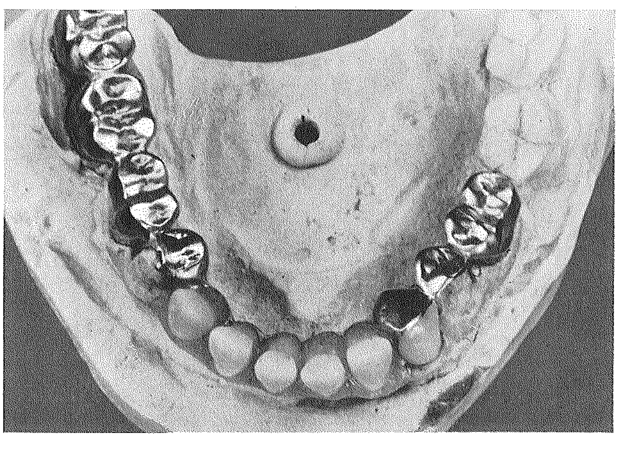


Fig. 139 Case of edentulous lower front region. The solution with the Bar *b* attachment combined with two CSP *a* attachments offers the best of stability along with perfect esthetics. Case 2 for text p. 178.

CHAPTER V

RESILIENT PARTIAL DENTURES

Partial-Denture Prosthesis is—strangely enough—a part of dentistry where principles have changed very little, compared to the general progress in science, materials and equipment. The comparison of textbooks written some twenty years ago with recent work show very little basic difference in the concept of clasp or attachment design. The new chromium-cobalt alloys with their unprecedented hardness and durability have done nothing but increase the persistence on the old principle of rigid anchorage for every case of partial prosthesis. The one-piece casting of such appliances make their construction simple for commercial and private laboratories, and the success of these appliances largely depends on the reduction of cost and of repairs. The achievements these new casting alloys have brought about are incontested and it would be unjust to belittle their value for a well defined group of partial dentures, the entirely toothborn partial denture. There, the principles and techniques as developed by TAGGART, AKERS, ROACH, SWENSON and others are in full accordance with what may be termed Dental Biostatics. The toothborn partial denture of the one-piece casting technique is an inexpensive substitute for the fixed bridge or the precision attachment bridge or partial denture. The other large group of partial dentures are the appliances which include saddle portions riding on the mucous tissue surface of edentulous areas. Such edentulous areas may be found as uni- or bilateral distal extension saddles or as large gaps between natural teeth (see p. 177, fig. 172). This group falls into the range of indication for the "Resilient Partial Denture".

RESILIENCE

Resilience, as referred to in prosthetics, is the property of the mucous tissue to yield in a smaller or larger measure, to the pressure received from the base of a denture in function and to "bounce" back after the pressure is relieved. Responsible for that property is the elasticity of the tissue covering the alveolar bone, and its vascularisation. The thicker the layer of soft tissue, the more resilience we find. The measure of resilience is in no relationship whatsoever with the physiological mobility of a tooth in its socket. In fact, the resilience of the mucous tissue of the alveolar processes ranges between 0.4 and 2 mm as against a resilience of 0.1 mm of a healthy tooth in its socket. The tissue resilience is 4 to 20 times the axial displaceability of an abutment tooth! This fact is consciously or involuntarily overlooked by most of the textbooks describing the rigid anchorage of saddle dentures. It is assumed that stresses of mastication are evenly transmitted to both supporting teeth and mucous tissue base, or then the alternative assumption is that the stresses distributed unevenly between the two supporting structures are harmless to the supporting teeth. Both assumptions are an attempt to escape the alternative, the resilient denture.

Naturally, a strong supporting structure (large number of remaining natural teeth, long roots, healthy parodontal tissue, little leverage) is less subject to damages from a rigid saddle denture. It may be useful to consider the principles for fixed bridge construction. Assuming that a bridge is to be made, using a large number of abutment teeth, it is perhaps admissible that one or in special cases even two cantilever pontics be added to a free end of the damaged arch. The leverage from such endstanding pontics is absorbed by a large number of strong abutment teeth. With a small bridge, this must appear inadmissible to every conscientious practitioner. In fact, the profession would regard this as gross malpractice. However, it does not seem to shock the same profession if large distal extension saddles are attached rigidly to some few abutments. As tissue resilience is always larger than the physiological mobility of a healthy tooth, the abutment teeth are being displaced beyond their physiological range of mobility before the saddle tissues even start to resist the denture base. The practical proof for the difference between movement of resilience by the saddle and the movement of an abutment tooth under similar stresses of mastication is given by the saddle denture without attachment or clasp. A match is first placed onto the center occlusal region of a saddle. When the patient is asked to close the movement of the saddle towards its tissue base is visible to the eye. If the match is placed on a healthy abutment tooth adjacent to the edentulous area, and the patient is again asked to close, no movement of the tooth is visible. It follows that if this saddle denture is rigidly attached to the abutment teeth, the movement of resilience is arrested by them and the vertical stresses directed onto the saddles are converted into rotational stresses with the fulcrum somewhere within the area of anchorage. If only the two teeth adjacent to the distal extension saddles serve as abutments, the fulcrum of rotation will be within the apical third of their roots. As soon as the rigid anchorage extends over several abutment teeth, the parts of anchorage lying mesially to the fulcrum will exert a traction towards the occlusal on the respective abutment teeth. The fulcrum teeth will suffer most, because their movement is rotational, a movement of torque.

In order to avoid this torque, the clasp design may provide for an occlusal rest with elastic clasp arms on the teeth adjacent to the saddle extensions. The analysis of the denture movement under masticatory stress shows that the main fulcrum of the rotational movement is placed in the occlusal rest while the degree of elasticity of the clasp arms determine the remaining tooth movement within the socket. The stresses are now received by the abutment teeth and the distal part of the alveolar process. Similar distribution of stresses is obtained by interposing a hinge between a rigid clasp and the distal extension saddle, with the advantage that no elastic forces create that torque within the abutment tooth. The only acceptable solution with a one-piece cast partial with distal extension saddles would be a denture which would permit a resilience movement in the first phase, which would be stopped by an occlusal or distal rest. Thus the occlusal rest, in rest position, would not contact the abutment tooth. Such solutions have been sought by different authors, the practicability of such techniques is doubtful, however. Movement in a one-piece clasp denture is difficult to obtain if sufficient stabilization is to be coupled with it. Reciprocation of clasp arms are easily obtained in a rigid fixation, while in a movable fixation the contacting surfaces of clasp and tooth are congruent in one position only. Only true spheric surfaces could maintain their congruence in different relative positions. Also, the movable clasp denture is a hopeless food trap. The stressbreaking device must therefore be either a closed or a selfcleansing system.

Every partisan of the rigid fixation of distal extension cases is no doubt in a position to corroborate his conviction by successful cases. He is advised to try the following experiment on one of his successful cases: The patient is given, in addition to his rigid appliance, a stressbroken, "resilient denture" and is asked to try it out for a few weeks, and then to go back to his rigid appliance. If the resilient denture is correctly constructed, the patient will *inevitably* prefer it to the rigid denture. He will state that with the rigid denture "he feels his teeth every time he chews", while with the resilient denture "he forgets his teeth". This fact alone, the comfort to the patient, should, apart from all biological aspects of the problem, score in favour of the stressbreaking principle.

This stressbreaking principle is closely coupled with the stress-directing principle. Stressbreaking alone does not eliminate the majority of damaging effects to the abutment teeth. A traumatic occlusion in natural or artificial teeth, premature contacts and incorrect setting up of teeth sometimes do more damage than the rigid fixation of a saddle denture. The less natural anchorage there is, the more it will be necessary to concentrate on the direction and also on the quantity of stresses the denture, the abutment teeth and the alveolar processes are to receive. The profession is generally prepossessed with the idea that the natural dentition consists of 32 teeth, and the artificial set of teeth of 28 to 32. An adequate dosage of stresses may necessitate to reduce not only the number of teeth, but also the size of their masticating surfaces. No man masticates well because of a given amount of masticating surface. He chews well, if he can make the best use of his masticating surface, and he chews well even if this good masticating surface is small.

THE PURPOSE OF STRESSBREAKER JOINTS

A denture is a lifeless material which is to be placed into a surrounding of live tissue and will be influenced and moved about by a variety of forces. Neither physics nor mathematics can possibly analyze the whole variety of physico-biological influences which reciprocally occur between denture and tissues during the masticatory process. Variable factors are of such an illimited and everchanging number that every theory about the best solution to incorporate a prosthesis into live tissue will embrace only part of the facts. If certain rules and considerations are to be placed at the basis of this work on resilient partial dentures, they must be corroborated by experience, experience which empirically has brought about the proof of the prevalent factors influencing success or failure.

The main idea of connecting the rigid and the resilient part of a partial denture by a stressbreaker joint is to distribute the stresses received by the saddle part among the two different bases: (a) the natural teeth in their bony socket, (b) the soft tissue covering the alveolar bone. The stressbreaker joint also directs the movements of the saddle part, freeing some movements and preventing or diminishing others. All movements of the saddle part occur between (a) rest position, (b) the working position immediately preceding the return to rest position. In rest position, the saddle should rest without pressure against the mucous tissue base. The stressbreaker joint in this phase has a stabilizing (static) function. During the moving phase, the joint has a directing (dynamic) function for the saddle. This directing function depends on the design of the joint with its gliding surfaces, but also on the number and distribution of joints and lastly, on the extent and distribution of mucous tissue surfaces in contact with the saddle part of the denture.

The directing function of the individual joint is determined by the number and degrees of freedoms it has. In order to understand what freedoms of movement are, let us again vizualize the distal extension saddle denture without fixation to the natural teeth. Such a denture may be moved about in different directions:

(1) It can be separated from the base by forces of traction or gravity.
(2) It can be tipped in different directions: laterally, mesially, distally (rotations).
(3) It can be displaced with a translatory movement (best illustrated by the "bodily" movement in Orthodontia) mesially, distally, transversally and towards its tissue base.

It has become clear that certain of these movements are entirely uncalled-for, others are within the purpose of resilient dentures. The stabilizing function of the joint calls for counteraction of all movements liable to separate the saddle from its mucous tissue base: Traction in an occlusal direction, gravity. In function, the joint should also prevent or reduce certain tipping or rotatory movements along with all translatory movements towards the mesial, distal or in a transverse direction; movements which would place the saddle base outside of its determined reciprocal and congruent contacting position with the resilient mucous tissue base. In other words, all intended movements should occur while the whole saddle base is in contact with the tissue, they should be true movements of resilience. The saddle must be allowed the following movements (fig. 145):

(1) Tipping movement of the distal part of the saddle from rest position to full resilience position.
(2) Translatory movement of the whole saddle from rest position to full resilience position.
(3) Rotatory movement of the saddle around its sagittal axis on the working side, and a similar reciprocal movement on the balancing side.

This applies for both unilateral and bilateral distal extension saddle dentures.

With these three freedoms of movement, the joint still leaves an ample amount of stresses to be absorbed by the groups or the total splint of natural abutment teeth.

Apart from the purely mechanical qualities and properties, the joint must fulfil various other demands:

(1) It must be strong enough to withstand breakage and wear.
(2) It must be small enough to be hidden from view.
(3) It must be simple to mount and to replace.
(4) It must not be a food trap and it must be selfcleansing.
(5) It must be demountable for the purpose of periodic cleaning.

THE PRACTICE OF STRESSBREAKING

The stressbreaking principle is observed in nature everywhere, and man has adopted it in all fields of technical sciences. The oldest example is probably the fastening of a ship to its mooring. Nobody in his proper mind would even think of rigidly attaching a ship to its dock, even in the safest of tide-free harbours. Rigid axels of motorcars have been replaced by the individual suspension of wheels and shock absorbers.

In dentistry, the stress breaking principle in the past has been put into practice by various means.

The oldest is the clasp without occlusal rest, which was abandoned because of the damage suffered by the abutment teeth from the scraping action of clasp against tooth, and the damage to gingival and parodontal tissues resulting from the gradual resorption of the alveolar bone with gingival displacement of the clasp.

The idea was improved by elastic clasp arms between rigid clasp and denture saddle. These clasp arms are usually too short to give a proper measure of elasticity which is physiologically adequate to the natural mobility of an abutment tooth. Long clasp arms, with a loop towards the mesial or distal (fig. 140) are better, but the danger with such clasp arms is the possible deformation.

Since the birth of the conventional type precision attachments, these were used as stressbreakers in distal extension saddle dentures. When the attachment begins to show a certain amount of wear, it allows for a restricted individual movement of the tissueborn part of the denture. Unfortunately, precision attachments were not *built* for this purpose, hence the frequent breakages from fatigue of the metal. Also, a precision attachment in which there is space for movement between matrix and patrix is not a precision attachment any longer, because it is an attachment and a stressbreaker joint in one.

A far better solution than the preceding ones is offered, if a movable link is interposed between attachment (clasp) and the resilient saddles. This link is called a (stressbreaker-) *joint*. Fig. 141 shows the principle of a resilient partial denture which consists of three basic parts.

(1) The supporting or attaching structures: Clasps, continuous clasps, precision attachments, removable splints.
(2) The joint (or joints).
(3) The mucosa supported saddle part with bilateral stabilizing device (lingual bar, palatal plate).

THE AXIAL ROTATION JOINT

Thirty years ago, ALFRED A. STEIGER started on this idea, at a time when such thoughs were considered excentric. At the same time, ROACH in the US showed his ball joint which subsequently was abandoned again because of

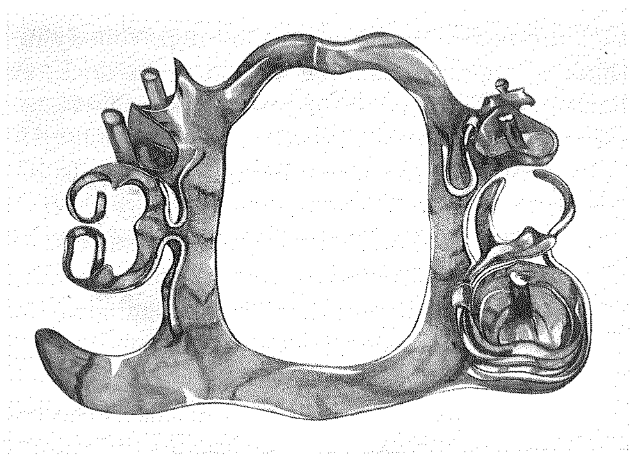


Fig. 140 An example for spring suspension of a partial denture. Loop wires break the stress transmitted from the denture to the abutments.

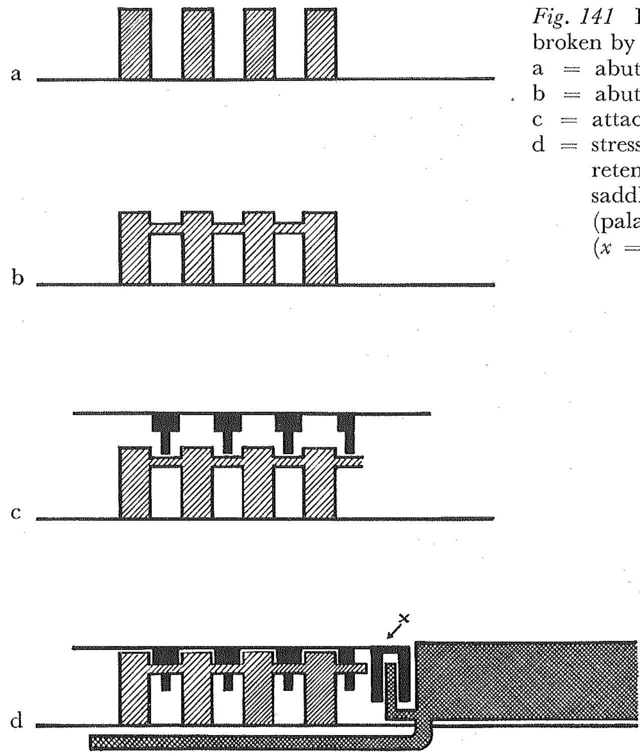
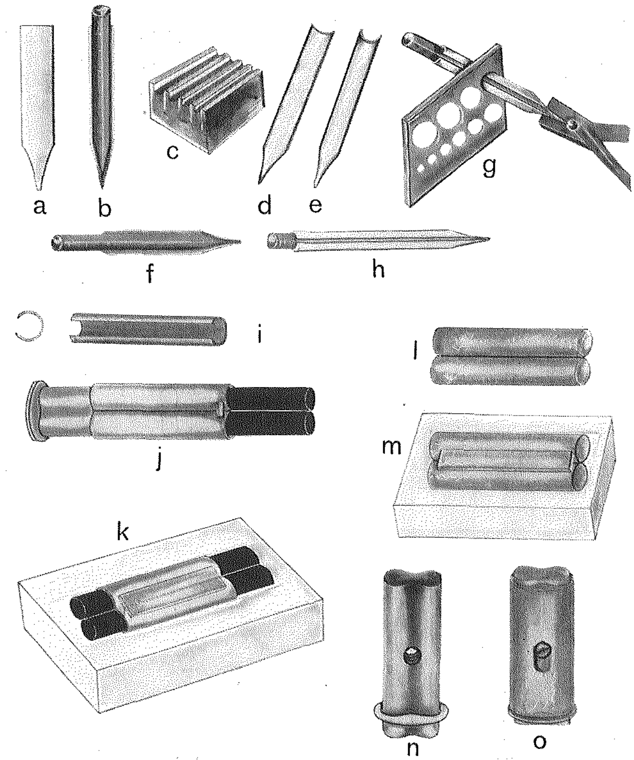


Fig. 141 Principle of resilient dentures stress-broken by joints.
a = abutments.
b = abutments splinted.
c = attachments as a means of retention.
d = stressbreaker joint as a link between retentive structure and resilient saddle. saddle part of denture, with lingual (palatal) bar.
(*x* = stressbreaker joint)

the fragile stem of the ball, insufficient stability, excessive wear and movement. Steiger invented the *Axial Rotation Joint* (fig. 144).

Originally, the facilities of the dental gold industry were not available to produce stressbreaker joints or precision attachments. Thus, it was necessary to make them by hand. Fig. 142 illustrates the manufacturing process. The original model of the AxRo joint looked slightly different from the model which is on the market today. The difference in the shape of the cross section of rod and shell is not fonctional but simply a difference in the manufacturing process. While the original male of the joint was made from two wires soldered together and the female of two open tubes soldered together, the new model is machine made, by metal drawing. In order to make the tubes by hand, a piece of sheet of a durable and tough alloy is cut to proper size and shape (a). With a steel rod of proper size, the sheet is given the shape of a channel (b) on the grooving block (c) made of wood. By drawing the grooved sheet, wrapped around a steel core (f), through the draw plate (g), an open tube is made (i, j). Two such tubes are placed on a soldering block with the openings facing each other (k). Two graphite pins serve as soldering matrix. The solder flows between the two tubes and forms a re-enforcement of the completed tube. The

Fig. 142 The manufacture of the original AxRo joint (hand made).
a = piece of sheet, cut to size and proper shape. b = sheet and grooving wood. c = grooving block. d, e = grooved sheet. f = grooved sheet with drawing iron. g = drawing the tube on the draw plate. h = drawn open tube. i = tube in cross section cut to proper size. j = tubes approximated for soldering. On the left side, a completed rod is inserted as a key, on the right, two graphite pins are visible. k = assembled tubes on the soldering block. l = two wires approximated. m = soldering of the wires. n = completed AxRo-male. o = completed AxRo with male and female, screw inserted.



male of the joint is simply made by soldering two wires together (l, m). The solder obliterates the groove between the wires. This accounts for the special shape of the cross section of the joint. Finally, the hole for the screw is drilled below the middle of the rod, and with a threader, the screwthread is made (1 mm) (n). Into the tube of the joint, a window of 1 mm in width and 2 mm in length is cut. The screw is made by threading a 1-mm wire. The slit in the screwhead is made with a fine saw. The soldering base at the base of the male part is made from a piece of sheet and is cut out to proper contour with burs.

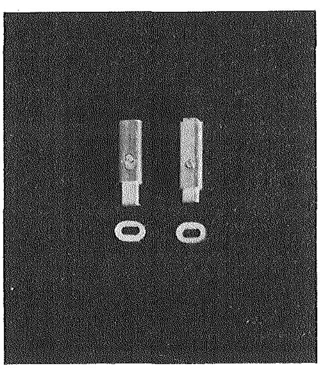
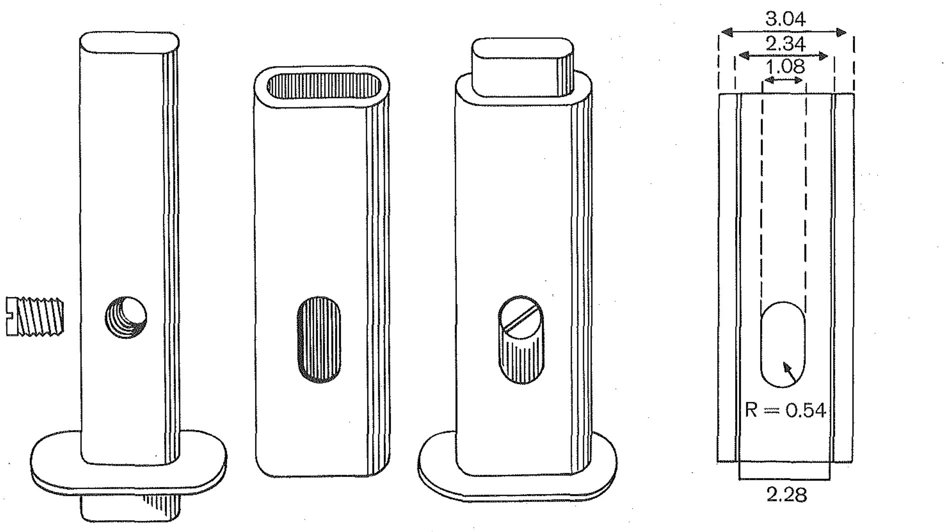


Fig. 143 AxRo and Ro joints; natural size (factory made). Below: soldering sleeve.



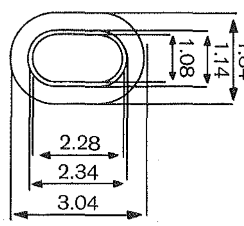


Fig. 144 AxRo joint, details. From left to right: Screw, male with soldering base, female with oval window, assembled AxRo joint, measures of joint.

Naturally, several AxRo joints can be made at a time, by using sufficient length of material and cutting the soldered rods and tubes into pieces of the proper length of the joint.

The parts of the axial rotation (AxRo) joint are (fig. 144):

(1) The male, a flattened cylinder with a screwhole of 1 mm ⌀.
(2) The female, a tube congruent to the male, with an oval window on one of the flat sides.
(3) The 1 mm screw has an SI metric thread.
(4) The soldering base, used as a soldering foot for the AxRo male.

As the joint comes from the manufacturer, it has only one degree of freedom, a purely axial movement. This movement is limited by the length of the oval window in the female part, or in the mouth, by the resilience of the tissue. A free end saddle, connected to the attachment with an AxRo joint will make a truly axial movement only when force is applied to the static centre of the saddle (fig. 145b). The more the force is applied distally from the static centre, this purely axial movement becomes coupled with a rotational movement (fig. 145c). As the new and unused AxRo joint only allows an axial movement, the male part must be slightly modified so it will allow for a *restricted* rotational

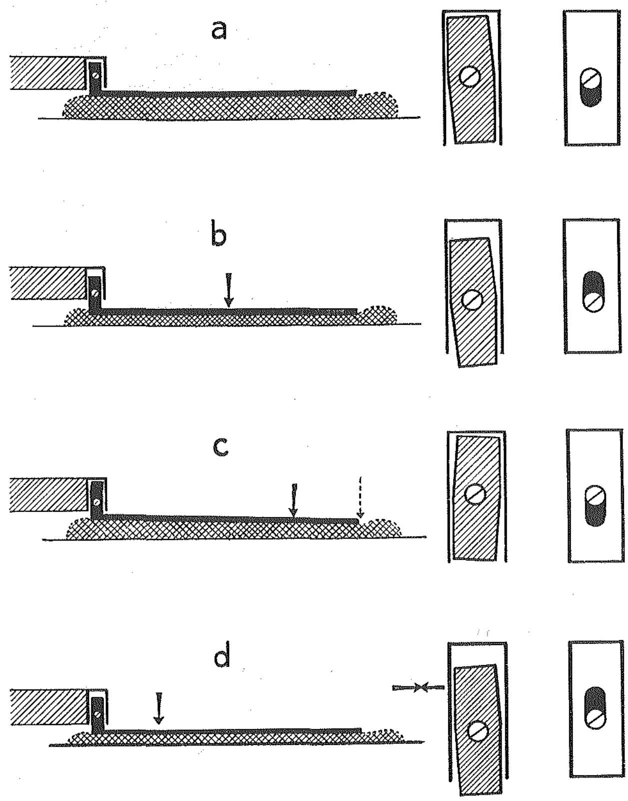


Fig. 145 Function of the AxRo joint shown schematically on a sagittal plane.

a = rest position, no pressure on base, screw at the occlusal end of the oval window.

b = masticatory pressure on bearing centre of saddle. The saddle makes a true translatory movement, the screw indicates the travel of the male within the female, although the resilience would hardly ever reach such a measure on a purely translatory movement.

c = masticatory pressure within the distal part of the saddle: Rotatory movement around a transversal axis. Note the rotated position of the joint without resilience movement.

d = masticatory pressure applied to the mesial part of the saddle. Result: translatory movement. Tipping towards the mesial is prevented by the mesio-occlusal part of the male joint being blocked against the tube of the joint. Through the translatory movement, the screw is in a depressed position within the oval window.

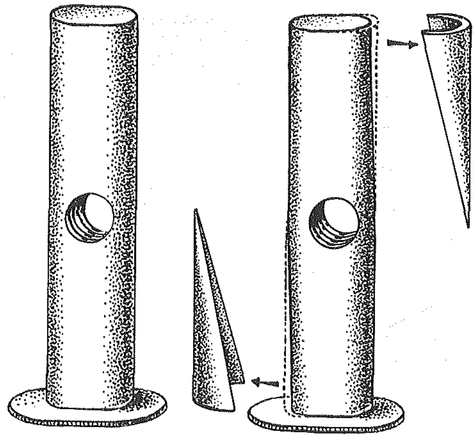


Fig. 146 Illustration of relief on the male AxRo and Ro joint to free the rotational movement. The surfaces to be relieved are the disto-occlusal and the mesio-gingival. These reliefs, shown here in a strongly enlarged picture, are *very slight*, see text.

movement (fig. 146). This relief on the rod of the joint is done only when the case is finished and after the denture has been worn for a few days. The relief is so slight that it is barely visible by eye. Fig. 147 explains the measure of relief for a given length of saddle.

With a length of the joint from screw to base of 1.5 mm, a saddle length of 40 mm and a resilience of 2 mm, the thickness of the relief shown in fig. 146 is of not even one tenth of a millimeter. The formula also shows that the relief is larger, the longer *AB* (length of the joint) is. Excessive relief aswell as faulty relief are the cause of failures. No relief must be given to the mesio-occlusal and the disto-gingival areas of the AxRo male. These are the stop surfaces against the distal dropping of upper and the distal lifting of lower saddles (fig. 145d).

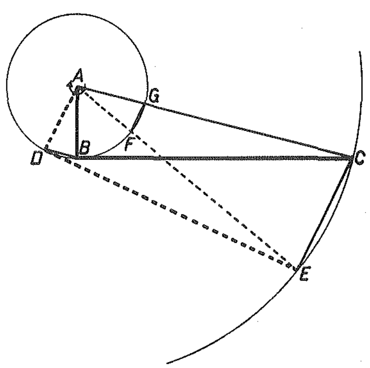


Fig. 147 Formula for measure of joint movement relative to saddle resilience.

$$AFG = ABD; \quad AFG \quad AEC$$

$$\frac{DB}{EC} = \frac{AB}{AC}; \quad AC^{-2} = AB^{-2} + BC^{-2}$$

Example:

AB	$=$ 1.5	mm	(length of joint from screw to base)
BC	$=$ 40	mm	(saddle length)
EC	$=$ 2	mm	(resilience of tissue)

$$\frac{DB}{2} = \frac{1.5}{1602.25}$$

$$\underline{DB = 0.07494 \text{ mm (relief)}}$$

Naturally, the practitioner will not use the formula in order to know the proper measure of relief. The formula is intended only for the comprehension of the problem. The case, after insertion, is left for a few days. On disassembling the joints after this short period of wear, the places to be relieved are marked by shiny spots. These spots are slightly shaved with a sharp scaler. A second check after another few days usually shows that enough has been relieved.

It was said that forces applied to the static centre of the saddle result in an axial or translatory movement, while forces applied to the distal of the static centre result in a combined axial and rotatory movement. It would follow that forces applied to the mesial of the static centre would produce a rotatory movement in the opposite direction, a movement which would lift the distal end of the saddle and depress the mesial end. Such a movement is arrested by the above mentioned mesio-occlusal and disto-gingival "stop-surfaces" of the AxRo male. The resulting movement is therefore again axial and translatory. What about excessive wear of the joints? They wear very slowly and years of service may be expected from them. They are easy to replace, while the natural teeth are irreplaceable. This is a fact to which dentist and patient should be reminded. The wear must be placed into the mechanical part rather than risk loosening of the natural teeth. A patient, complaining after years that his denture moves too much, or "hangs" a bit (in upper cases) may be reminded that replacing joints on his denture is similar to having parts replaced on his automobile and that the machine in his mouth was designed to save his teeth and therefore is to suffer the wear.

FUNCTION OF THE AxRo JOINT

The AxRo joint is designed for bilateral free end saddle dentures and is always used in pairs, never single. The use of the AxRo joint in unilateral free end saddle cases will be explained later (p. 157). Fig. 148a to c explain the function of the joint in the different possible phases of mastication.

(a) Upper case in rest position, cross section in a frontal plane. The screws of the joints rest against the occlusal margin of the oval window.

(b) Forces of mastication are evenly applied to both saddles at once. The measure of tissue resilience determines the length of the path the male travels within the female and may be measured by the distance the screw travels away from the occlusal margin of the oval window. With masticatory forces diminishing again, the screw again travels into rest position.

(c) The force of mastication is applied unilaterally. While joint *A* remains in rest position and makes but a slight rotational movement, joint *B* on the working side makes an axial movement combined with a slight rotational movement. Note the compensating rotational movement on the resting side.

If force is applied to the mesial third of the saddle, with axial, translatory

a

b

c

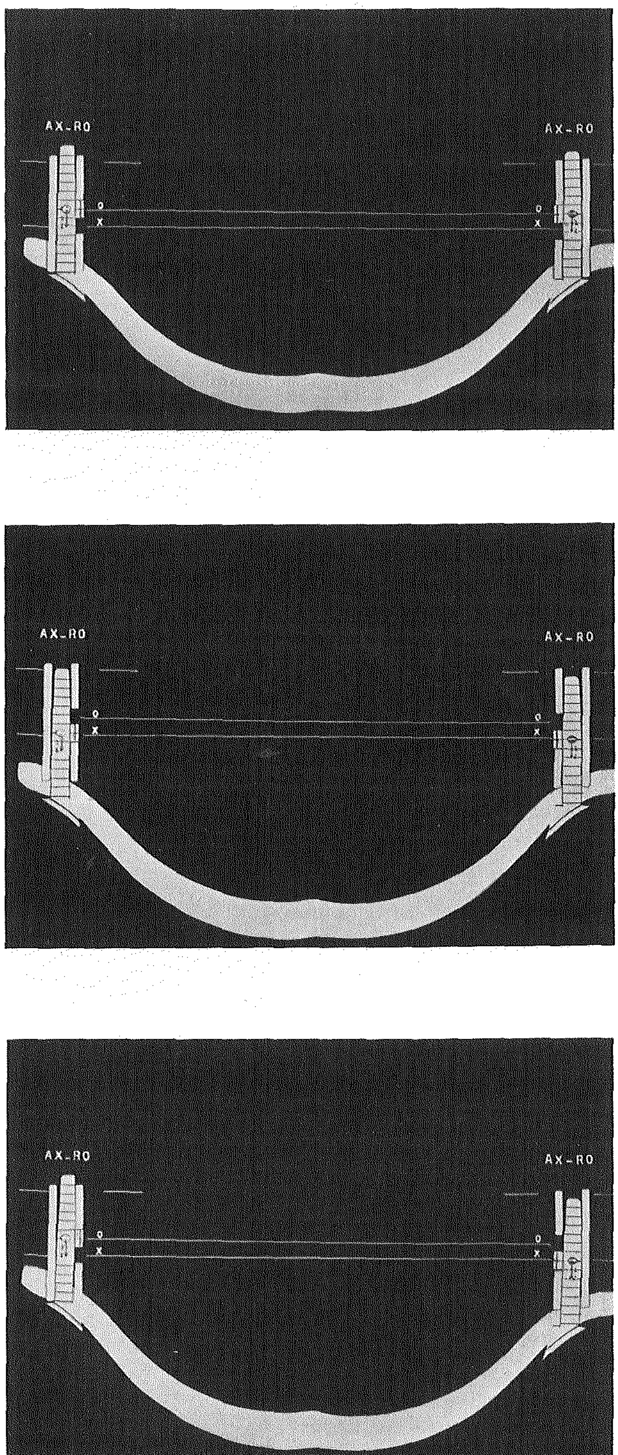


Fig. 148 Function of AxRo joint projected to a frontal plane.

a = rest position.

b = bilateral masticatory pressure.

c = unilateral masticatory pressure.

movement, the rotational tendency is arrested by the "stop-surfaces" of the joint, the abutment receives a stress which is directed from distal to mesial. Hence the necessity of splinting at least two end-standing abutments. Forces acting in another direction than axial (lateral, distomesial, mesiodistal) are not stressbroken, because in a denture with correct articulation and occlusion—with the accent on the occlusal pattern—the lateral forces must be only a fraction of the axial forces and are therefore negligeable. Lateral forces are therefore arrested by the bilateral suspension of the saddles and by the alveolar process.

a

b

c

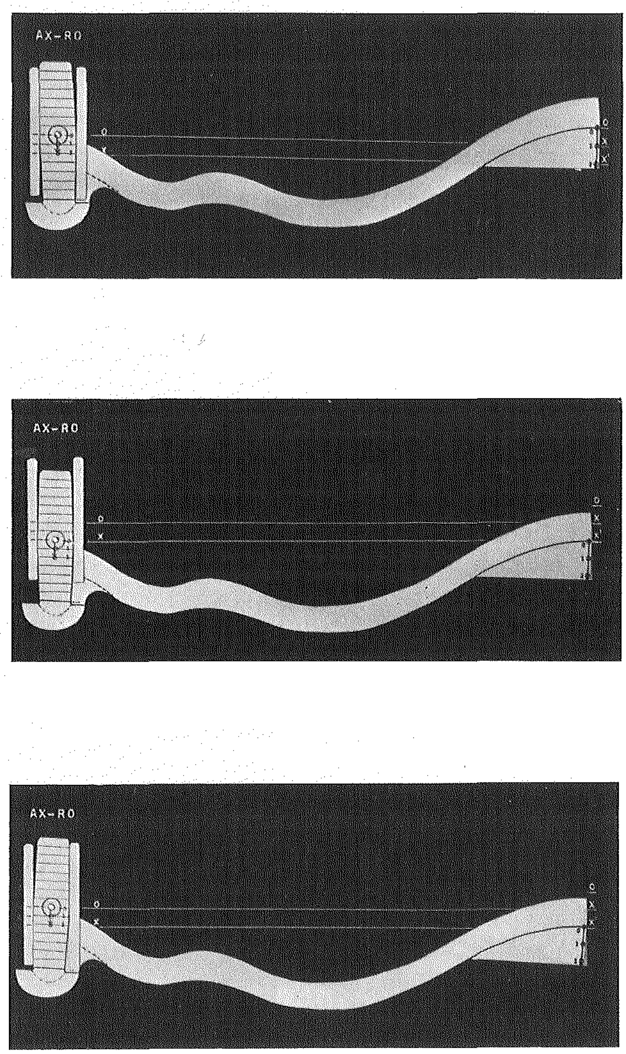


Fig. 149 Function of AxRo joint projected to a sagittal plane.

a = upper case in rest position, sagittal section (reversed).

b = vertical forces applied to the static centre of the saddle, resulting in a true axial, translatory movement of saddle and male part of the joint.

c = force applied to the distal third of the saddle, resulting in an axial and slight rotational movement.

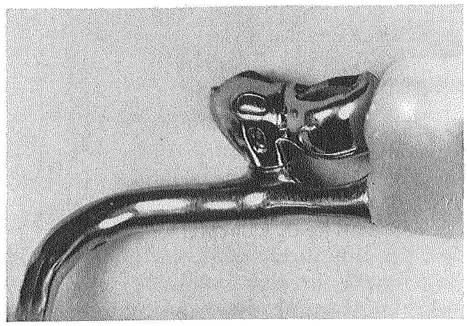


Fig. 150 Mounted AxRo joint in rest position. Female soldered to two CSP attachments, male soldered to lingual bar of bilateral saddles.

UNILATERAL FREE-END SADDLE EXTENSIONS, THE ROTATION JOINT

Unilateral free end saddles must always be anchored bilaterally such as it is the rule with every conventional partial clasp denture. On the free-end saddle side, an AxRo joint will give the saddle the necessary freedoms of movement mentioned above. On the toothborn side, however, there must be a joint compensating for the movements the saddle will make when in function. If we should choose a rigid anchorage on the toothbearing side, this anchorage would tend to force the anchoring abutments into a rotational movement originating in the free-end saddle side. By interposing a joint which will only allow a rotational movement, this rotational stress on the anchorage is avoided. This joint which has no axial, but only rotational freedom, is called the Rotation (Ro) Joint. It differs from the AxRo only inasmuch as the oval window in the female is replaced by a round window, slightly larger than the diameter of the screw (fig. 151). Unretouched, this Ro joint has no freedom whatsoever. With the technique of relieving, already described for the AxRo, a *slight* movement for rotational movement is obtained, just sufficient to compensate for the axial and axio-rotational movements of the free-end saddle. A frequently observed mistake is to place an AxRo joint on the compensating side. The AxRo male on the free-end saddle side is kept in its rest position by the tissue base underneath the saddle. In a lower case, the joints of both sides (the males) are joined by a lingual bar, but this lingual bar is not tissue supported. Therefore, the lingual bar might be moved up and down by the tongue, if saddle side and compensating side (toothbearing side) were to have an AxRo joint. A Ro joint must therefore be mounted on the compensating side. In upper cases, this mistake will not show as readily as in the lower arch, because

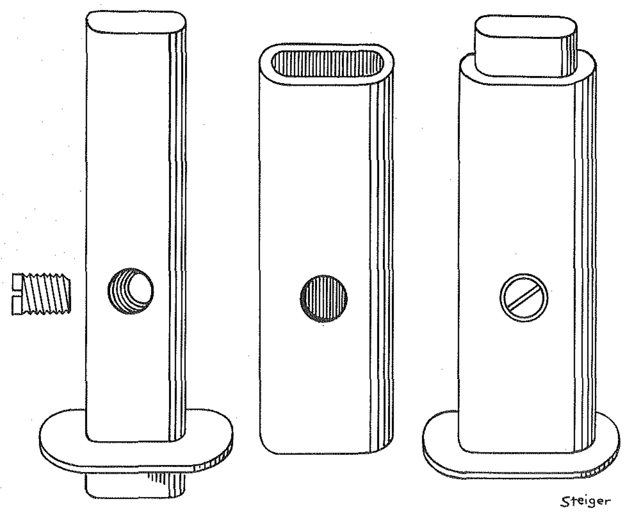


Fig. 151 Ro joint. The difference lies only in the shape of the window in the female. Instead of the oval window of the AxRo female the window of the Ro is round. Thus, no translatory movement is possible. Without reliefs, the Ro has no freedom at all. Adequate reliefs allow for restricted rotatory movements.

the connection between saddle and compensating side, the palatal bar or plate, rests on tissue itself, which the lingual bar of mandibular cases does not. The palatal bar or plate will be widest on the saddle side, and narrowest on the other, therefore, resilience is only desired on the saddle side, while the toothborn side compensates for the saddle movements.

In order to reduce the wear of the joints, two Ro joints may be placed on the compensating side. Thus, wear is distributed over more surfaces. This mainly applies to upper cases, where the weight of the appliance may, after years, tend to separate the distal part of the saddle appliance from the tissue surface.

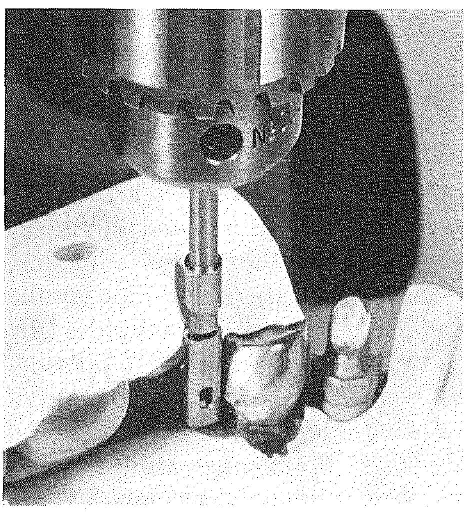


Fig. 152 Mounting of AxRo female with joint holder on parallelometer. The teeth are held in their position by a plaster key.

MOUNTING OF THE AxRo- AND Ro JOINTS

AxRo- und Ro joints must always be parallel of axis to each other. As shown earlier already, a case will include at least one pair of joints. As long as they are parallel to each other in a longitudinal axis, their arrangement is chosen according to the given case. Their long axis of the cross section need not be parallel, so that normally the joint will stand perpendicular to the working axis of the model, with the flattened sides parallel to the alveolar crest or to the sagittal plane of the model, whichever seems more convenient. The joints are placed either into the bulk of an artificial tooth or into an interproximal recess between two CSP attachments, where it will not interfere with the tongue (see casuistry, page 181).

For each joint, the manufacturer provides a soldering base (fig. 151). This soldering base will first be soldered to the base of the male part at an angle which is given by the inclination of the underlying tissue. Since the joint is always mounted on the lingual (palatal) incline of the alveolar crest, the soldering base will almost always stand at an angle. Purpose of this soldering base is to obtain a large soldering surface towards the lingual bar or palatal plate. The female of the joint must be ground in on the inclination of the soldering base (fig. 153).

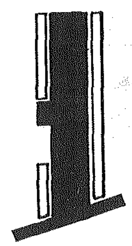


Fig. 153 Soldering base soldered to male of AxRo at the angle of the tissue base.

The length of the joint must be established according to the length of the adjacent teeth. With teeth elongated by periodontal disease, almost the full length may be used, while with short teeth, the joint may have to be cut down almost to half its size. Cut away little from the portion gingival from the window in the female, and more from the opposite end. Between window and margin, there should be at least 2 mm left.

On the parallelometer (or on the Parallelofor), the joints are parallelized and brought into their proper position for soldering. First, the female is seated by sticking it on the joint holder (see accessories p. 92, fig. 85p). The female is fastened in its proper position on the model (fig. 152), invested and soldered, then, the male is fixed into the female in rest position, i.e. with the screw at the occlusal margin of the oval window. At this point, the lingual bar or the palatal plate are waxed up, and the male joint with its soldering base is lowered into the wax of the bar or plate, thus leaving its print on the wax surface. This print in the cast will make an accurate soldering seat (fig. 157).

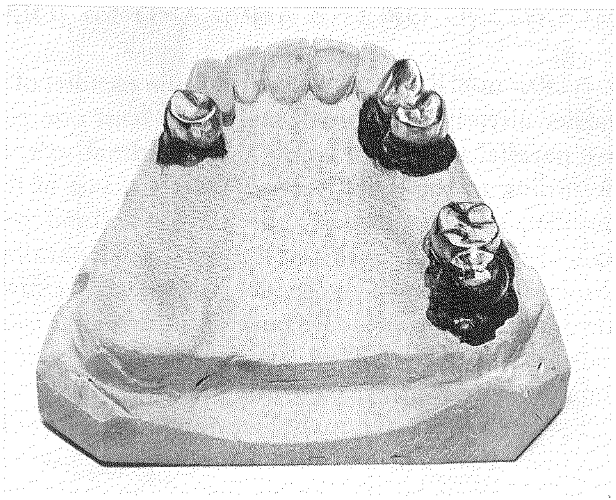


Fig. 154 A unilateral free-end-saddle case with three groups of abutments. The CSP attachments are finished (4 + 34 78).

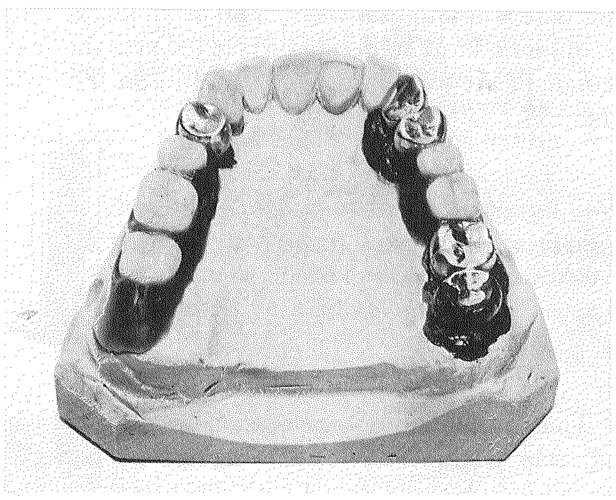


Fig. 155 Teeth set up for articulation.

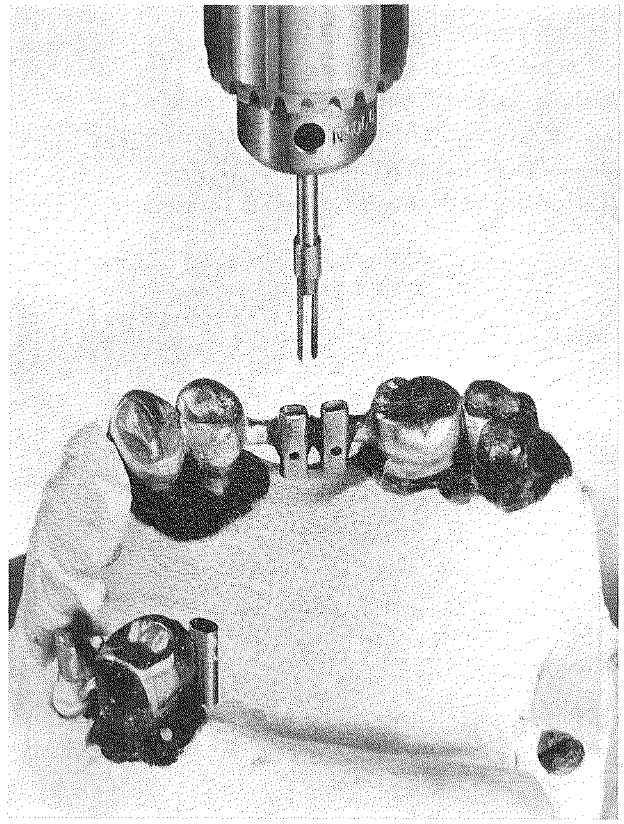


Fig. 156 Two Ro joints on toothborn side and one AxRo on the free-end-saddle side are mounted with joint holder and parallelometer and fastened with sticky wax for soldering.

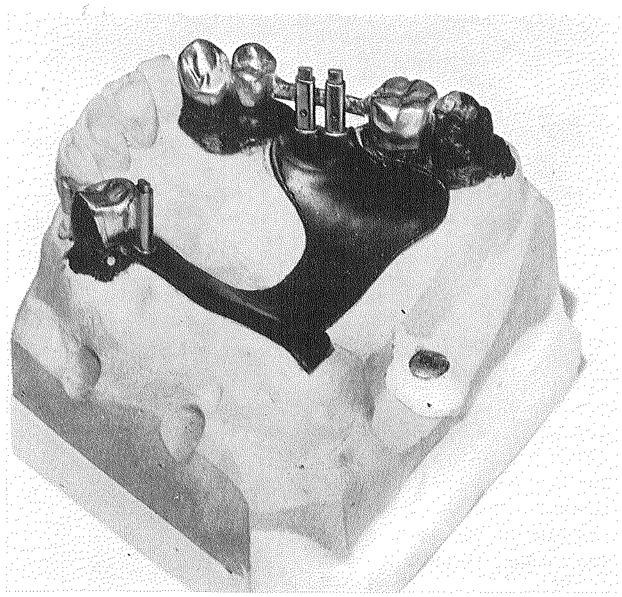


Fig. 157 Palatal plate waxed up, AxRo- and Ro females soldered, and males with soldered soldering bases inserted into females to leave their imprint in the wax of the palatal bar. When the palatal plate is cast, the bases of AxRo- and Ro males will fit into their respective soldering seats.

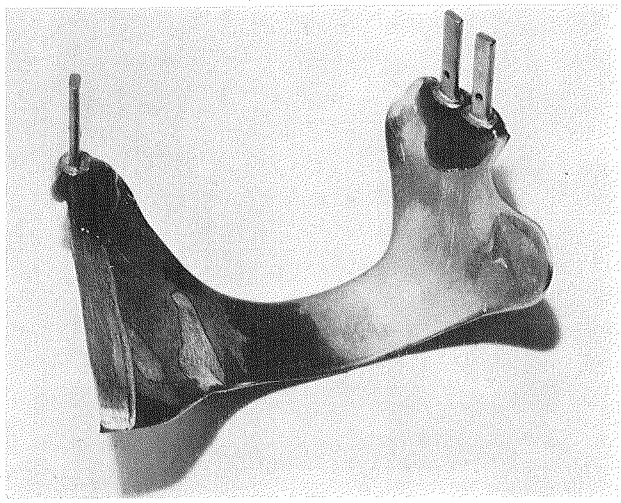


Fig. 158 Palatal plate with soldered joint males.

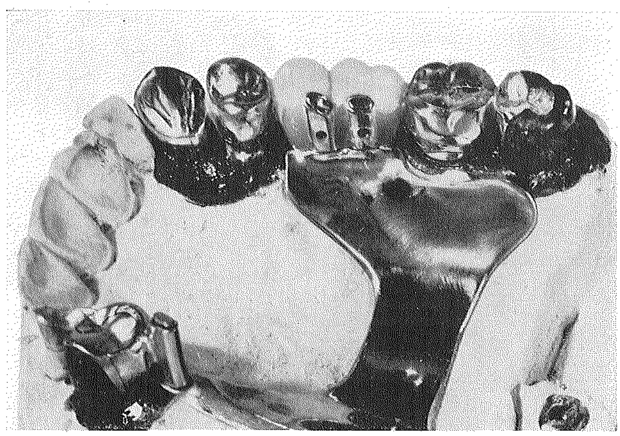


Fig. 159 Attachments in place.

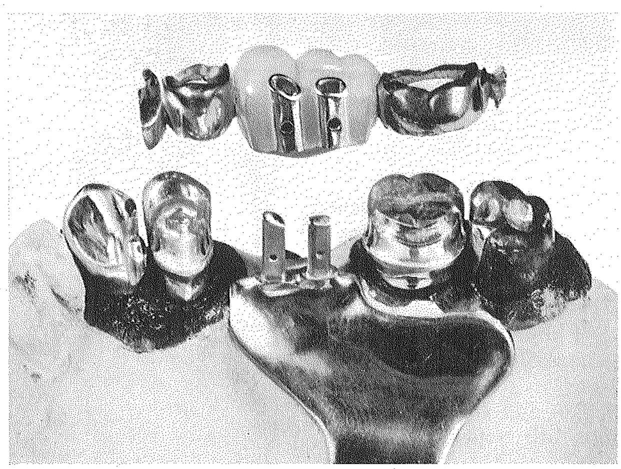


Fig. 160 The toothborn bridge removed from the abutments. Different designs of CSP attachments are shown. The two Ro joint females are situated within the anatomical contours of the pontics and thus do not interfere with the tongue.

After casting the lingual bar, palatal plate or bar, the males are soldered (fig. 158). The relative soldering position of AxRo- or Ro males to their base must be retained accurately. In the original size the male is longer than the female. Thus, in rest position of the joint, the tip of the male is higher than the rim of the female. In the plaster key which is taken over the AxRo or Ro and the cast base, the soldering base and the tip of the male is reproduced,

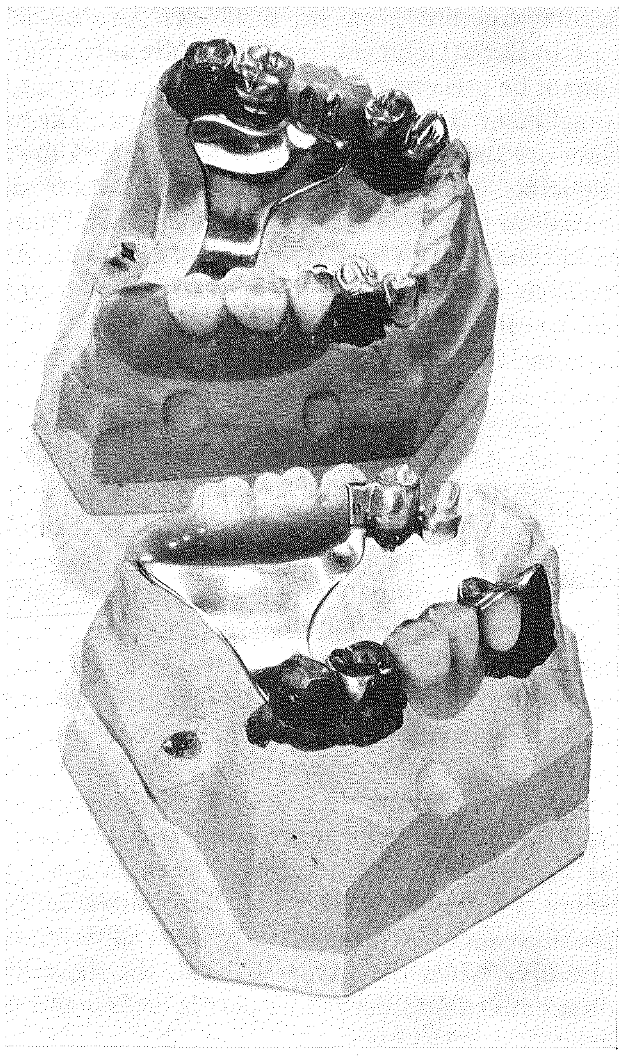


Fig. 161 Finished cases. Note how the AxRo- and Ro joints are imbedded in the teeth and the acrylic. The abutment construction of the upper left cuspid is a three-quarter base with post and core for a porcelain jacket crown.

while the body of the male is hidden. After disassembling the joint, the male is repositioned in the key according to the imprint of its two extremities.

Processing of the acrylic

Before waxing up the teeth in the position determined by the try-in, the females of the joint are covered with one layer of tinfoil. This tinfoil sheet will just leave enough space later for the movement of the saddle along the outside of the females. When the teeth are waxed up, the females with the attachments are removed and the space around the males is filled with dental cement. The saddle part of the denture is then flasked and processed in the usual way.

There are cases where both the supporting structure (toothborn) and the saddle structure (resilient, tissueborn) are mounted in acrylic, which is the case in Bar-attachment free-end saddle cases (fig. 162). Naturally, such a case cannot be processed in one flasking. The anterior, toothborn part with the bar attachment is flasked and processed first. The walls contacting the resilient posterior section must be plane and parallel to each other and to the axis of the joints. These walls are polished, and subsequently the posterior section is waxed up into close contact with the finished part of the anterior section. The saddle part is then flasked, processed and finished. Thus the imperceptible gap between the acrylic of anterior and posterior parts of the denture will allow the translatory, axial movement of resilience of the saddles. By just slightly tapering this gap from the height of the AxRo screw towards the gingival, the rotational freedom is given to the case. (fig. 146)

RELINE OF RESILIENT DENTURES

Lower cases

Lower cases in general need relining after a shorter period of time than upper cases, because of the smaller bony base which is more subject to resorption. The proper time for relining may be judged from the position of the joint screw in the oval window. In the beginning, the rest position of the screw is at the occlusal end of the oval window. In a case needing relining, the screw will stand anywhere from the middle to the gingival end of the window. If the saddle is lifted until the screw touches the occlusal end of the window again, there will be a space between saddle and tissue, a space which needs to be filled by relining. Therefore, the joints will be immobilized in their conventional rest position and the relining impression is done with a plaster wash without pressure. When the plaster is hard, the denture is taken out, the joints are disassembled and the saddle part is flasked and processed in the conventional way.

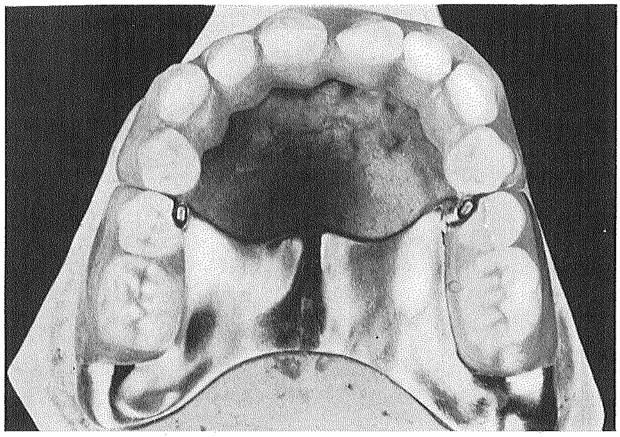


Fig. 162 Bilateral free end extension saddle case with front part toothborn on four abutments splinted with the Bar attachment. See also fig. 182, p. 193. Note the barely visible gaps mesial to the two AxRo joints.

Upper Cases

Upper cases are far less subject to alveolar resorption than lower ones. Relining, however, will be necessary in some cases, though after a comparatively long time. Anybody who has had to reline upper partials with metal framework knows that relining them the same way as lowers is an unsatisfactory procedure. The relining material would have to coat the tissue side of the palatal plate or bar, thus increasing its thickness beyond comfort to the patient. Also, the acrylic does not adhere satisfactorily to the metal surfaces. Relining after the conventional fashion is therefore only indicated in cases where there is a full acrylic palatal plate. The procedure for compensating the loss of tissue is therefore different. A plaster impression is taken over the denture in the mouth. A model is poured from it, and the joints are disassembled. The joint males are removed from their soldered base, new joint rods are inserted into the females in correct rest position and soldered at their base. This means that a plaster key of the teeth must be taken before the joint rods are removed, teeth and acrylic are removed from the metal framework, and after soldering of the new joint rods, the teeth are remounted into proper position, tried in the mouth, and the case processed. Usually, it is sufficient to replace the males, but sometimes, it may be advisable to replace the females at the same time.

SPECIAL DESIGNS FOR RESILIENT PARTIAL DENTURES

Partial dentures connected with the remaining tooth arch by stressbreaker joints are, strictly spoken, never completely stressbroken. Part of the stresses transmitted to the supporting tissue base are still deviated to the abutments. The aim for further development therefore goes towards still more eliminating uncalled for and harmful stresses. Conditions are much improved already, if

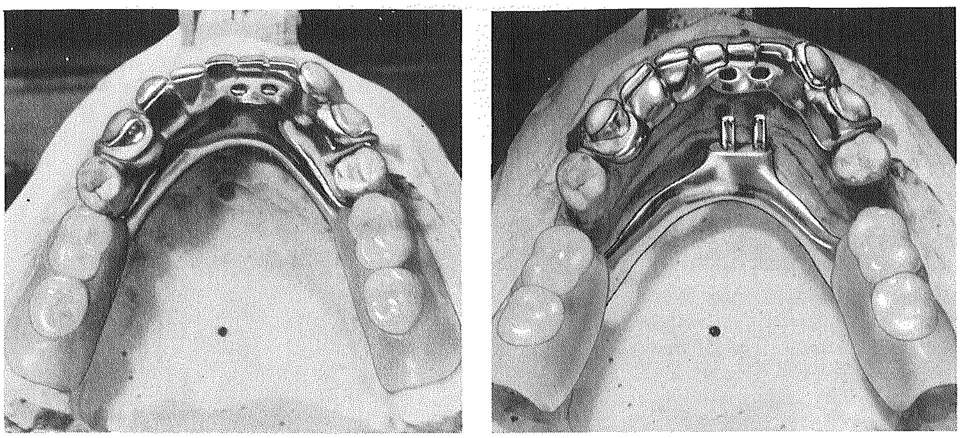


Fig. 163 Double free end saddle case with two Ro joints. Hinge movement.

the joint connection between saddle part and supporting teeth is removed as far as possible from the bearing center of the resilient denture, into the bearing area of the remaining arch of natural teeth.

Fig. 163 shows a lower bilateral free-end saddle denture with two Ro joints hidden in the artificial two central incisors of a bridge. These two Ro joints represent a simple hinge. For the long lever represented by the saddles only a very slight freedom of the Ro joints is necessary. The arrangement of two instead of just one Ro joint prevents any undesired lateral movements of the denture.

The Sphere Joint

Unfortunately, it is not always possible to place the joints—as in the above described case—so far away from the bearing area of the resilient saddles, simply because of the lack of space. The sphere joint technique applies only to complete splints or bridge splints which include abutments from bicuspids to bicuspids (fig. 164). The denture is snapped into place and gets its retention on the palatal surface of the cuspid-bicuspid area of abutments. The saddle denture carries an arm on either side. Each arm has at its extremity a ball head which fits into a hollow sphere in the palatal surface of the splint. Ball and hollow sphere alone would not retain the denture in its proper position, because, with a ball joint on each side, the suspension is that of a hinge with illimited rotational freedom. The denture would fall down with its posterior part. The retention in rest position is obtained by the two arms which rest in a groove in the palatal surface of the splint. The groove runs from the hollow spheres back to the distal of the last abutment adjacent to the saddle. It is

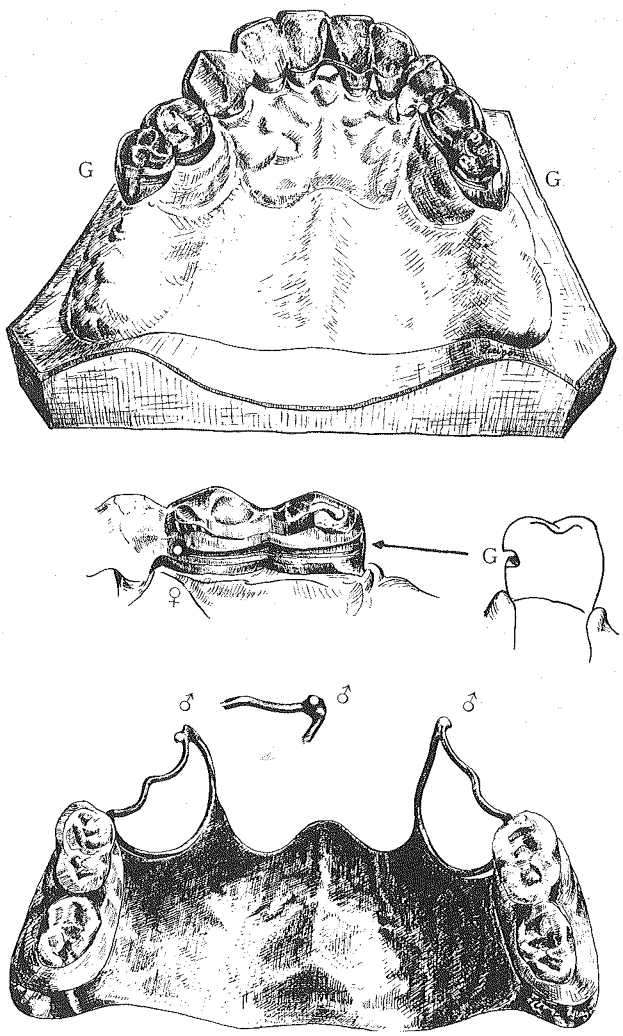


Fig. 164 The Sphere joint. The model above shows a complete front splint. On the palatal surface of the bicuspids a groove (*G*) is visible, mesially terminating in a hollow sphere ♀ between first bicuspid and cuspid. The groove is marked by a white spot. The middle illustration shows the groove as seen from the palatal side, and to the right, in cross section. The groove becomes broader towards the distal. Below, the denture, made of a cast palatal plate, with two elastic outriggers, both fitted with a spheric end ♂. Sphere and outrigger snap into the hollow sphere and groove of the fixed splint shown above. The patient removes the denture by slightly squeezing the denture laterally.

narrower at the mesial end, and broader at the distal. In rest position, the arms rest against the occlusal step of the groove. Under masticatory stresses, the arms make a slight rotational movement and are brought into approximation of the gingival step of the groove. The denture must have a certain amount of elasticity to permit insertion. It is simply snapped into place. For removal, the patient slightly compresses the sides of the denture and thus unlocks the denture. The tissue born denture must have a maximum of bearing area on the tissue.

The advantage of this construction lies in the fact that the rotational axis between the two joints is far removed from the bearing area of the saddles and of the palatal plate. When a hinge joint is mounted on the distal of the last abutment, the distal part of the saddle transmits most of the masticatory pressure to the tissue while the mesial part transmits none at all. In the sphere lock solution, the whole saddle bears on the tissue, because the suspension lies within the metacenter of the abutment polygon.

In specially selected cases, it may be possible to avoid even the stressbreaker joints or at least part of them in order to suspend and anchor a resilient partial denture within the complex of remaining natural abutments. Such solutions were already described by STEIN, E. MÜLLER and others at the beginning of this century. The basic idea is that three points determine a plane, and those three points must be found in the remaining dentition in order to suspend a denture and keep it in its proper position. This suspension is possible without rigid or semirigid (stressbroken) connecting links. The plane formed by the three suspension points should be as nearly as possible an isosceles triangle. If we vizualize the suspension of a triangle in an upper dental arch, by using undercut areas for the angles of the triangle, it becomes clear that only two of the three angles at a time may be inserted, while the third angle will still be occlusally from the undercut area. The same applies to the denture designs. Two outriggers will catch in an undercut area, the third angle of the triangle will have to be either a visor attachment which clamps down as a catch lock on a post of the denture or it will be a stressbroken attachment (precision attachment with joint, elastic clasp) or a rotating lock (fig. 165a).

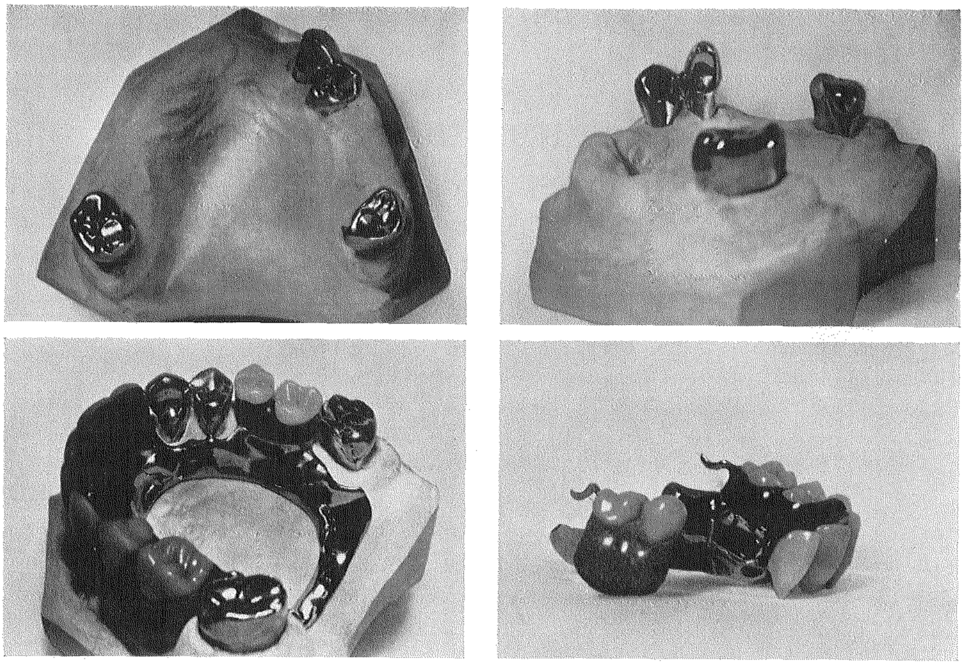
The outrigger lock, the visor attachment and the ear lock are such devices which may be used for partially or totally free suspension.

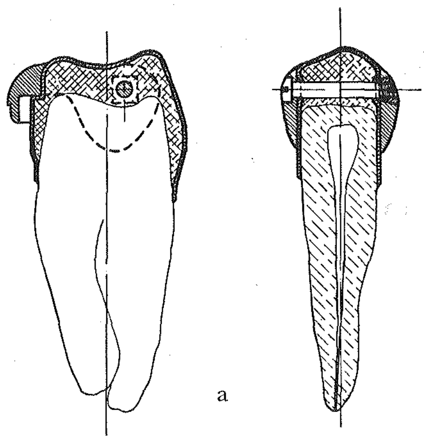
The Outrigger Lock

The sphere joint used in the previous case may be used in a completely different way. While in the sphere joint it acts as a hinge, it can serve as a simple retainer against forces which tend to separate the denture from its base. With the hollow spheres on the gingival side of pontics, the outriggerlike arms of a denture reach underneath these pontics and the ball shaped bulb of the arm rests in the hollow sphere. Again, one or two ball joints alone would not hold the denture in place. A third support must be found which completes the *plane of support*. Therefore, this design is limited to cases where the arrangement of abutments allows for such a plane. In the case shown in fig. 166 this third support is found on the molar. Thus, no stresses are transmitted to the weakened front region of abutments during mastication. On the contrary, the balls move away from the hollow spheres as masticatory stresses on the denture increase.

The Ear Lock

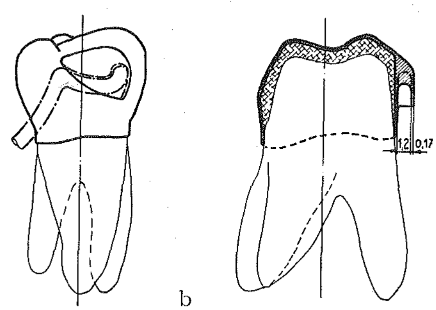
In many instances, it will be found difficult to place attachment and joint, predominantly in cases with short abutment teeth in the incisor and cuspid area. The relative bulk of attachments on short front teeth will be felt more disa-





a

*	saddle		saddle	
0			v.cl.	0
7			*3* 4	7



b

Fig. 165 A denture with two outriggers and a visor clasp. Four abutments are left. The two outriggers catch in corresponding notches of the cast crowns of the two second molars (b) the post visible in the picture of right lower corner is caught in the bore of the visor attachment (right top a).

greeably than on bicuspid or molar teeth. Also, the frictional surface of attachments and joints is excessively reduced on such short abutments, and the joints will wear prematurely. This is where the ear lock is ideal. It must be said, however, that it is not only used in cases with short teeth, but functions equally

* For explanation of signs see casuistry p. 181.

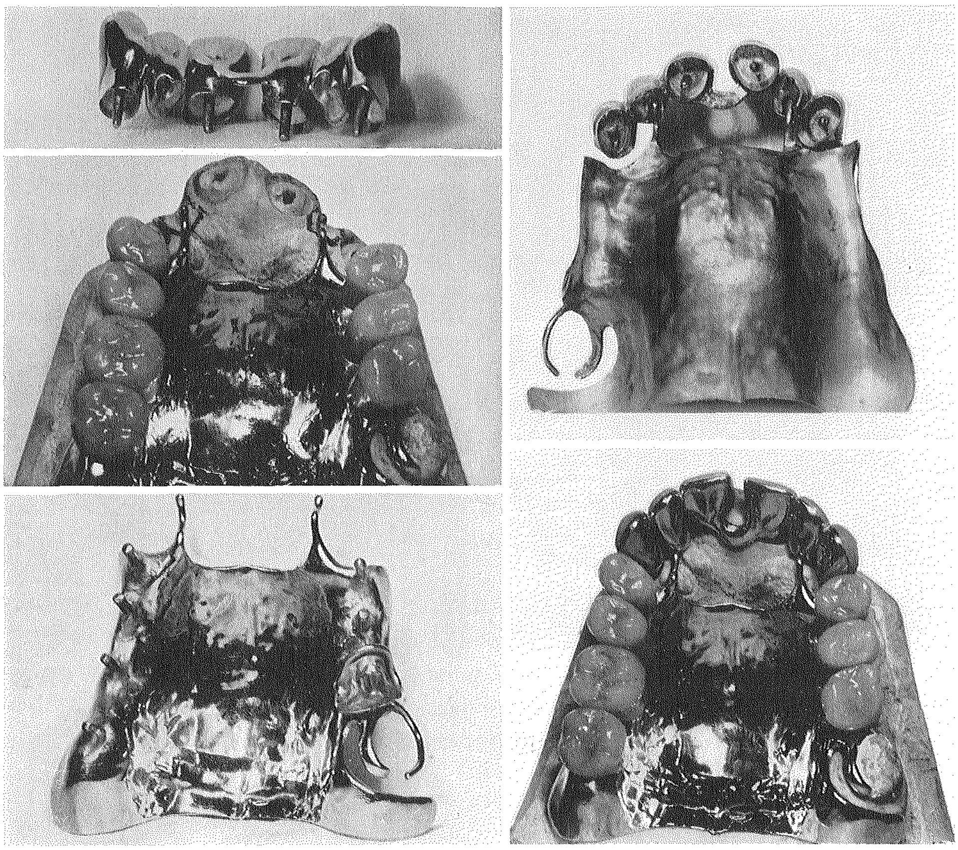
a

b

c

d

e



	0			0		Cl
	2			2		
3		*1*	*1*		*3*	7

Fig. 166 The outrigger lock. Remaining teeth: Two central incisors and two cuspids, devitalized, the left second molar, vital. Solution: Front bridge with four abutments, two pontics. Lingually, on the gingival surface of the pontics, the hollow spheres are visible into which the outriggers of the denture will fit. The outriggers are locked in their position by the clasp on the second molar, which has a very short crown. Leverage by the clasp is negligeable. a = bridge from cuspid to cuspid. b = model with denture without bridge. c = denture. d = bridge and denture from tissue side, note position of outriggers in the pontics. e = denture and bridge on model.

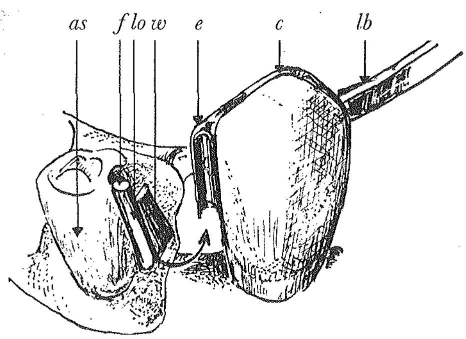
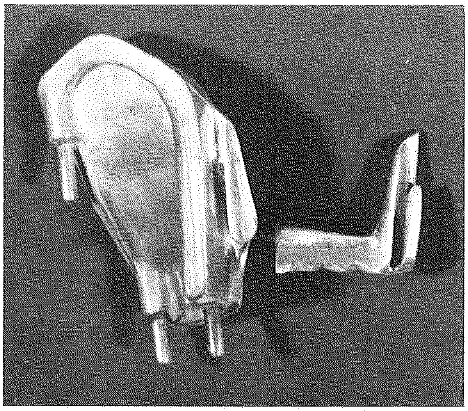


Fig. 167 Ear lock. *as* artificial tooth and saddle. *f* flange of the lock. *lo* lock. *w* web of the lock. *e* ear. *c* CARMICHAEL crown on cuspid tooth. *lb* lingual bar, connected with the stabilizing joint on the contralateral side. The arrow shows the direction of insertion of the lock into the ear.

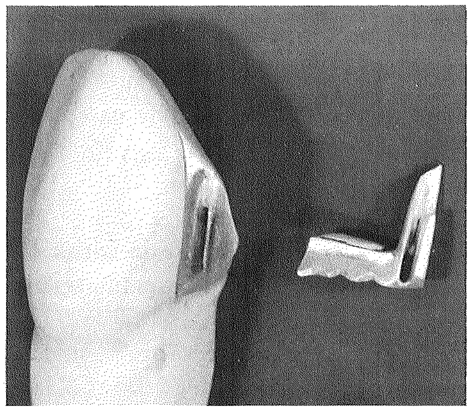
well on long teeth. As it is completely concealed from the labial (buccal) by the first artificial tooth of the denture, it's esthetic value is very high.

The ear lock consists of a box as the fixed part, and a congruent flange as the movable part. The box is soldered distally to the abutment of the tooth adjacent to the saddle area, the flange is incorporated into the saddle (fig. 167). The box is open towards the labial (buccal) and the flange is inserted labio-lingually (bucco-lingually) (fig. 167, 168). After insertion, the flange is locked against removal towards the occlusal by the web of the lock (fig. 168c), but not against

a



b



c

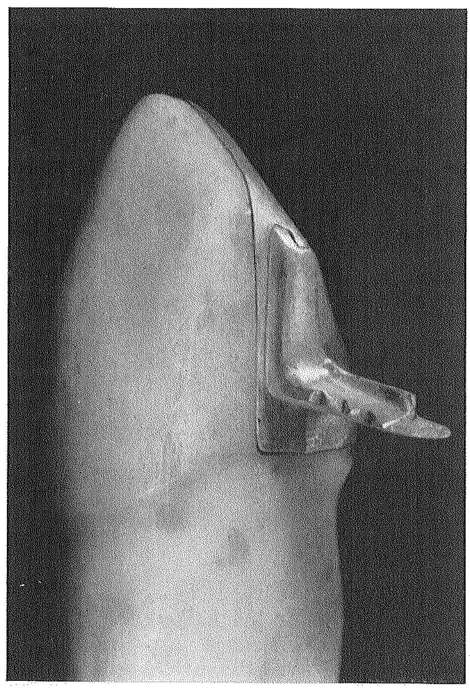


Fig. 168 The ear lock. a = ear lock on a half crown of a vital cuspid tooth, with fixed part soldered to the distal side of the crown and movable part turned by 180° to show the catch which locks into the ear. The serrated part is incorporated into the acrylic of the saddle or soldered to the gold base or framework. b = the same view with crown in place on the abutment tooth. c = ear lock assembled.

removal towards the labial (buccal). Therefore, a contralateral anchorage must be found on the other side of the arch. This anchorage consists either of a second saddle between two abutments which is immobilized by a removable bridge, as shown in fig. 170 or with CSP attachments and one or two Ro joints as shown in fig. 189, p. 200. The ear lock now has only one degree of freedom, tissuewards, a pure translatory movement. In order to give it the slight rotatory freedom necessary for mastication on the distal part of the resilient saddle, slight reliefs similar to those described for the AxRo joint are given. These reliefs should only be made after several days of wear. The shiny spots on the surface of web and flange (disto-occlusally and mesio-gingivally) will indicate the proper place for the reliefs. The Ro joints on the contralateral side will compensate for the movements on the saddle side. From this description, it becomes clear that the ear lock may only be used unilaterally, on unilateral or bilateral free-end-saddle cases.

The Shell Lock

The contralateral fixation with a locked saddle calls for a special explanation (fig. 170). 3 CSP attachments serve as anchorage for the removable bridge, replacing the missing first molar. Underneath the molar, and attached to the lingual bar, a short rod and two spikes are visible. They fit into a congruent part on the tissue side of the molar pontic. The rod in itself would retain the denture from slipping towards the ear-lock side, but the two spikes, slightly conical, by their grip prevent a rotation around the axis of the rod. This principle was copied from the shells of oysters and mussles (fig. 169). These shells open and close like a hinge. At the very moment the shell closes completely, the ridges and furrows of the two shells interdigitate and thus allow one single position only, the closed position in which the rims of both shells meet accurately. This construction is called the Shell Lock (see below).

Fig. 170, 171 explain the application of the shell lock in a unilateral free-end-saddle denture. The movement of the saddle, joined to the abutment tooth

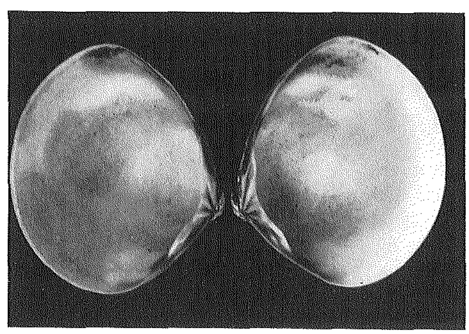
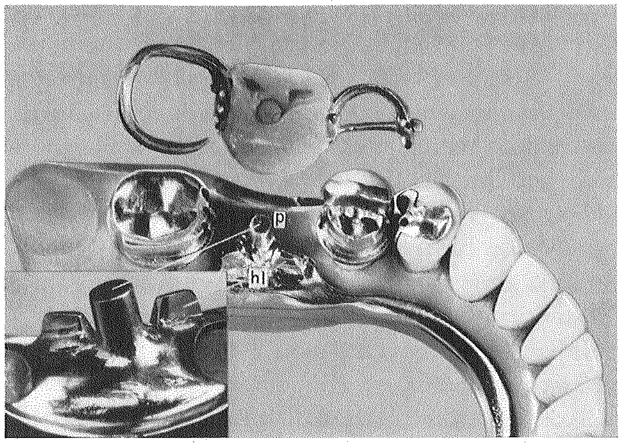


Fig. 169 The two shells of a mussle. Note the interdigitation of ledges and grooves which assures the exact fit of the margins of the shells each time they are closed.

Fig. 170 The shell lock. On the contralateral side of an ear lock joint, the partial denture is locked with a shell lock. A post *p* and the two hinge ledges *hl*, on a small, gingiva supported base and attached to the lingual bar, fit into congruent recesses in the gingival surface of the pontic. The removable bridge is retained by two CSP attachments, and an occlusal rest in the inlay of the first bicuspid. The cut shows the detail of the shell lock.



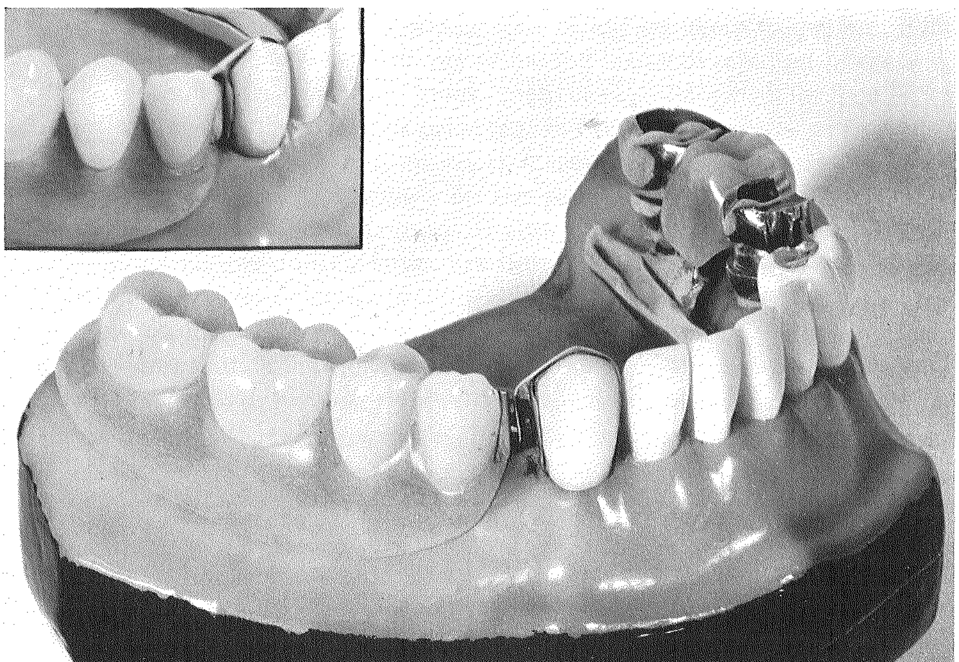


Fig. 171 The ear-lock-shell-lock denture before complete insertion. The first tooth of the saddle must be of acrylic, it hides the lock (see cut).

by an ear lock, requires a slight compensating movement on the contralateral side. Instead of making a fixed bridge with an attachment and a compensating joint (Ro joint, ball- and socket lock, etc.) a small saddle is made between the bridge abutments, a saddle which is joined to the lingual bar. The post *p* on this saddle serves as rotational center while the two hinge ledges *hl* lateral to the post imitate the ledges observed in the shell of mussels. Both post and ledges are reproduced in the base of the pontic which is the body of the removable bridge between the two abutments. The contact of ledges and grooves thus prevents rotational movements in a horizontal plane while the elasticity of the tissue under the saddle alone will allow a slight rotational compensating movement in a frontal plane for the resilience of the free-end saddle of the other side.

Excellent function, easy cleaning and the possibility of modifications on the case at a later date—if further losses of teeth should occur—are the great advantages of this design.

CHAPTER VI

THE PLANNING OF REMOVABLE BRIDGEWORK AND PARTIAL DENTURES

Every professional man must face failures once in a while. Such single failures, from the standpoint of the patient, outweigh scores of successful operations, and the better the name and the quality of work—not forgetting the size of the fee—the more a failure will impress the patient and last but not least . . . the fellow dentist! Along with high quality of work therefore must go a high sense of responsibility and judgement. The reader must have decided for himself that the work described in this book is unfortunately closely connected with the means at the disposal of the patient. It would not be ethical to propose such reconstruction work to somebody who would be likely to get into debt rather than renounce to the possibility of having his teeth repaired in the way proposed to him. On the other hand, such work, performed for people of sufficient means must be worth its price tag, and thus the *prognostic* value rather than the immediate beauty and appropriateness of the reconstruction is to be the first consideration. A prognosis on the prospective time of service, even with the most conscienscious diagnosis, is always something more or less vague, since so many factors and variables are influencing it. Poor health and poor care are the foremost deleterious influences. To teach a patient to take care of his mouth and of his reconstruction work and to check up on his results is almost as important as the work itself. The patient's health largely depends on his way of life and on his nutrition. Although we can teach him a few fundamentals about health, experience tells that it is a sadly small minority who will put such theory into practice.

BIOSTATIC FACTORS INFLUENCING THE PLANNING OF RECONSTRUCTION WORK

The first question is: Can we preserve the teeth with which the patient presents himself for examination? Which are the elements which are beyond hope of recovery and must be sacrificed; which are the elements susceptible to recovery by elimination of infectious or traumatic factors, or by immobilization, and last, which are the teeth on which the ultimate result will depend.

Thus, three categories have been clearly separated and require separate consideration. The limit between the first and second category is certainly not an easy one to determine and the decisions in this respect will vary from one extreme to the other. On one side will stand the man who will take no chances, who is convinced that every devitalized tooth is a crime to health, but also the other man who wishes to make things easy for himself, who *does not wish to do any endodontia*, who is afraid of all "if's". On the other side, we find the man who will yield to every plea of his patient to save a tooth or more, who closes his mind to possible consequences and who cannot see his case on the study models diminished by a few elements. Hence it follows that it would be useless to try and determine a limit between teeth to be extracted and teeth to be saved, because only experience and personal weighing of the different factors involved will always and ever solve the problem at hand. For a diseased tooth, these factors are: *Diagnostically:* Vitality, mobility, traumatic occlusion, degree of infection, and *therapeutically:* Extraction, periodontal therapy, endodontia, spot grinding, splinting. Once the biological and pathological problems are solved, the next step is to analyze the problem of statics or rather biostatics which must determine the design and concept of the restorations.

Where bridge- and partial denture work is involved, a process of destruction is in progress in the patient's mouth and the goal of reconstructing such a mouth is to arrest, or at least slow down further destruction, along with restoring function and esthetics to the highest possible degree. In other words, destroying factors must be eliminated, slowed down, or compensated by artificial means. When eventually it has been decided which teeth may be used as abutments for reconstruction work, and all the preliminary measures, surgery, periodontal therapy (including elimination of traumatic occlusion) and endodontia have been taken care of, remains the problem of statics for the construction. Here are clearly two widely different categories of cases: (a) The *spaced dental arch*, and (b) the *shortened dental arch* (fig. 172).

The limit between abutment supported and mucosa supported parts of the artificial replacement must be found. The cases in fig. 172 are arbitrarily chosen as typical ones among thousands of variations. Equally arbitrary are some of the solutions concerning the distribution of tooth supported and mucosa supported areas (3, 4, 5, 9) because with few abutments left, the stresses to which they are to be sujected may be considered excessive. However, these stresses may be reduced by an adequate reduction of the occluding surfaces of the artificial teeth. On the other hand, it should be understood that in cases 4, 5, 7, 9 the mucosa supported areas can or sometimes must include the whole palatal area. The mucosa supported area then cuts into or includes the abutment supported area.

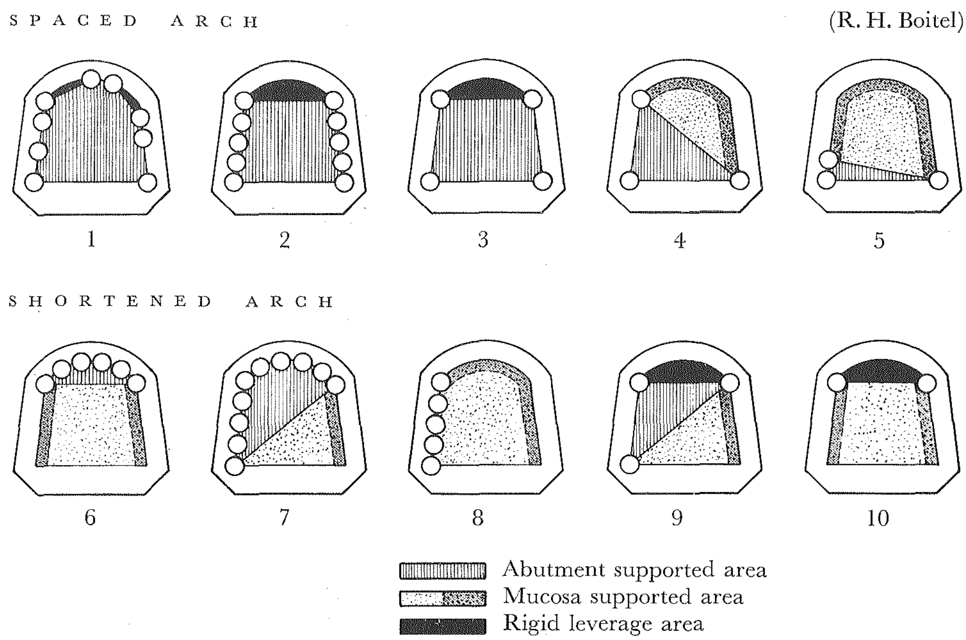


Fig. 172 Classification (Boitel)

SPACED ARCH

No.	Spaces between abutments	Abutment supported area	Mucosa supported area	Rigid leverage area	Replacement
1.	small (various)	maximum	–	small	fixed bridge partial denture rigid
2.	large (1)	large	–	large	fixed bridge partial denture rigid
3.	large (3)	large	–	large	removable bridge partial denture rigid
4.	large	medium	medium	none	resilient partial denture
5.	large	small	large	none	resilient partial denture

SHORTENED ARCH

No.	Spaces between abutments	Abutment supported area	Mucosa supported area	Rigid leverage area	Replacement
6.	none	small	large	none	resilient partial denture
7.	none	medium	medium	medium	resilient partial denture
8.	none	small (linear)	large	none	resilient partial denture
9.	large	medium	medium	large	resilient partial denture
10.	large	small (linear)	large	medium	resilient partial denture

Case 1 (of classification fig. 172)

If all the abutments are above doubt as to their prognostic value, both from the standpoint of periodontal disease and of caries susceptibility, this is the classical case for a complete, fixed bridge. Unfortunately such favourable circumstances are the exception, and usually there are very good abutments along with weaker ones. If one tries to visualize what the patient's mouth may look like after 5, 10 or 15 years time, one may find that certain destroying processes then may still have progressed, if slower than before treatment.

The extension of the artificial replacement at the cost of further abutment teeth is only possible if the replacements are removable. Removable work may involve removal for the dentist only and not for the patient. A CSP attachment bridge or partial denture is ideal for the purpose, because the case may be modified according to circumstances. The case developed earlier for the technical procedure is best suited for this type of situation (see p. 133).

Case 2 (fig. 172)

The edentulous front. This case is usually solved either by a fixed bridge which often is, from the esthetic point, unsatisfactory because of loss of tissue (long teeth) or by a partial clasp denture, which either rocks from the frontal leverage or must be retained by an undue number of clasps to avoid movement. A classical case for the bar attachment (see fig. 139, p. 142).

Case 3 (fig. 172)

Two good molars and cuspid teeth are left. If all teeth are vital, the best design will include two three-quarter crowns for the cuspids, two full crowns for the molars, stabilization of the four abutments by a bar attachment, CSP attachments on the two molars or on all four abutments. The removable part may or may not leave the palate open. With devitalized teeth, the design remains basically the same except that on such roots, no crown would be built up. They would receive Richmond caps over which the bar of the bar attachment is soldered. With two good cuspids and two doubtful molars, the cuspids would be joined by a bar with bar attachment, the two crowns are fitted with CSP attachments, and the removable part is stressbroken on both saddle parts by four AxRo joints. The case can thus easily be changed into a uni- or bilateral free-end-saddle extension case.

Case 4 (fig. 172)

This case is an extreme status which, by most practitioners would rightfully be solved by a full denture. However, inspite of all the progress of dentistry, there are cases totally and utterly hopeless for full dentures for various reasons. Thus even cases as this sometimes ask for an answer other than the forceps.

The solution: Immobilization of + 3 7 on one side by bar attachment. CSP attachment on all 3 abutments if vital, toothborn part of removable denture with *narrow* occlusal surfaces, two Ro joints on toothborn side, 1 AxRo near single molar. Full palate coverage. Another solution of a similar case is found on p. 169, fig. 165.

Case 5 (fig. 172)

Group immobilization of the two molars, CSP attachments on all 3 abutments, two AxRo joints, full coverage of palate.

Case 6 (fig. 172)

This is the classical double free-end saddle extension case which is the most frequent, in mandibular or maxillary reconstruction. Splint for the six anteriors, consisting of three-quarter crowns, pinlays, Richmond crowns, bases of Jacket crowns on devitalized teeth or veneer crowns with buccal porcelain or acrylic veneers. On the endstanding abutments, CSP attachments, with the patrices joined by a rugae bar, two AxRo joints distal to the attachments, two saddles joined by a palatal plate of chosen width in maxillary cases, and a lingual bar in mandibular cases (see p. 183). For devitalized teeth, combination of bar attachment and two AxRo joints (see p. 193).

Case 7 (fig. 172)

Unilateral free-end saddle extension. Depending upon the number and condition of remaining abutments, groups of two or three abutments, or all abutments are splinted together. If the splint is extended over four or more abutments, it is admissible to add one element as a cantilever at the end of the splint to improve the esthetics and to facilitate the construction of the CSP attachment. Moreover the resilient part of the denture will not be able to damage the distal gingival papilla of the endstanding abutment tooth. CSP attachments on the endstanding element and on at least two abutments of the contralateral side, joined together by a rugae bar. Ro joint in the region of the bicuspid-molar region, AxRo joint distal to the element next to the saddle, palatal plate respectively lingual bar (see pp. 188, 189).

Case 8 (fig. 172)

Unilateral free-end saddle, with abutments on one side of the median line only. Splinting of remaining abutments. CSP attachments on at least 3 of the splinted abutments. 2 AxRo joints, not far apart from each other, in the middle of the splint, soldered to the lingual bar or palatal plate, and the saddle covering the edentulous area. This case is also classical for the method, because with a line of support only, a rigid attachment of the denture would result in a lingual tipping of the abutments when stresses are applied to the saddle side. Loosening of the abutments is inevitable. With AxRo joints, the denture may make movements of resilience on the lateral saddle aswell as in the incisor region without transmitting any but small impulses to the abutments (see p. 184).

Case 9 (fig. 172)

Unilateral free-end saddle, three abutments left. Stabilization by bar attachment. Tooth borne part of denture with narrow occlusal surfaces. Free-end saddle extension with hinge joint (see p. 197).

Case 10 (fig. 172)

Two abutments are left. If those abutments are mandibular cuspids, a durable case can still be obtained without extractions and with a good prognosis. Such a case is solved by the Dolder bar joint (not to be mistaken for the bar attachment). For details about the bar joint see p. 218. As the bar joint is usually made on devitalized teeth, the reader may object that this does not correspond with the claim that the vitality of the abutment teeth must be preserved at all cost. This is one case where the issue would be led "ad absurdum", because with only two teeth left as a possible retention for a denture, which otherwise would perish within a short time, the devitalization gives us a chance to save them. Usually, such last remnants of a natural dentition are teeth with elongated crowns, where alveolar resorption has already set in. *In a stressbroken denture*, the reduction of the leverage of the abutments is a most favourable factor, while in rigidly attached dentures, a reduction of leverage is illusory. Abutment and denture are then statically one and the whole length of abutment plus denture tooth is decisive for the leverage. In the Dolder bar joint, the stressbreaking device is as near to the gingival surface as possible and thus eliminates the full leverage of a crown, natural or artificial.

If the two remaining cuspid teeth have short crowns, they may remain vital, and the Dolder bar joint is soldered between two three-quarter or veneer crowns.

CASUISTRY

The cases presented represent a choice of typical situations the practitioner has to deal with in daily practice. The solutions suggested—appliances completed from five to twentyseven years ago—should contribute towards a better understanding of the preceding chapters. A manual on a technic of construction can suggest but certain single aspects of a large and complex problem. It cannot teach the reader medical thinking and therapeutical understanding, it does not teach fundamentals and cannot treat all of the important factors which determine success or failure. If it did, nobody would care to read such a book, the mere volume of it would be prohibitive. The present material must therefore be considered as a contribution towards the improvement of partial denture prosthesis rather than the demonstration of intricate gold work and the mechanical solution of prosthetic problems. For the planning of a partial denture case, the fundamental principles of operative dentistry, the prognostic evaluation and the proper application of the teachings on occlusion and articulation are as important as the manual skill and mechanical ingenuity.

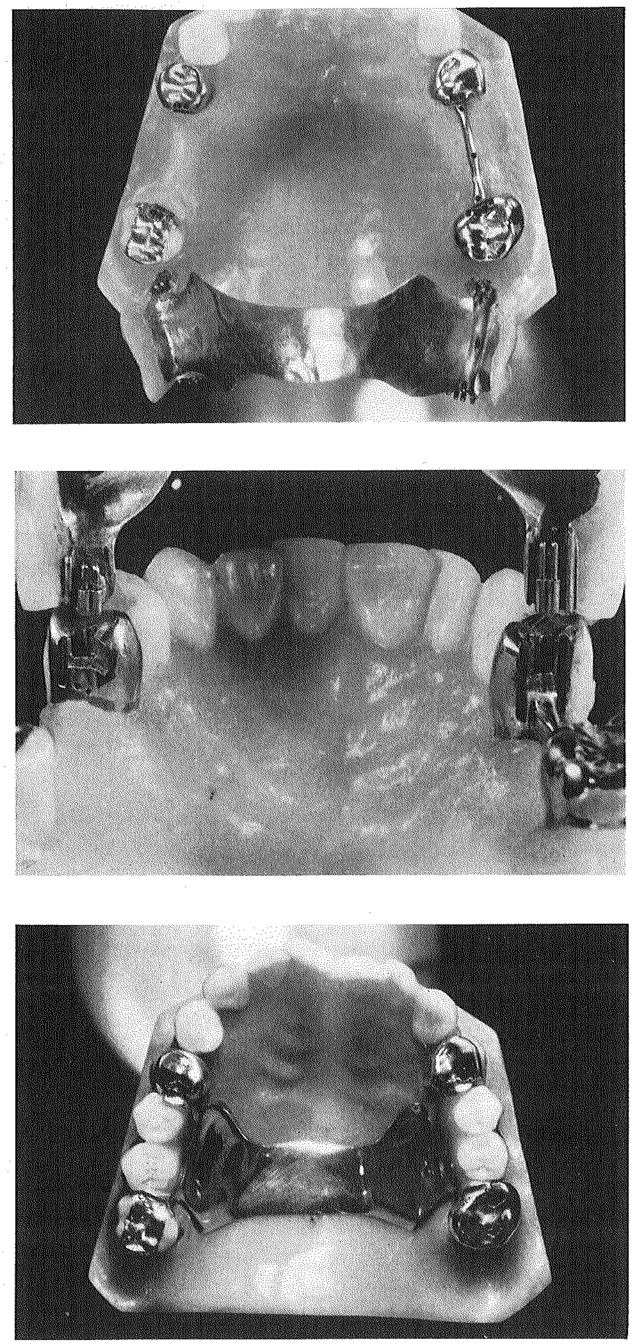
Signs and abbreviations:

AxRo	Axial rotation joint
Ro	Rotation joint
Ba	Bar attachment
CSP	Channel-shoulder-pin attachment
Cl	Clasp
El	Ear lock
O	Outrigger joint
S	Sphere joint
└┴┴┴┘	Splint or bridge

Italic figures: devitalized teeth
Figures above or below the lines of abutments and remaining teeth: Pontics.

Case No. 1

Fig. 173a–c A model case with four ready-made CSP attachments. On one side of the jaw, the two abutments have been joined by a Bar attachment. The middle illustration shows the detail of the attachments. Below, the assembled case.


a

b

c

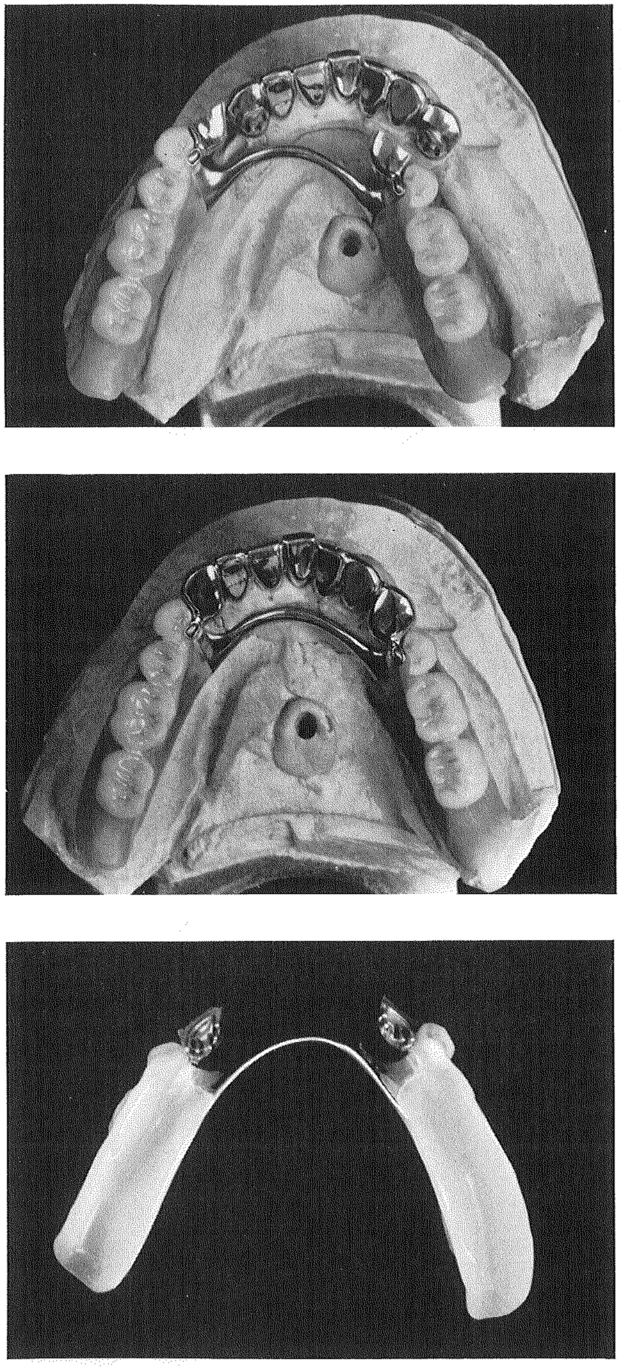
Case No. 2

Fig. 174a–c Abutments: Six lower anteriors, vital. Splint of six three-quarter crowns, with one bicuspid pontic. Solution: Two CSP attachments, two AxRo joints, two free-end saddles with lingual bar.

a

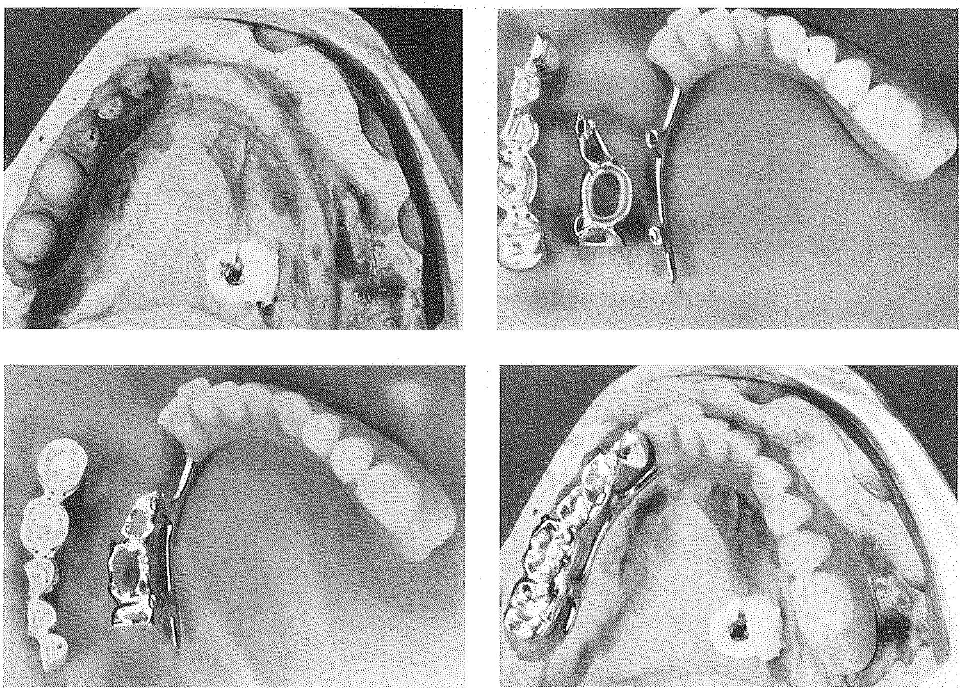
b

c



3 2 1 | 1 2 3

saddle AxRo 4 AxRo saddle

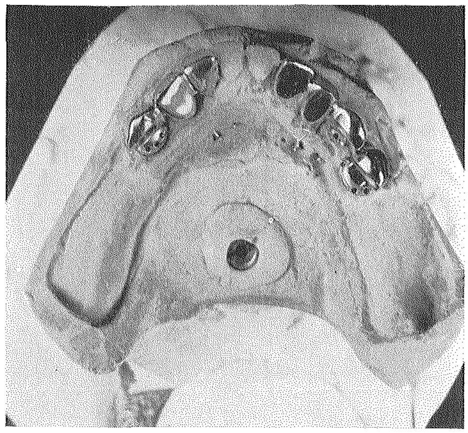


Case No. 3

saddle	3 4 5 6 7
	CSP CSP CSP
	AxRo AxRo

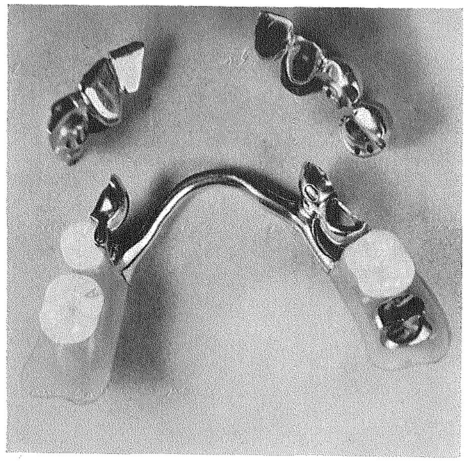
Fig. 175a–d This case is particularly difficult to solve without a stressbroken denture, because of the linear alignment of the abutment teeth on one side of the arch only. Abutments: Five vital teeth. Solution: Three three-quarter crowns, two full crowns, splinted into one unit. Three CSP attachments were made in order to get sufficient space between the two AxRo joints. The large saddle is attached by the lingual bar and the two AxRo's. The joints provide for movement in the sagittal plane (incisors) and movement in the frontal plane (molar region).

Case No. 4



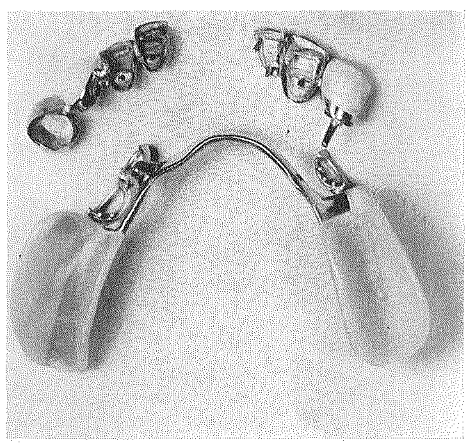
a

Fig. 176a–d Abutments: On the right side, two vital and one devitalized teeth, on the left side, three vital teeth. The two central incisors were not touched for esthetic reasons, the pinlays and three-quarter crowns were made so as to show a minimum of gold. Solution: Two splints of each three abutments. On the right side, a single CSP attachment, on the left side, a double CSP attachment, making use of the pontic. Two saddles and lingual bar, connected by two AxRo joints.



b

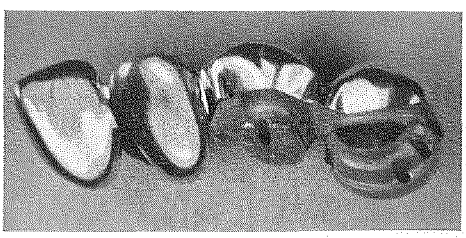
saddle	4	3	2	1	1	2	3	4	5	saddle
	CSP							CSP	CSP	
	AxRo								AxRo	

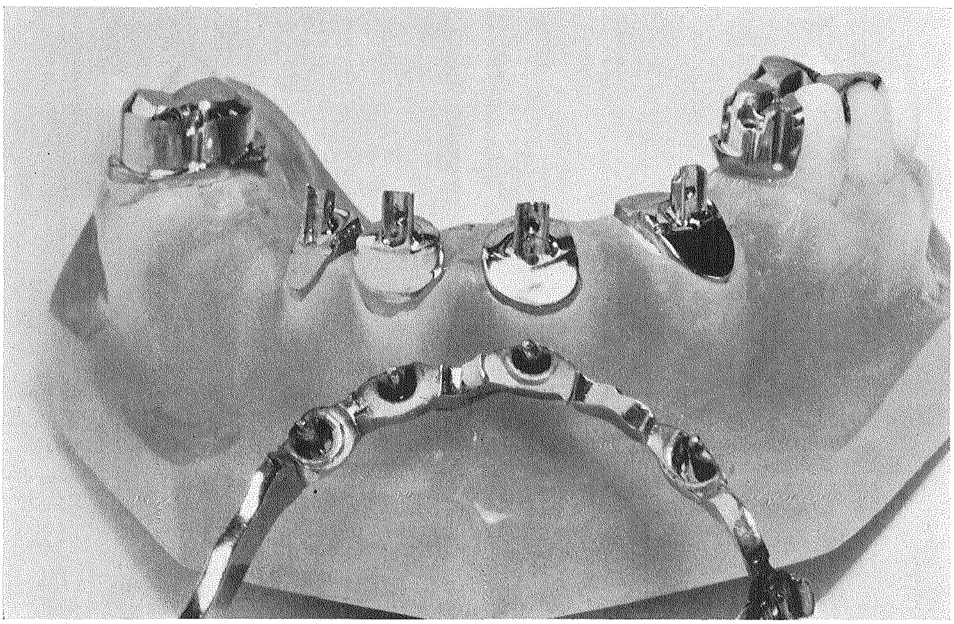


c

Detail of | 4 5

d





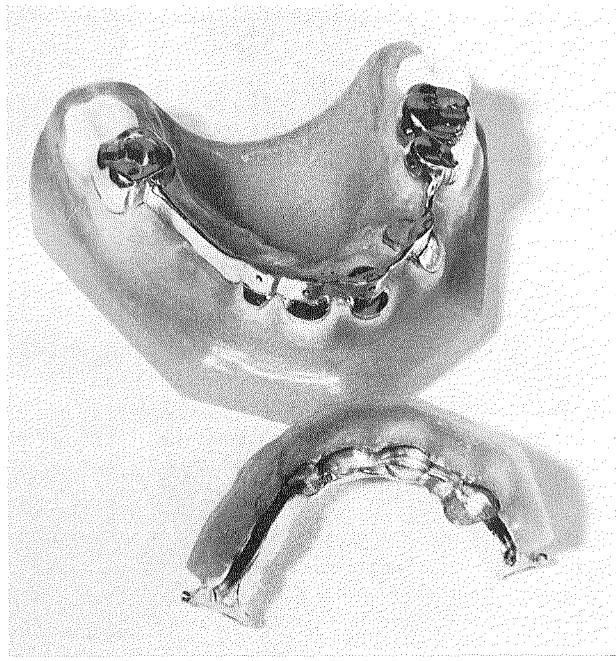
a

Case No. 5

(Courtesy Dr. O. Staehelin, Winterthur)

b

c



d

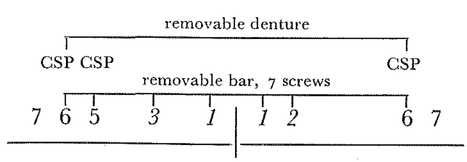
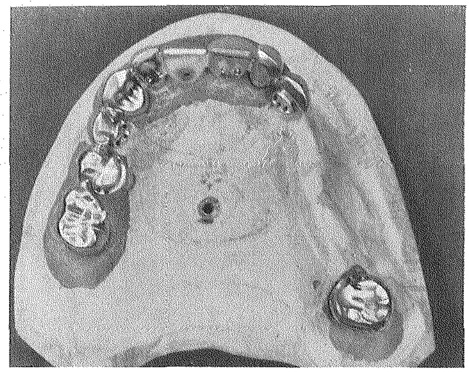
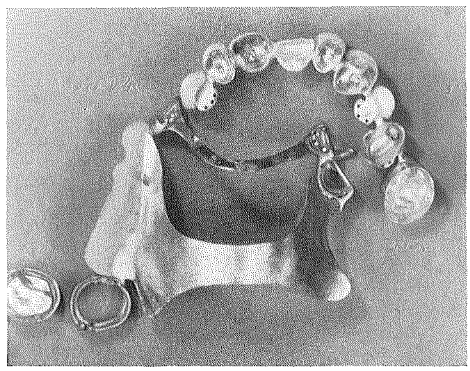


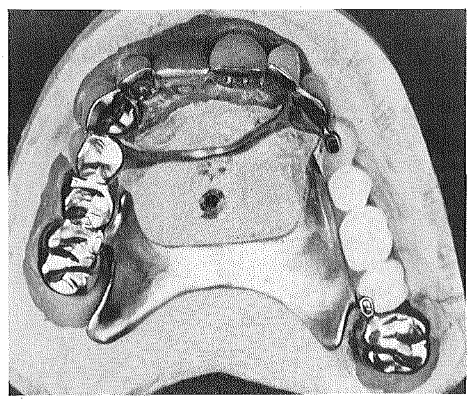
Fig. 178a–d This is the model of an actual case which demonstrates what the possibilities of a skilled mechanic are if the prognostic value of the teeth splinted by a Bar attachment is not the same for all abutments. With devitalized teeth, especially if the endodontic work immediately precedes the prosthetic reconstruction, the risk of a recurrent apical infection is always present. Therefore, the abutment teeth fall into two groups, the first formed by vital teeth and devitalized teeth of undoubtful prognosis, the second, by teeth loosened by previous traumatic occlusion or parodontal disease, or with treated apical infection. The second group is liable to contain elements which will fail before others, and which therefore will have to be extracted without prejudicing the whole reconstruction. Solution: The Bar is fastened by a group of two CSP attachments on the left side, one CSP attachment on the right side, and little rail attachments for each devitalized tooth in the front region. Each attachment is immobilized by a screw inserted from the buccal side and accessible in the mouth with a screwdriver. The denture, with porcelain teeth mounted in acrylic on the bar-patrix, is removable for the patient, while the bar itself is only removable by the dentist.

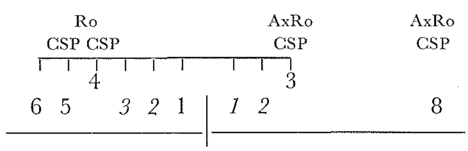
Case No. 6

Fig. 179a–c Abutments: Four devitalized and four vital teeth. The space between the left lateral incisor and the third molar was too large for a fixed bridge or rigid partial denture. Solution: The teeth from right first molar to left lateral incisor were splinted with four Richmond crowns, one three-quarter crown on the vital central incisor, and two full crowns. A "cantilever" cuspid pontic was added to the splint in order to improve the esthetic effect and because of easier construction of the CSP attachment. The two CSP attachments on right 4 and 5 were joined to the CSP attachment of left 3 by a rugae bar, to facilitate insertion for the patient. The resilient saddle of the left side is connected to the attachments of left 3 and 8 by two AxRo joints. The compensating movement on the right side is given by the Ro joint between right 5 and 6. If the bearing surface of the resilient part may seem small, such was the wish of the patient, a dentist!


a

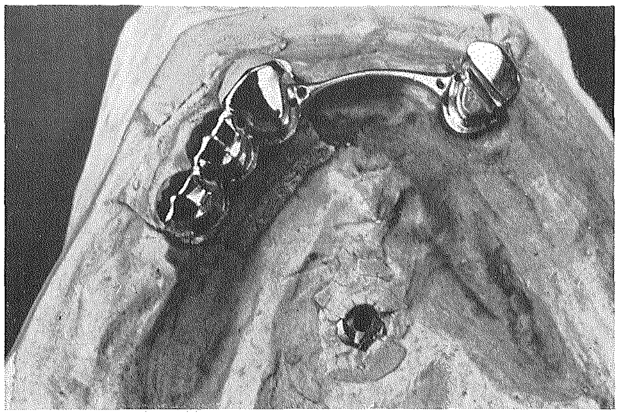

b


c

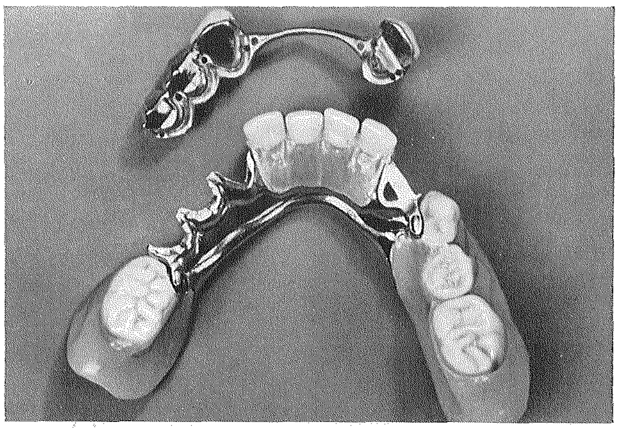


Case No. 7

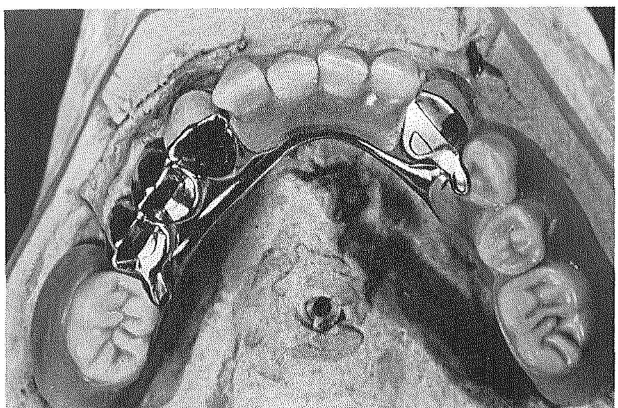
Fig. 180a–c With only four abutments left in the mandibular arch, complete stabilization by splinting had to be obtained. Four CSP attachments and a Bar attachment carry the toothborn part of the denture. The two saddles are stressbroken by two AxRo joints.



a



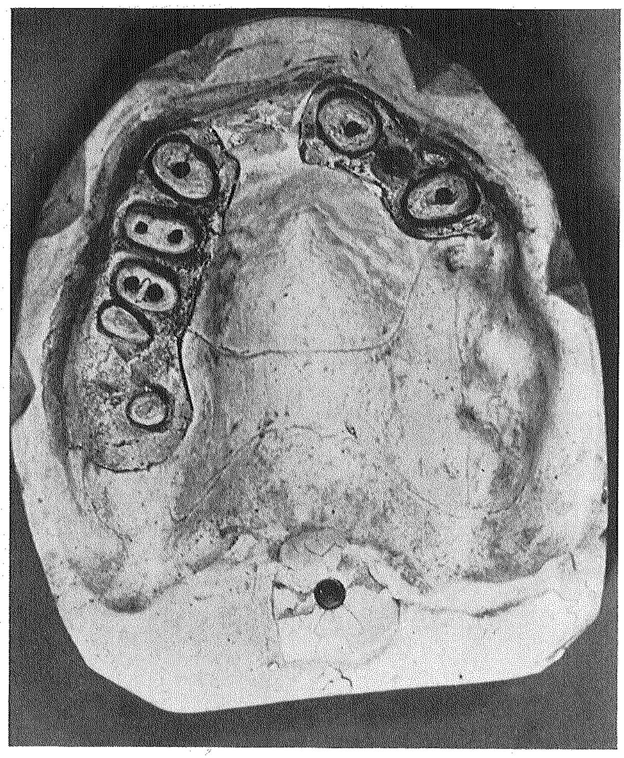
b



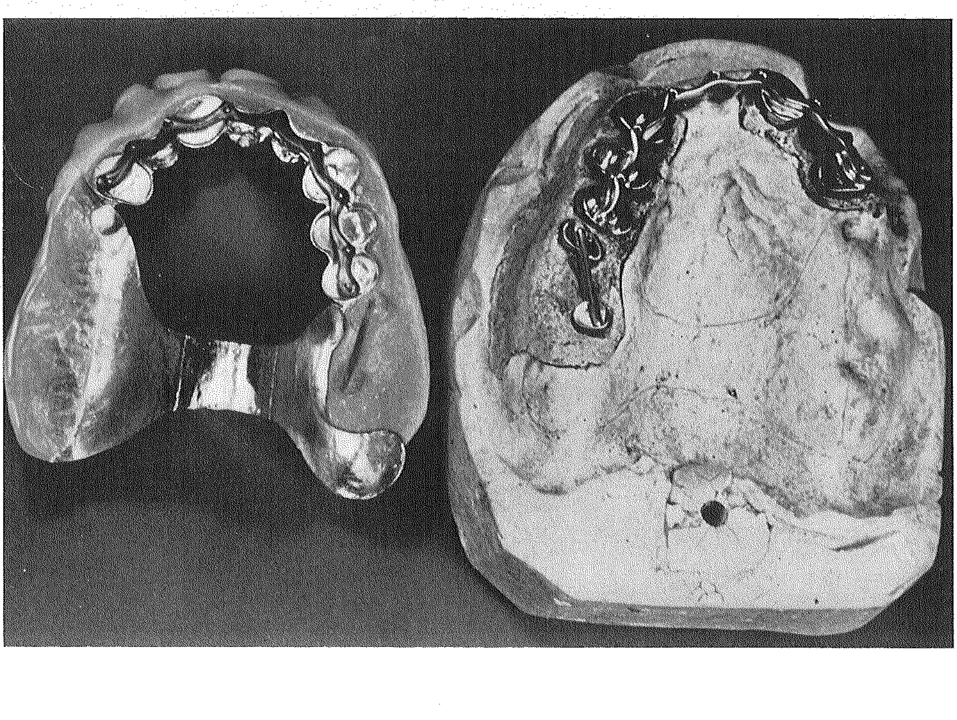
c

		3		3	4	5		
saddle	AxRo	CSP	ba	CSP	CSP	CSP	AxRo	saddle

Case No. 8

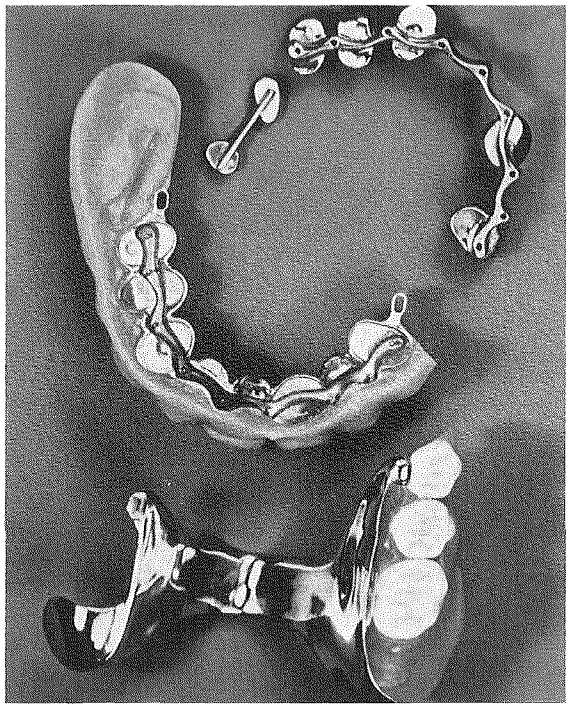


a

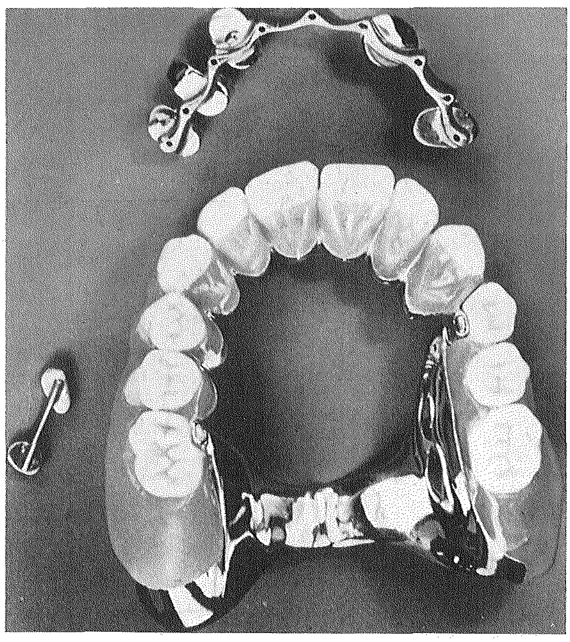


b

Fig. 181 a–d Abutments: Five devitalized teeth and two devitalized roots of the right first molar. The molar roots were kept in order to give the patient the benefit of one entirely toothborn side of the denture. After 5 years of wear, these roots were extracted because loosened. Solution: Bar attachment splinting five abutments. The bar is arched from one pinhole to the other in order to get sufficient space for porcelain teeth (fig. 181 b). Fig. 181 c shows above: the fixed part, the bar; middle: the toothborn part of the denture; below: the resilient part of the denture. On the saddle side, an AxRo joint, on the toothborn side, a Ro joint. After the molar roots were extracted, the round window of the Ro joint was enlarged gingivally into an oval window, which changed into an AxRo joint. The acrylic was sawed through behind the second bicuspid, thus freeing the saddle with the first molar. So, without costly changes, the case was changed from a unilateral to a bilateral distal extension saddle case.



c



d

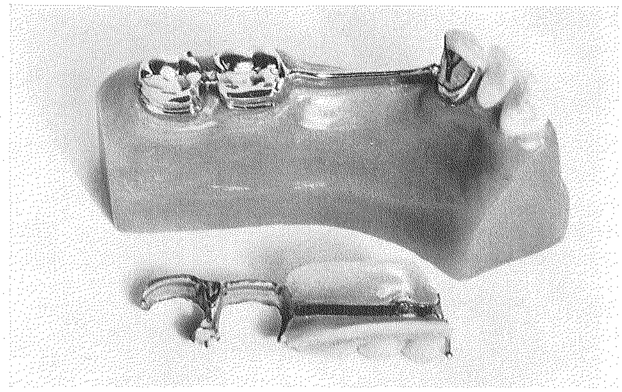
Ro Ba AxRo saddle

6 5 4 3 | *1 3*

Case No. 9

(Courtesy Dr. O. Staehelin, Winterthur)

a



b

3 7 8

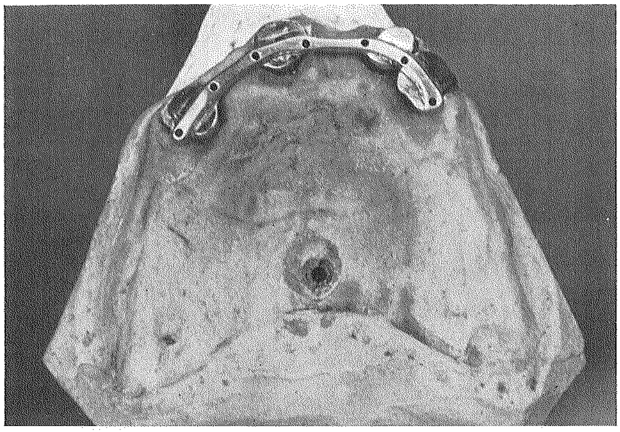
Ba CSP CSP

removable bridge

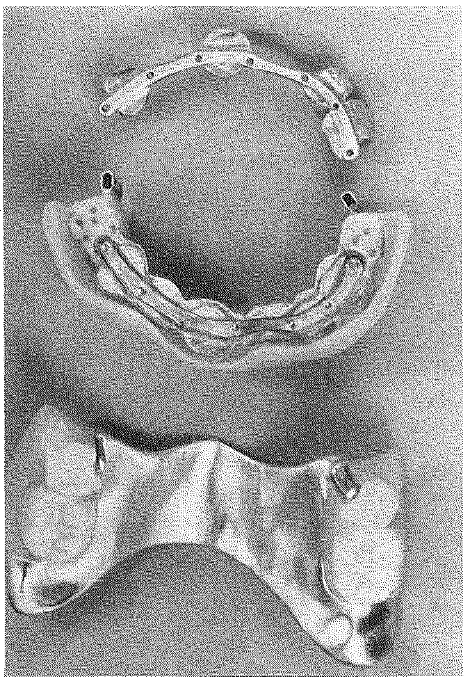
Fig. 177a–b This model case shows the solution of a case where from extractions or surgery lost tissue on the buccal side must bere placed. Splinting with the bar serves to stabilize the abutments.

Case No. 10

a



b



c

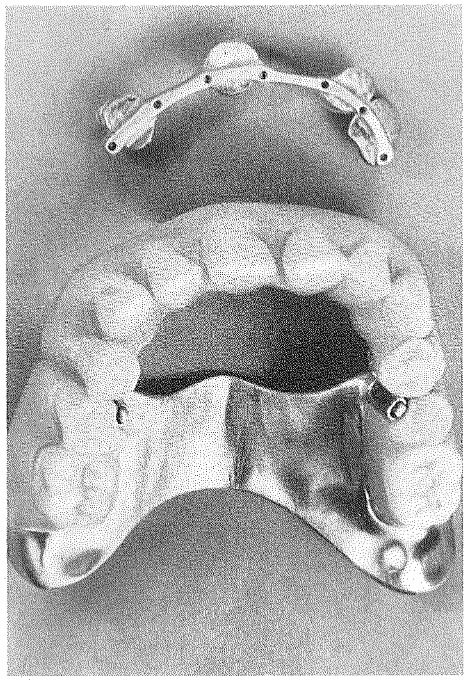
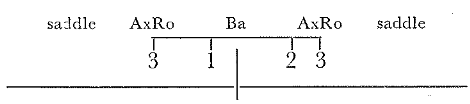
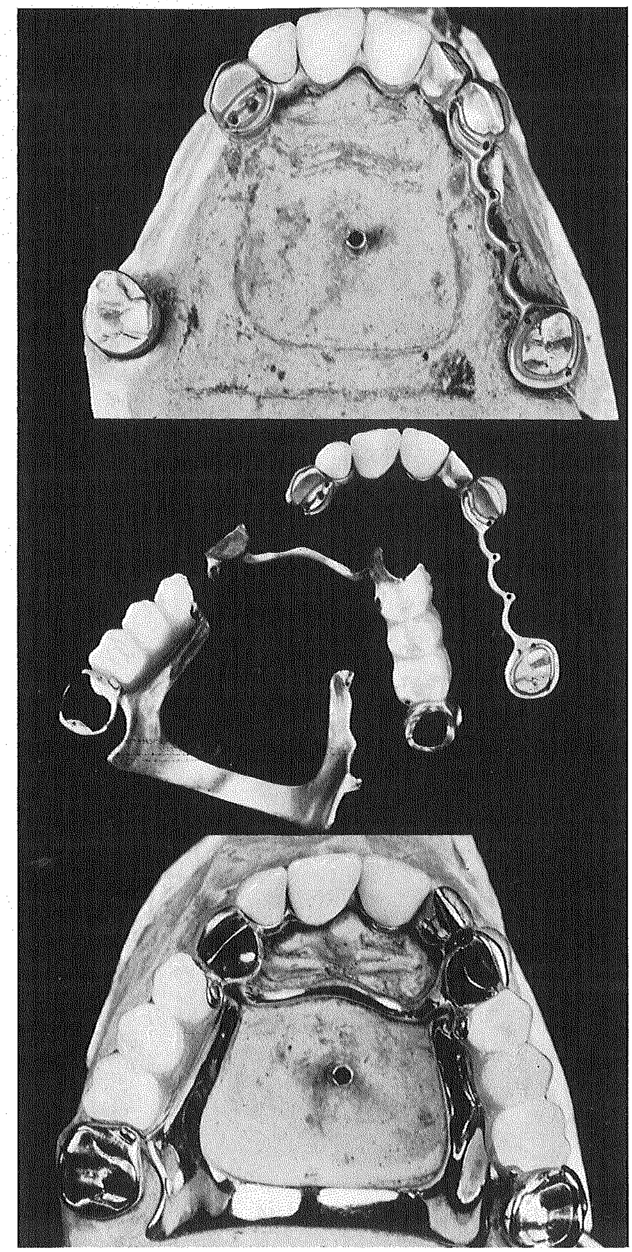


Fig. 182a–c Abutments: Four devitalized teeth in the front, after removal of an old bridge and extraction of several teeth. Solution: Bar attachment splinting the four abutments. On the toothborn part of the denture, eight teeth were mounted. Distal to them, two AxRo joints, and bilaterally, resilient saddles with a palatal plate.



Case No. 11

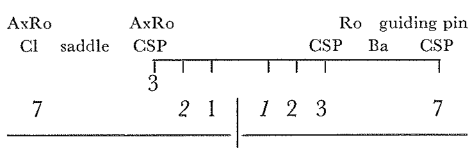
Fig. 183a–c Abutments: Five vital and two devitalized teeth. The right second molar had surgery for parodontal pockets and was therefore doubtful, though vital. Solution: Splinting from right lateral incisor to left second molar. The bar is arched to provide sufficient space for porcelain teeth. Abutment constructions: 2+: Three-quarter-Richmond base with core for porcelain jacket crown, 1+: Three-quarter-thimble crown for porcelain jacket crown. +1: Three-quarter-Richmond base with core for porcelain jacket crown, +2: Three-quarter crown, +3: Richmond crown, +7: Full crown. 3+ was added to the splint as cantilever pontic, in order to remove the resilient saddle from the gingiva distal to the lateral incisor, and for aesthetic reasons, because a jacket crown was preferable on the lateral than a Richmond crown. Fig. 183b shows the three parts of the denture: above the fixed splint, in the middle the toothborn part with rugae bar, and below, the resilient part. The two removable parts are joined by two AxRo, one Ro joint and a guiding pin near +7. The latter is simply a substitute for another Ro joint. In case 7+ should have to be extracted (it has now been 10 years from insertion of the case) the simple change of enlarging the saddle distally over the extraction wound solves this problem.



a

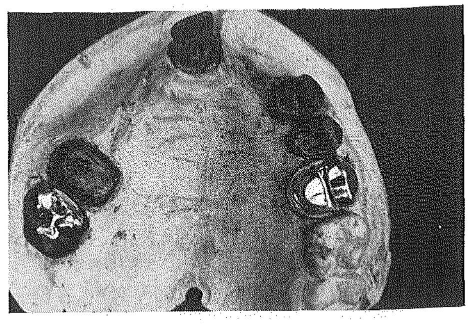
b

c



Case No. 12

Fig. 184a–d Abutments: Six vital teeth. Solution: Splinting of all abutments. The edentulous areas are bridged by a bar. The bar is arched in order to leave sufficient space for porcelain teeth. The retention of the removable denture is afforded by the two Bar attachments and the six CSP attachments. The transversal palatal bar only serves as stabilization against deformation of the removable part by the patient.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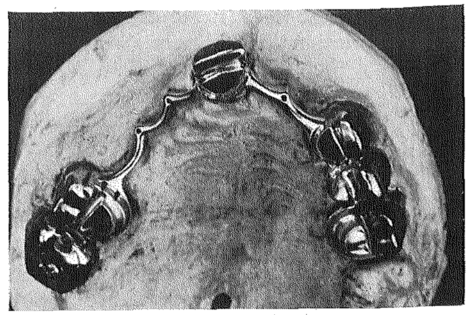
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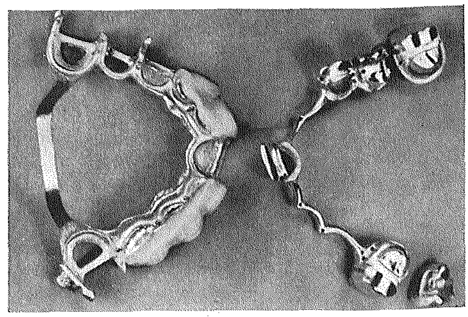
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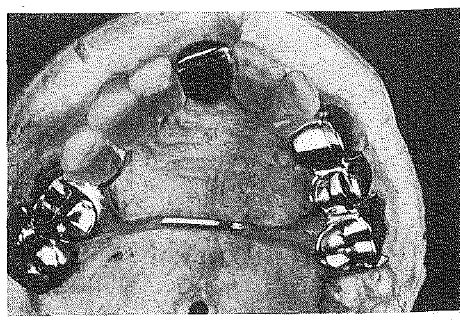
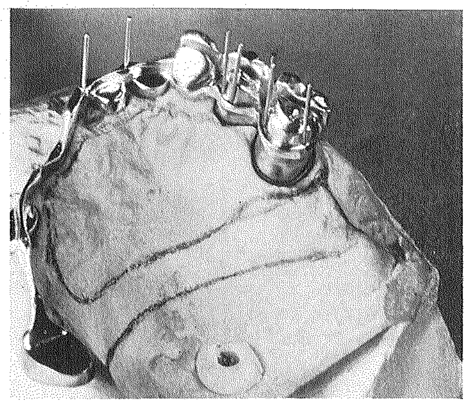

d

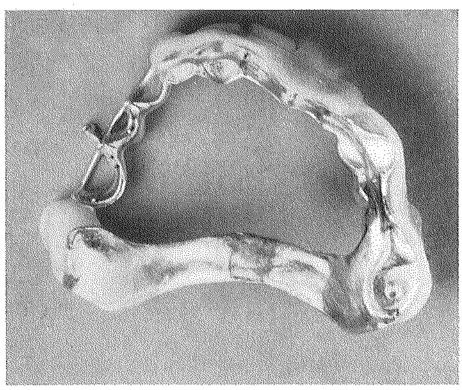
CSP CSP Ba Ba CSP CSP CSP

7 6 1 | 4 5 6

Case No. 13

Fig. 185a–c Abutments: Three vital and four devitalized teeth. Previously, the patient had worn a bridge for some 30 years. A large cyst had then to be removed from the region of 3 2 +, with considerable loss of tissue. Still, the bridge was then made because the patient never shows his gingivae, even if he tries to. Solution: Splinting of all remaining abutments by the bar retention of the entirely toothborn partial denture by the Bar attachment and three CSP attachments. Fig. 185a shows the finished matrix with some of the stainless steel pins inserted. The bar is screwed together on the central incisor (not visible in the picture) because of marked divergency of abutment preparation on the left side from the root canal posts on the right side. Because of the large extent of the splint, the addition of the left second molar is not harmful to the stability of the abutments. The palatal bar only serves to stabilize the denture against handling by the patient.


a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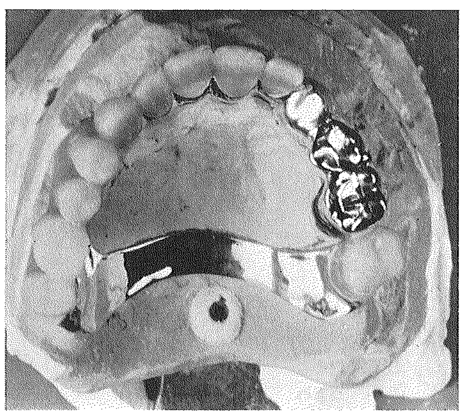
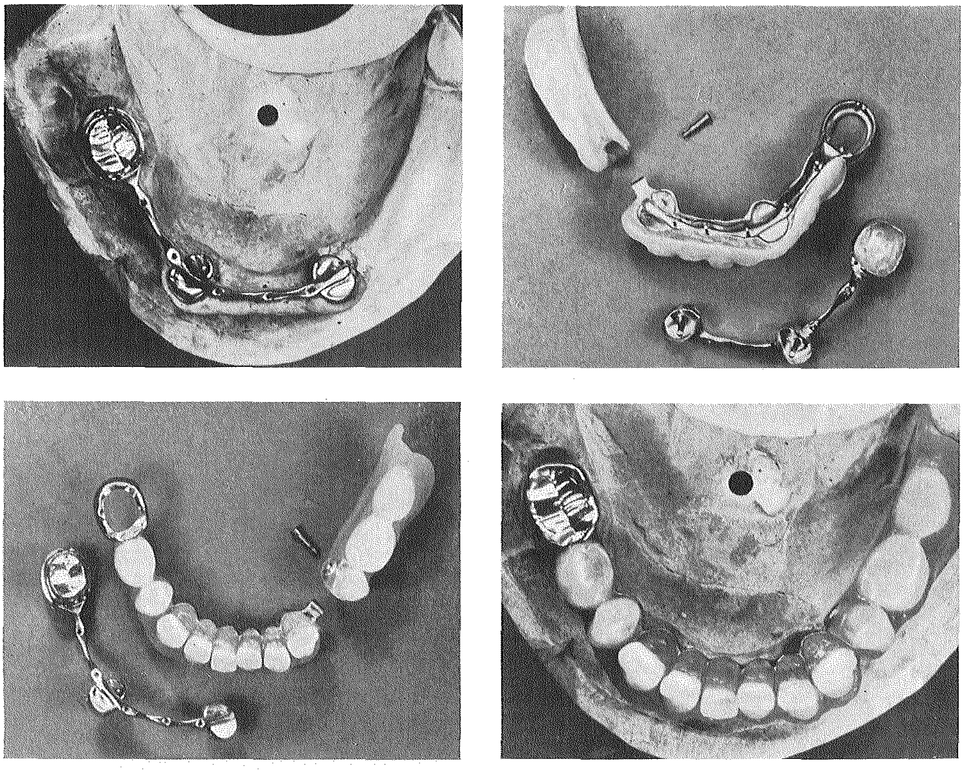

c

Ba CSP CSP CSP

7 5 | *1* *2* 3 4 5

a b c d



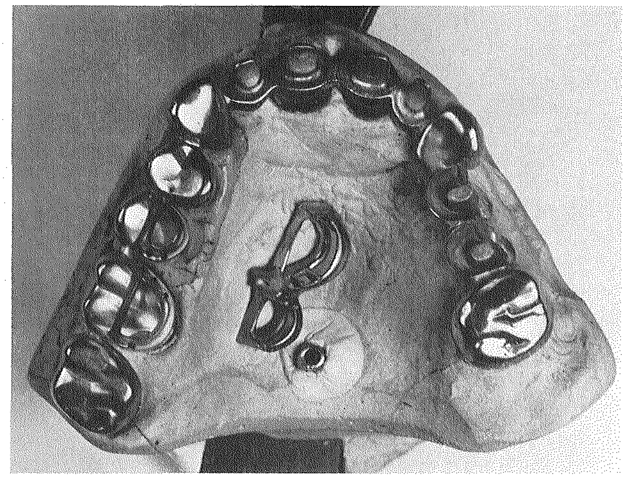
Case No. 14

7 3 | 3

CSP Ba hinge saddle

Fig. 186a–d This case is the clinical version of the model case on p. 137, fig. 134a–c. The patient had worn a front bridge from cuspid to cuspid, along with a clasp partial denture which both created unhygienic conditions. Moreover, the bridge with its linear anchorage was well on the way to loosen the two abutments. Solution: Splinting of the three abutments by the bar. Retention of the denture by the Bar attachment and one CSP attachment. The saddle is stress-broken by a hinge. Control X-rays after 6 years shows a solidification of the bone socket of the two cuspids. The hinge has been twice changed in 7 years because of wear.

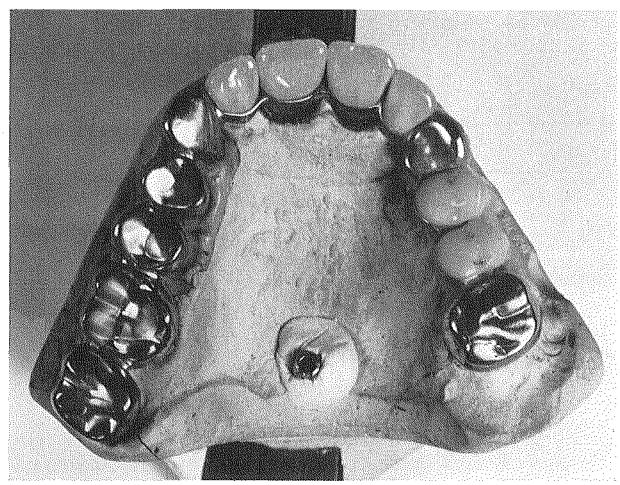
Case No. 15



a

Fig. 187a–c The purpose of this reconstruction is (a) stabilization of a damaged arch with parodontal disease, (b) cosmetic rehabilitation. A poor partial denture along with traumatic occlusion had favoured unhygienic conditions and periodontal inflammation. Solution: Complete splint, bridging the edentulous areas. Abutment constructions: Right second and first molar: Full crowns, right second and first bicuspid: Three-quarter crowns, right cuspid: Pinlay, central incisors: Three-quarter-Richmond bases with cores for porcelain jacket crowns (idem for incisor pontics), left first molar: Full crown. The CSP attachment on the latter serves a special purpose: The prognosis of the central incisors is—over the years—somewhat doubtful because of moderate length of the roots and because of the excessive length of the bridge on the left side. It must be anticipated that these incisor roots will fail before the other abutments do. The bridge can then be sawed off behind the pontic of the right lateral incisor, and removed from the left second molar because of the CSP attachment. With the three CSP attachments (6 5 + and + 7) and two AxRo joints, a resilient partial denture can be constructed without removing the splint on the right side.

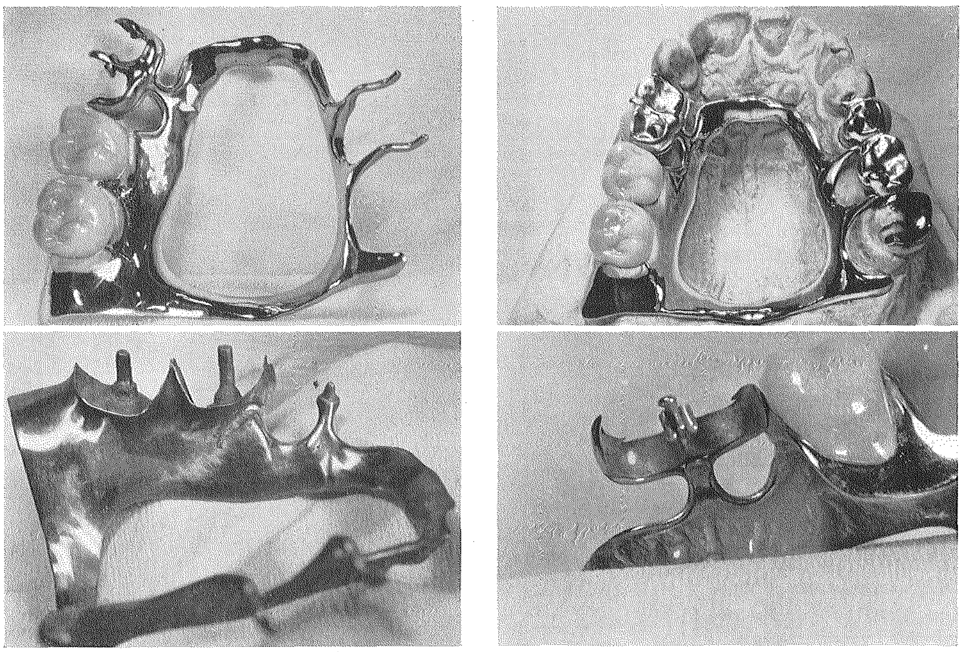
b



c

Formula see bottom opposite page

a b



c d

Case No. 16

saddle cl o o

6

5 4 3 2 1 | 1 2 3 4 *5* 7

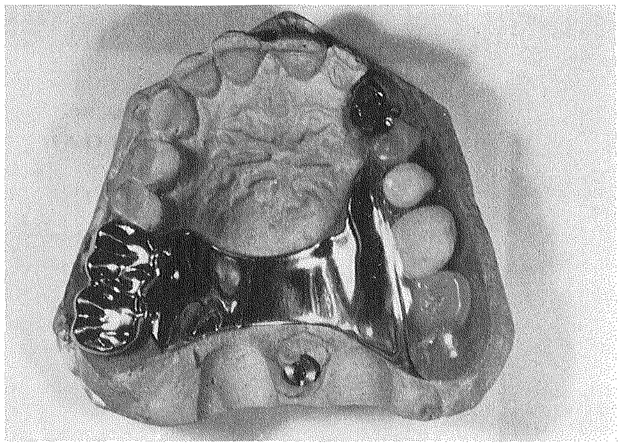
CSP CSP CSP

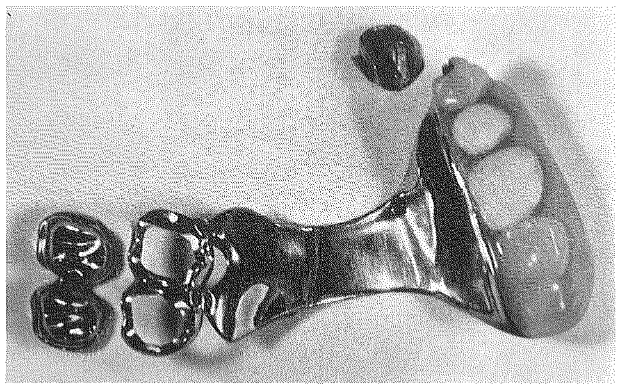
← 7 6 5 4 3 *1* | *1* 6

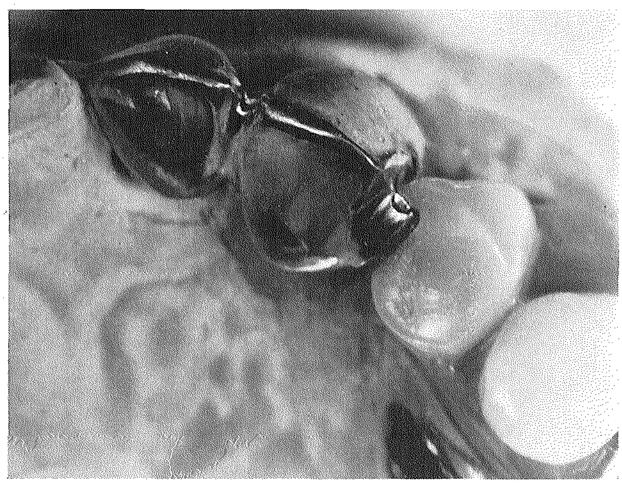
Fig. 188a–d Outrigger denture. The bridge on the left side serves as retention for the outriggers which reach into the interproximal spaces between abutments and pontic. The fixation on the right first and second bicuspid is obtained by a cast clasp with elastic arms. To prevent deformation of the clasp wires, a small peg from the casting of the plate fits into a congruent seat on the lower side of the clasp. Left top: Denture with outriggers and clasp. Left bottom: Detail of the peg before soldering of the clasp wires. Right top: Denture on the model, the outriggers reach below the bridge. Right bottom: Detail of the clasp. Two wire loops, soldered at their extremities only and between the wire loops the peg which fits into the base of the clasp. The peg serves to push the clasp off the tooth on removal of the denture.

Case No. 17

Fig. 189a–c Ear lock denture. Only three abutments were used, the left cuspid for the ear lock, and the two molars for the CSP attachments. Soldered to the CSP attachments and the palatal plate are two Ro joints which compensate for the movements of the saddle. The enlargement (bottom picture) shows the fit of the ear lock and the camouflage by the facing of the first tooth on the denture saddle (vide fig. 168). (The three-quarter crown on the lateral incisor (c) was added just before insertion of the case, therefore it is not yet visible in fig. a.)


a


b


c

Ro CSP	Ro CSP									el saddle
7	6	5	4	3	2	1	1	2	3	

VARIOUS DESIGNS OF SWISS STRESSBREAKER JOINTS

The rising success of the principles put into practice by STEIGER since 1923 has not remained unnoticed by other authorities in the field of partial prosthetics. After BEAT MÜLLER first published his BMB joint in 1947, the idea of stress-breaking rapidly spread and prompted a wave of new inventions. It would go beyond the scope of this manual to enumerate, explain and criticize in detail all the stressbreaker joints now on the market in Switzerland.

On the other hand, some of these more recent inventions have proven their value and their durability over a variable period of years. It is in tribute to the ingeniousness and work of their inventors that the authors have offered a limited space to each of them for their own contribution. The following articles are arranged in the chronological order of the appearance of the respective joints: B. MÜLLER, A. BIAGGI, R. FISCHER†, M. FREY, E. DOLDER. For the hinge joint, the authors have endeavoured to express the views of the protagonists of this joint.

THE BMB JOINT

By Dr. med. dent. BEAT MÜLLER, Zurich (Switzerland)

The free-end-saddle extension denture must fulfil both a static and a prophylactic task. The anchoring part of such a denture must splint the remaining elements of the shortened or the spaced and shortened dental arch in order to protect them against individual trauma from masticatory forces. Between splint and saddle there must be a mechanical connecting device, a joint, which during mastication imparts to the mesial part of the saddle a pressure equal or nearly equal to the pressure found in the middle part of the saddle. Thus the bearing capacity of the mesial half of the saddle is increased without hindering the resilience movement of the saddle on the mucosa. This movement must be even on the whole length of the saddle, as it is in a full denture with a centered bearing area.

The BMB joint, first published in 1947 and on sale since 1948 fulfils the above described functions. It consists (fig. 190) of a flat box of rectangular cross section, a flat bracket which fits into the slot at the base of the box, and a wire loop spring which holds the two parts together. On the flat box, the short end of the spring fits *loosely* into a channel, while the long end of the spring is *immovably* seated in the notched tube situated at the back of the flat bracket. The soldering areas for the BMB joint are (a) on the back of the box (placed against the distal of the clasp or precision attachment adjacent to the saddle space), (b) on the horizontal extension plate of the bracket (soldered to the cast base or meshwork of the saddle). The hooklike end of the bracket which fits into the slot of the box has no lateral freedom whatsoever. By filing a slight taper on the finished denture, a restricted lateral play is allowed for.

POSITION OF THE BMB JOINT IN RELATION TO THE ALVEOLAR RIDGE

The BMB joint is placed perpendicular to the plane of occlusion, over the lingual (palatal) slope of the alveolar ridge and it must rest against the crest of the ridge if it is to play its true part in the leverage system of the denture (fig. 191). The slot of the box should be placed distal from the last tooth by the width of the gingival papilla, close to the ridge, with the horizontal extension of the bracket pointing distally in the direction of the alveolar crest. BMB joints mounted in pairs must be parallel in a vertical direction, in a horizontal direction they may slightly diverge. The author suggests that where the alveolar crest drops steeply from the neck of the last tooth, it may be advisable to add an artificial tooth element to the continuous clasp, splint or attachment thus bridging the steep portion of the alveolar crest. Proper mounting of the box determines the correct position of the whole joint. It is best done on the parallelometer with a special holder.

FUNCTION OF THE LOOP SPRING

On the working side, the spring prevents the end of the hooklike bracket from sliding out of the slot in the box by opposing an elastic force. However, it allows to the bracket a certain degree of mobility within the slot. The spring prevents the mesial edge of the saddle from damaging the distal gingivae of the abutments adjacent to the edentulous space. The elastic deformation of the spring corresponds to a spring tension of 1.5 to 2.0 kg, a value tried and proven by 15 years of experience and exhaustive research. Fig. 190f–h shows the function of the joint in rest position, in a rotatory movement, the result of forces applied to the distal of the saddle, and a translatory, sliding movement, the result of forces applied to the mesial half of the saddle.

FIXATION OF THE LOOP SPRING

The fixation of the spring in the two corresponding channels of the box and bracket is increased if the loop of the spring lies in a shallow groove of the acrylic of the denture base. In addition, the long end of the spring lies

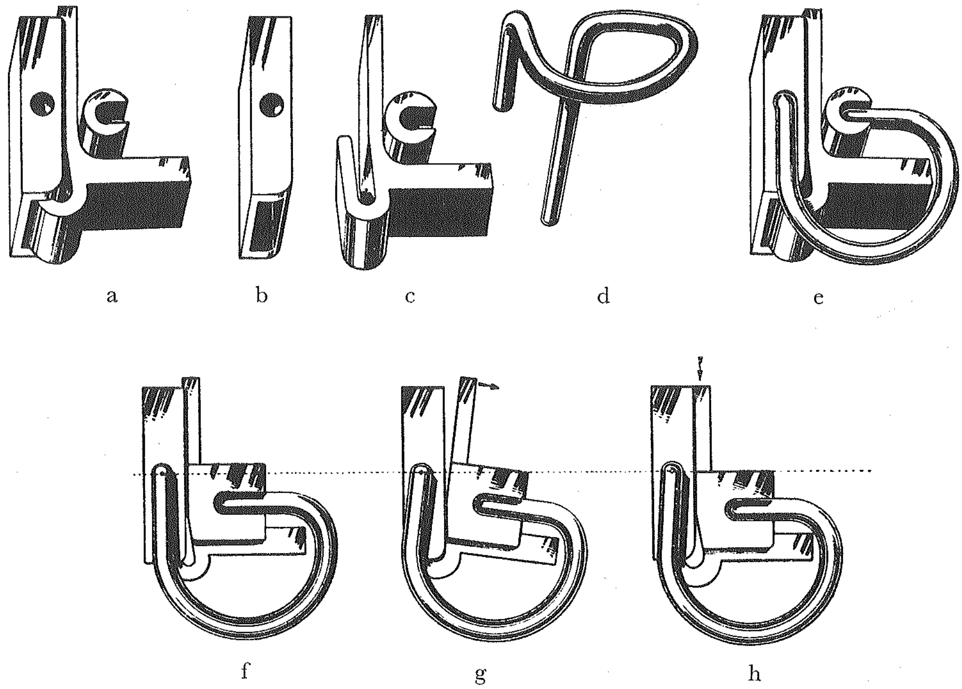


Fig. 190 The BMB joint. a = box and bracket assembled. b = box, c = bracket, d = spring. e = complete joint assembled. f = BMB joint in rest position. g = rotational movement (hinge movement). h = translatory movement.

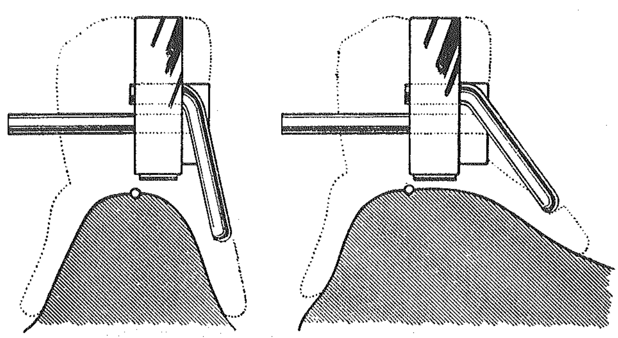


Fig. 191 The two drawings show the different angulation of the spring according to the inclination of the alveolar process.

Fig. 192 Upper bilateral free-end-saddle case with continuous clasp and two BMB joints. The grips on the continuous clasp splint the abutment teeth.

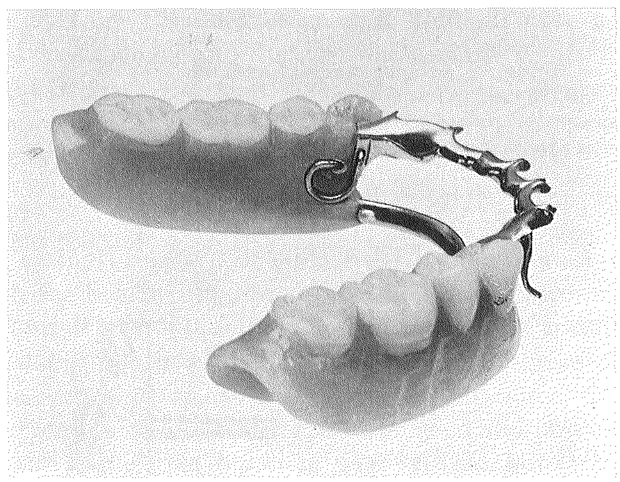


Fig. 193 Lower bilateral free-end-saddle case with continuous clasp and two BMB joints.

in the acrylic material of the tooth covering the joint. Since the bracket lies underneath the cover of an acrylic tooth, the channel of the bracket perforates the buccal face of this tooth, and the corresponding end of the spring is cut off flush with the tooth surface. The channel in the acrylic should be tight in size, so the spring has to be forced through. Accessories facilitate the technical procedure. A special wire gauge holds the two ends of the wire loop in their

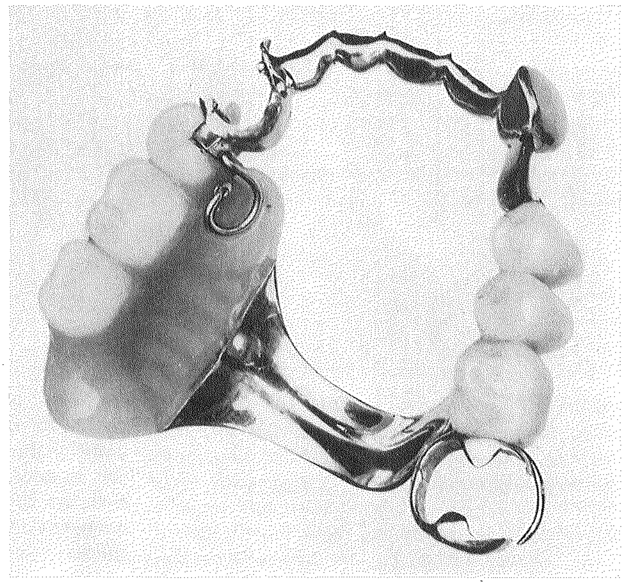


Fig. 194 Upper unilateral free-end-saddle case with continuous clasp, a BMB joint on the free-end-saddle side and (invisible) a BMB lock on the toothborn side.

proper relationship when the angulation between loop and straight ends must be changed (fig. 191). A matrix holds the two parts of the joint together in place of the spring during the working procedure. A drill serves to prepare the transversal hole in the acrylic tooth for the long end of the wire and a broach gives it the proper tight fitting dimension. The wires must be heat treated before use.

BMB joints, used for double free-end-saddle cases, are used in pairs, and the boxes of each joint are rigidly joined to each other by either a splint-clasp, or CSP attachments with a rugae bar. BMB joints come in two sizes, standard and small, with a red mark for upper left and lower right, and a blue mark for upper right and lower left. One is the mirror picture of the other.

In unilateral cases, the BMB joint on the saddle side is combined with the *BMB Lock* on the tooth bearing side (fig. 195, 196). Instead of the BMB lock, the Ro joint may be used.

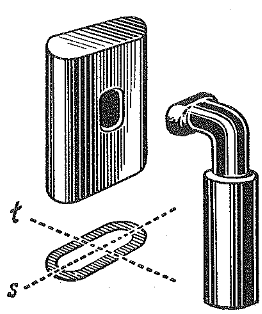


Fig. 195 The BMB lock. The box has an oblong window with the long diameter in vertical, the short diameter in horizontal position. The bolt which is soldered to the resilient part of the denture, has a head which fits into the window of the box, but is at right angles to the window. For insertion, the denture must be rotated in order to fit the bolt into the box. Once inside, the bolt is turned and locks.

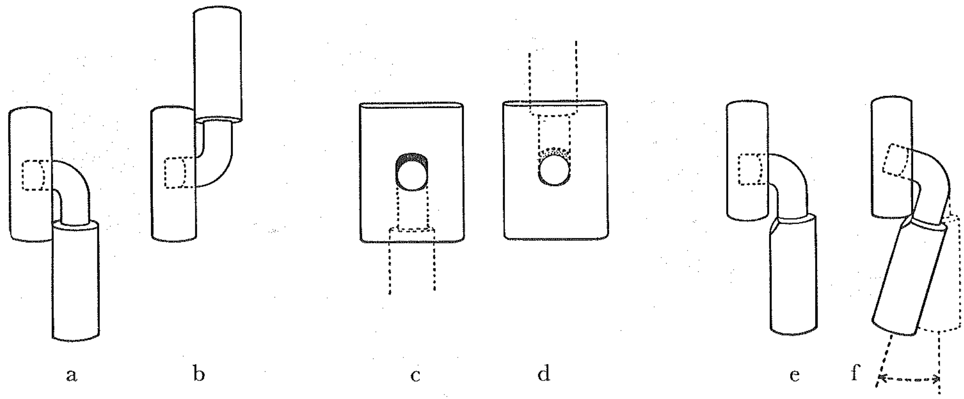


Fig. 196 a and b show the lock mounted for a lower or upper case in cross-section. c and d show the lock in locked position from the lingual side for lower and upper cases. e shows the lock in rest position, f with an exaggerated rotatory compensating movement.

THE BIAGGI JOINT

By Dr. Augusto Biaggi, Brugg (Switzerland)

The Biaggi joint was conceived from the idea to create a joint which should as much as possible protect the abutment teeth from all forces acting on the saddle of a partial denture. Along with a good stabilization in rest position, it should give enough freedom of movement to the saddle. Its main indication therefore lies in cases with a badly reduced and periodontally damaged dental arch.

The Biaggi joint consists of four parts (fig. 197):

(1) The cylinder with a conic apex.
(2) The backing with the small cone.
(3) The spiral pressure spring.
(4) The screw.

The cylinder with the conic apex is slotted, with an internal screw thread. The small cone with the guiding pin for the spring, attached to the backing is almost congruent to the bottom of the cylinder and its size is such that it cannot escape from the slot in the cylinder. The screw closes up the top of the cylinder. It carries a slot for the screwdriver on the top side, and a shallow depression for the spring on the bottom side.

ASSEMBLING THE JOINT

The small cone attached to the backing is inserted into the cylinder with the connecting arm sliding down in the slot until the tip of the small cone

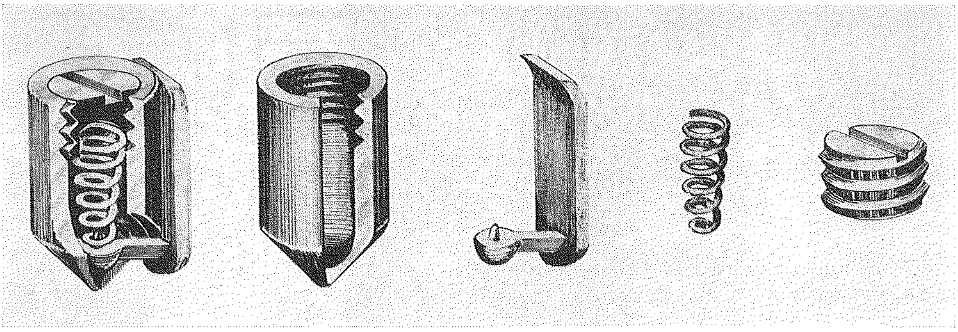


Fig. 197 The Biaggi joint. a = section through the assembled joint. b = section through the cylinder and its screw thread. c = backing with small cone and centering pin for the spring. d = spring. e = the screw is hollowed out interiorly (see a) in order to receive the top of the spring.

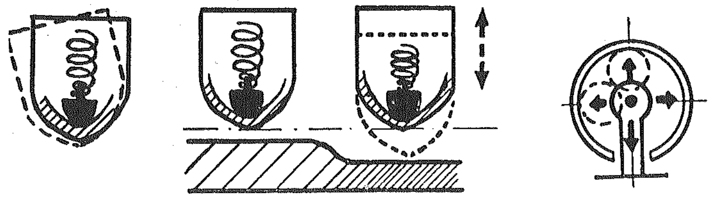
rests at the bottom of the cylinder apex. The spiral spring is then inserted with the narrower end resting on the guiding pin over the small cone. The screw is then screwed tight which already gives a certain initial tension to the spring in rest position.

MOUNTING THE JOINT

The backing is soldered to the anchoring part of the denture (attachments, continuous clasp, etc.). The cylinder, fitted with an appendix, is mounted into the acrylic of the saddle. Care must be taken that cylinder and backing are mounted in close contact, because this alone guarantees the joint's function as a stop against tipping mesio-gingivally. During the mounting procedure, the joint must be blocked. This is done by removing the spring and replacing it by a small piece of tube which is placed over the guiding pin and contacts the tightened screw.

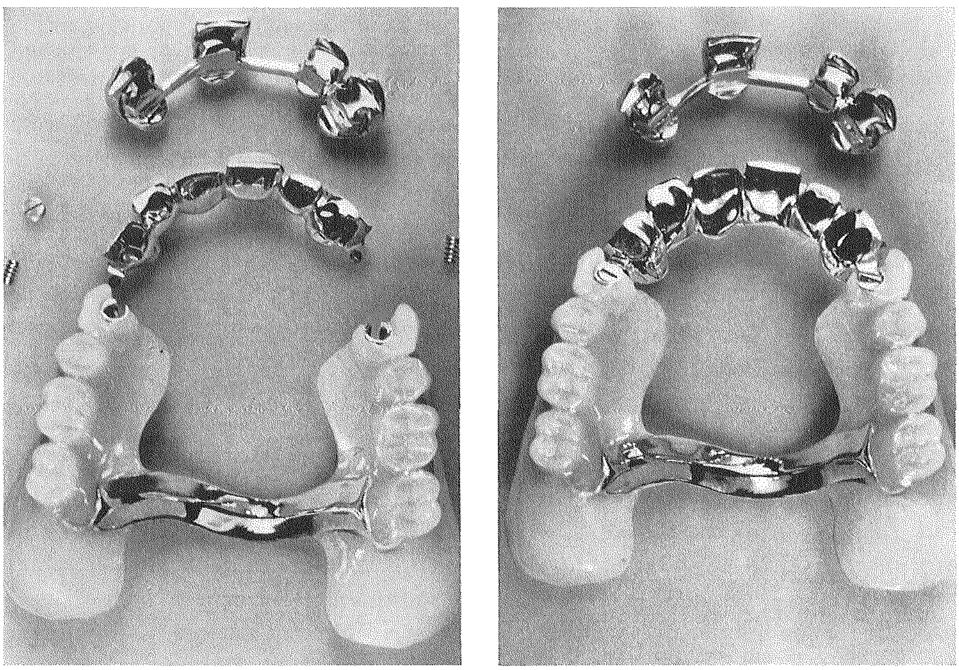
FUNCTION OF THE JOINT (fig. 198)

The Biaggi joint is the joint with most freedom of movement in all directions, rotation and translation movements. In rest position, the small cone is secured by the spring in its seat at the bottom of the cylinder. From this position, the cylinder can be tipped distally with the saddle along with a rotational movement of compensation in relation to the contralateral side. Moreover, a movement of axial translation (parallel resilience movement of the saddle) is possible. This movement alone frees the small cone from its seat in the cylinder and the excursions of the joint from rest position are as large as the



a b c d

Fig. 198 Function of the Biaggi joint. a = rotatory movement. b = rest position. c = translatory movement towards the tissue. d = freedom of movement towards all sides.



a b

Fig. 199 Double free-end-saddle maxillary case with Biaggi joints.

freedom of movement of the small cone inside of the cylinder. The horizontal movements of the saddle are therefore always arrested by the declivities of the alveolar process and never by the small mechanical parts of the joint which are not built to receive such stresses. The only forces transmitted to the abutment teeth are those transmitted by the very weak spring inside the cylinder. In bilateral use of the Biaggi joint there is no danger of reciprocal inhibition of the joints, even if the divergency of the saddles is as large as

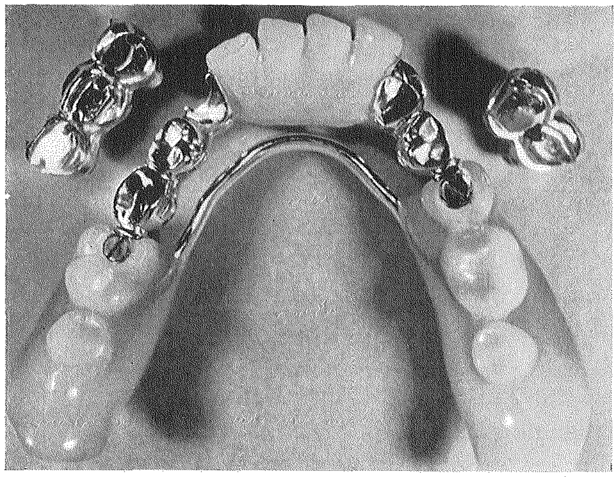


Fig. 200 Double free-end-saddle mandibular case with Biaggi joints.

70 degrees. The joint protects the delicate gingival zone distal to the last abutment tooth adjacent to the saddle portion. Biaggi joints cannot be used unilaterally. In bilateral cases, two joints are mounted distal to the last tooth on either side, while in unilateral cases, a contralateral compensating joint is necessary in the sense of a pure rotation joint. It may be called tongue and box joint, and is cast according to the individual case. Akin to STEIGER'S Ro joint, tongue and slot have a round window for the screw, and slight relief on the tongue frees the joint for the necessary compensating movement for the saddle side. The freedoms are the same as in a very restricted ball joint. If a pronounced transversal freedom is desired, both sides of the tongue must be strongly relieved in order to receive sufficient freedom between both inner walls of the box.

THE HINGE JOINT

PRINCIPLES OF THE HINGE SADDLE

A distal extension saddle may be compared with a plank placed on a freshly raked soil. The gardener knows that he may stand in the middle of the plank without damaging the surface of the soil, that on the other hand, the plank sinks into the surface if he stands on either end of it with the opposite end lifted over the surface. Similarly, the denture saddle, attached by one clasp gliding along the crown of an abutment tooth can support heavy stresses in its center, but very little on either mesial or distal end. Such saddles cause considerable damage, especially in the dangerous mesial zone, because the tipping action of the saddle is liable to injure the gingival papilla distal to the last abutment tooth.

The suspension of a saddle by a hinge fastened to the clasp or attachment on the abutment adjacent to the saddle prevents such damage, because no vertical movement of the saddle occurs in the mesial zone during masticatory action. The stressbreaker joints described previously in this book all allow a more or less restricted vertical movement of the mesial part of the saddle which results in the transmission of a small part of stresses from denture saddle to abutment teeth. The saddle of a hinge denture is non resilient on the mesial, while it is resilient on the distal end. Under masticatory stresses the vertical movement is therefore increasing, the more the stresses are applied towards the distal, while stresses applied to the mesial are transmitted to and born by the abutment teeth, particularly the distalmost abutment. In the example of the gardener and his plank, the plank would stand on rock on one end, and the gardener may stand anywhere between the rock supported end and the center part, even carrying a load without damaging the soil with the distal end of the plank. The more he walks from the middle towards the distal, the more the distal end will sink into the soil. This implies for the hinge saddle that the most distal part should be left free of artificial teeth and that the masticatory surface of the teeth must be largest on the mesial, smallest on the distal.

DESIGN OF THE HINGE SADDLE

The hinge saddle may be compared to an oar. Its distal end should be as large and as long as possible, large in order to get sufficient tissue contact, long in order to remove the center of resistance from the hinge. With regard to the teeth to be mounted on the saddle, it is a common error to believe that artificial teeth must have the same size as natural teeth. The hydrostatic principle, stating that pressure increases when the bearing surface diminishes, applies to mastication. For a given power of mastication, we increase the pressure between the antagonists by decreasing the masticatory surface. The bearing capacity of the saddle diminishes towards its distal extremity. By gradually diminishing the size of the saddle teeth, the loss of bearing capacity is compensated and an even pressure on the whole masticatory surface is obtained. At the same time, excessive pressure upon the mucosa underneath the distal part of the saddle is avoided. First and second bicuspid are mounted in their normal size, while the first molar is *smaller* than the second bicuspid and the second molar is about the size of a cuspid tooth. Third molars are never mounted. (In the case shown on p. 197 these principles had not yet been adopted, which accounts for the premature need for replacement of the joint for reasons of wear.

ANCHORAGE OF HINGE DENTURES

It would be utterly unreasonable to anchor a hinge denture on a single distal abutment tooth adjacent to the saddle. The anchorage must consist of a group of teeth splinted together either by a cemented splint or by a continuous clasp. Stabilizing lingual or palatal bars are indicated in many cases. These stabilizing bars rigidly connect the abutment anchorages on both sides of the arch, i.e. they are not attached to the movable saddle or saddles, but to the anchorage mesial to the hinge. An exception from this rule may be made in bilateral free-end-saddle cases, where both hinges can be mounted on the same axis. (See below: Mounting of hinges.) If circumstances permit and anchorage is found to be sufficient, hinge dentures can be designed without stabilizing bars. The anchorage of hinge dentures is obtained by precision attachments of various kinds (CSP attachments, bar attachment) or by rigid clasps or continuous clasps.

TYPES OF HINGE JOINTS

The earlier designs of hinge joints in this country were conceived by R. Fischer († 1956). His first design was a simple tube with a wire angled off at right angles at both openings of the tube. The tube was soldered to the anchorage while the ends of the wire was imbedded in the acrylic of the saddle. This design is basic to most types of hinges used in chromium cobalt alloy technics for partial dentures. Fischer modified this type of hinge by replacing tube and wire by interlocking cylinder sections and a connecting wire. A further step was the Hofer screw which holds together three cylinders. The two outer cylinders were connected by a wire or casting, serving as retention in the acrylic, while the middle section was soldered to the anchorage. The weak point of all hinges was wear and the resulting lateral play of the saddle.

Conod designed a hinge (fig. 201 b, c) which is very wear-resistant. It consists of three parts: (1) the screw, (2) a plate with a central cylinder, (3) a plate with two peripheral cylinders. The plates serve as soldering surfaces for the connection with the anchorage and with the retention part of the saddle. The screw locks the two parts. The contacting surfaces are large, wear is thus considerably reduced. The hinge comes in two sizes and is made of a very resistant platinum-gold alloy.

THE GERBER HINGE BLOCK

Any hinge joint previous to the hinge block has one disadvantage, namely the poor resistance to lateral stresses due to wear on the frictional surfaces between both parts. The hinge block has increased these surfaces considerably. It consists of three main and two auxiliary parts. The main parts are: a = the male, which is soldered to the abutment or clasp, b) = the female, incorporated into the extension saddle, and c = the screw which joins both parts to the functional unit. For the purpose of mounting, there are two auxiliary parts, a wedge d which compensates the taper on the male while mounting the hinge, and an excessively long hinge axis e which is used during the wax-up and curing of the saddle and which is then replaced by the permanent axis.

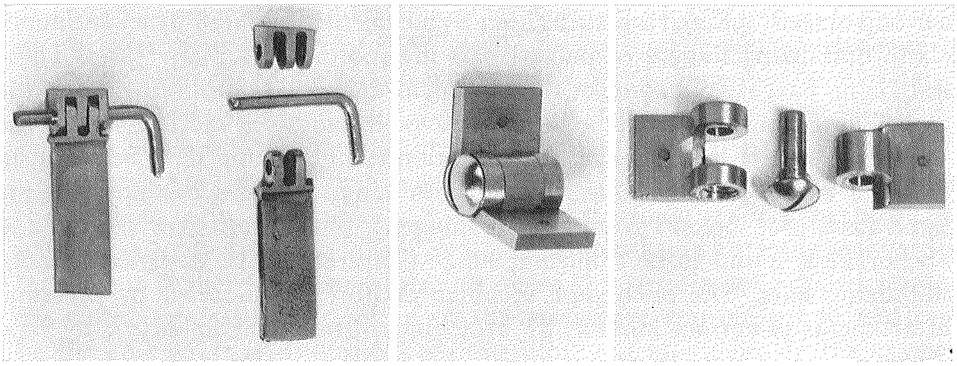
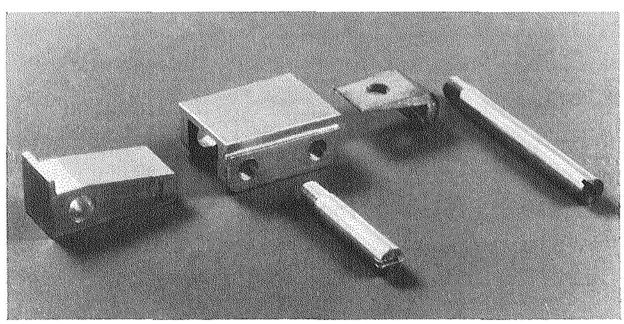


Fig. 201 a = Fischer hinge b = Conod hinge, assembled c = Conod hinge, parts

The vertical stop on the male prevents the female respectively the saddle from displacement towards the occlusal, from "kicking back", while the taper allows for sufficient hinge movement towards the tissue base.

MOUNTING OF HINGES

A hinge is mounted in the direction of the saddle and parallel to the occlusal plane. If, in bilateral distal extension saddles, a transversal stabilization of the saddles is desired, the two hinges must be mounted in such a way that the axis of both screws is identical. Saddles of different length therefore do not allow transversal saddle stabilization. In such cases the transversal stabilization is found by connecting the rigid anchorage or anchorages of both sides of the arch. The tooth adjacent to the last abutment tooth must be in close contact with the distal portion of the anchoring attachment, when the denture is in rest position, in order to prevent the distal part of the saddle from being lifted off the mucous surface by tongue movements. The axis of the hinge must be placed as near to the last abutment and as near to the base of the saddle as possible. A sufficiently strong retention for the acrylic saddle must be soldered to the distal end of the hinge.



a b c d e

Fig. 202 The Gerber Hinge Block. From left to right: a = male, b = female with, c = permanent axis screw, d = wedge for mounting male and female in correct relative position, e = temporary axis screw, used during mounting, curing and finishing procedures.

THE FREY JOINT

By Dr. Marc Frey, Ebnat-Kappel (Switzerland)

The Frey joint is a stressbreaker connection for free-end-saddle extension partial dentures, especially suited for the general practitioner who is not equipped for precision techniques.

Its basic purpose is to avoid—in a shortened dental arch—unfavourable movements of the abutment teeth caused by the free-end saddles. The conduction of stresses from denture to abutments is interrupted. It is important that the remaining teeth be splinted by the supporting structure of the denture. The damaging forces act on the abutment teeth as thrust or traction, forces in an axial direction of the abutment teeth are seldom responsible for damages to the supporting tissues.

The joint must be guided by its tip-prevention stop in order to guarantee an even resilience of the saddle (fig. 203).

The advantage of the Frey joint over other designs is mainly seen in the fact that the preformed parts are available in rods of combustible resin (fig. 204c)

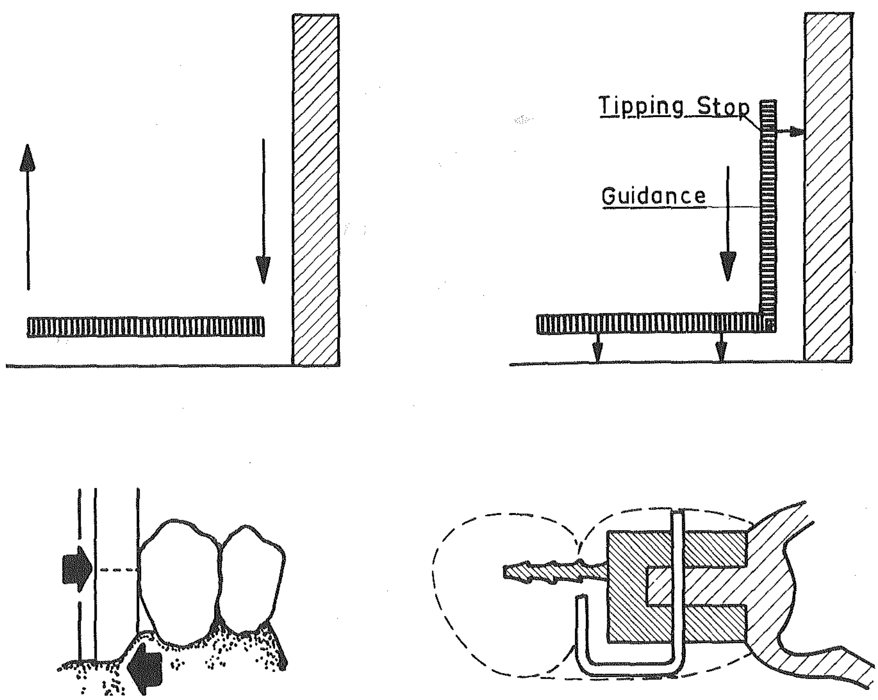


Fig. 203 The saddle, schematized as a float, would tip downward on the mesial, upward on the distal, if free. The guidance and the tipping stop of the Frey joint prevents this.

The drawing in the lower right corner illustrates the incorporation of the joint as seen from the occlusal: Patrix, matrix, and fixation wire.

which burns out like casting wax. Thus the joint can be cast with the supporting structure of the denture (fig. 205). The parts are: The T-shaped patrix, the U-shaped matrix, and the connecting wire (fig. 204a, b).

Matrix and patrix are available as resin patterns from which the desired amount is each time cut off (Durallium Prod. Corp. Chicago) (fig. 204c).

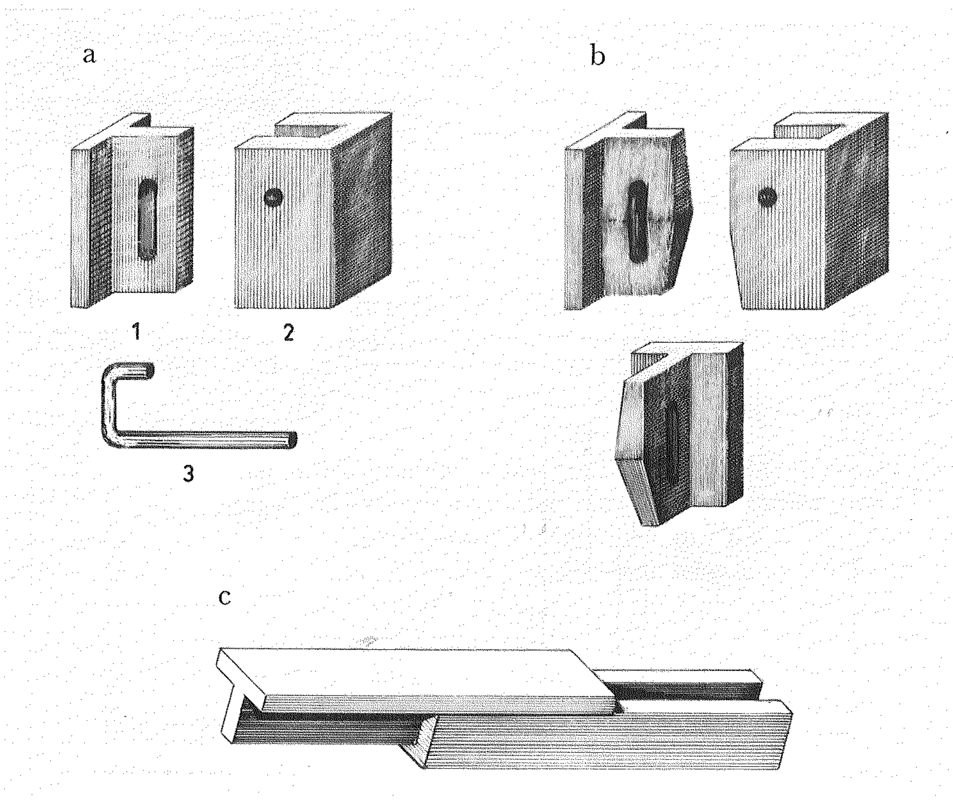


Fig. 204 a = patrix with oval window, matrix with round hole, unrelieved. b = patrix and matrix, with reliefs (exaggerated) which permit rotational or hinge movement. c = prefabricated rods from which the desired length of patrix and matrix is cut off.

TECHNICAL STEPS FOR MOUNTING THE FREY JOINT

(1) Preparation of the casting model and wax-up of the denture (continuous clasp, lingual bar, palatal plate.

(2) The desired amount of patrix and matrix is cut off from the respective resin rods.

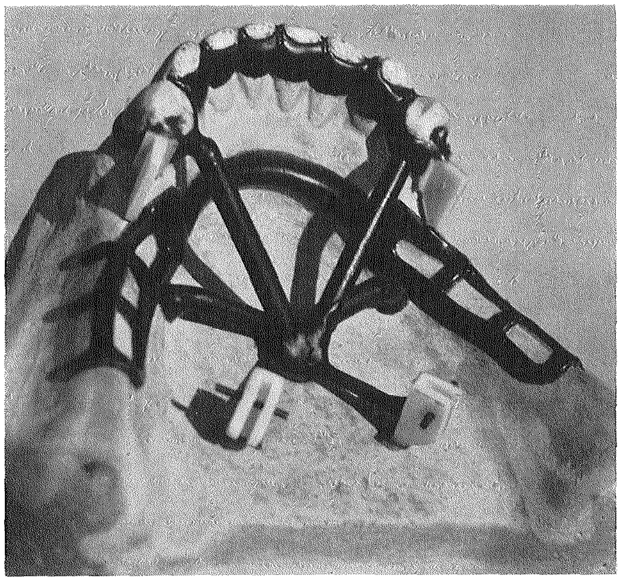


Fig. 205 Waxed-up bilateral free-end-saddle case. Note patrix of joints waxed to the distal of the teeth adjacent to the saddles and the matrices with each a sprue which will serve as anchorage in the acrylic. Inserted into the matrices are graphite pins.

(3) The pieces are trimmed to proper fit gingivally and occlusally.

(4) Patrix and matrix, assembled, are pierced with a 0.8 mm bur. The perforation in the patrix is widened gingivally to a slit (fig. 204b).

(5) Matrix and patrix are trimmed in order to obtain the desired rotational movement of the saddle towards the distal (fig. 204b).

(6) The patrix is fused to the waxed-up continuous clasp at each end. Both patrices must be parallel in a vertical direction.

(7) The matrices are attached to separate sprues.

(8) The perforations in the matrices are filled with graphite pins while the slits in the patrices are filled with investment.

(9) Burn out and cast.

(10) The matrices are cut away from the casting button with their sprues still attached. These sprues represent the retention of the matrices in the acrylic saddle. The matrix is fitted to the patrix. Very important: The matrix must be mounted in the most occlusal position of the perforation for the wire in relation to the slit in the patrix. Thus the saddle can only move gingivally, not occlusally.

(11) If the gingivo-occlusal height is small, the sprue of the matrix is soldered to the cast base of the saddle, otherwise it is simply incorporated into the acrylic of the saddle.

(12) The teeth are set up, with a hollowed-out plastic tooth over the joint.

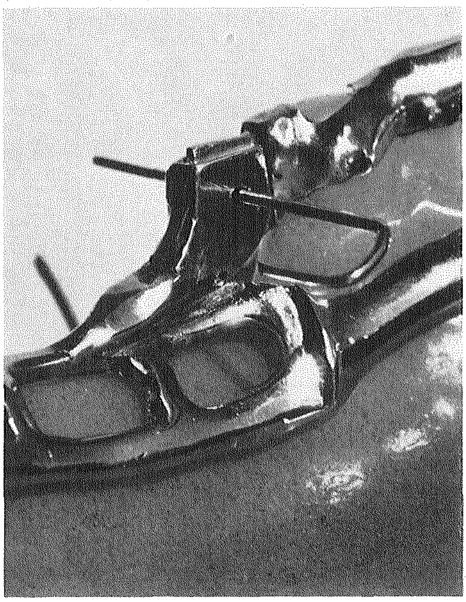
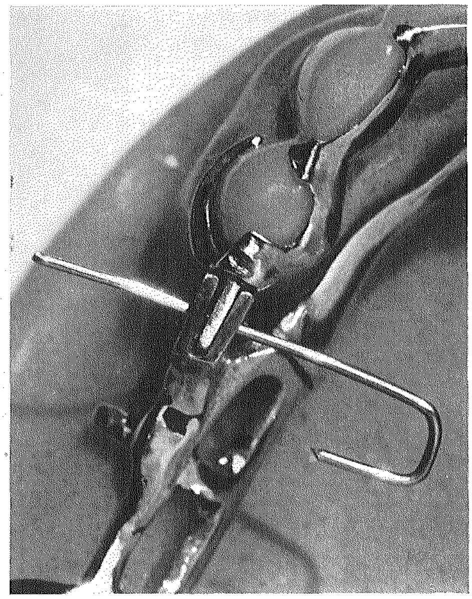
a   b

Fig. 206 a = finished joint with pin inserted. b = same view from the occlusal.

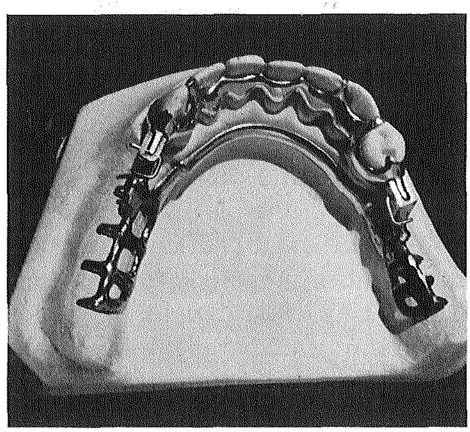


Fig. 207 Finished framework of the case.

(13) The 0.8 mm stainless steel connecting wire is bent U-shaped and adapted into the wax.

(14) The saddles are cured in acrylic, the denture is assembled and the connecting wires adapted. They are slightly activated to prevent them from falling out.

ADJUSTMENTS BY THE DENTIST ON THE FINISHED DENTURE

The rigid parts of the denture are checked for fit, the continuous clasp must fit the teeth accurately and must splint them.

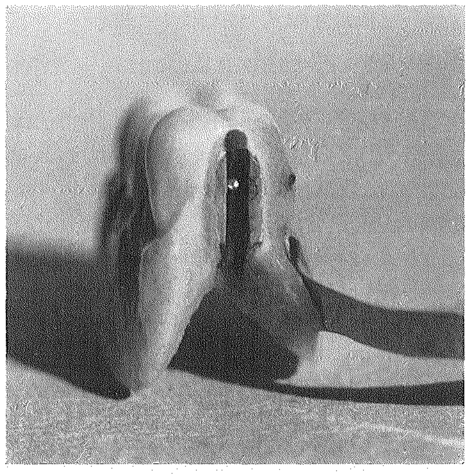


Fig. 208 Matrix, imbedded in the saddle under an acrylic tooth.

The mobility of the saddle part is checked: (a) The vertical movement may be increased by the use of a 0.6-mm connecting wire instead of the 0.8-mm wire, or by enlarging the slit in the patrix gingivally. The hinge movement of the saddle is made possible by grinding the mesio-gingival ends of the two flanges of the matrix. Rotation in a horizontal, bilateral direction is obtained by grinding the sides of the patrix flange.

Advantages of the Frey joint:

(1) Simple and inexpensive technique and materials.
(2) Good function.
(3) No repairs.
(4) The joint may be cast in any alloy which is stable in the mouth.

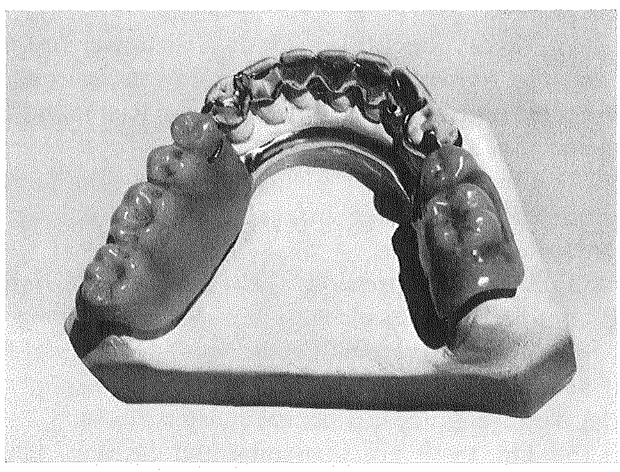


Fig. 209 Finished case with acrylic saddles. Porcelain teeth may be used except for the mesialmost tooth.

THE DOLDER BAR JOINT

By Prof. Dr. EUGEN DOLDER, Zürich (Switzerland)

The problem of obtaining stability in full lower dentures is still far from a solution which is universally satisfactory. On the other hand, the conventional clasp methods, used in cases only where few natural teeth are left, invariably hasten the eventual loss of these abutments.

The bar-joint denture has been realized in order to preserve two or more remaining teeth as a means of retention for full lower dentures and as receptors of a small part of the masticatory forces.

The roots of the remaining devitalized teeth are prepared to receive Richmond bases (Shortening Principle). The bar, soldered on or between the bases, splint the abutments into one single unit (Splinting Principle). This bar, together with an open tube (both of egg profile), adequately fitted into the gingival portion of the denture, functions as a resilience joint. The bar joint in frontal or sagittal position offers good retention to the full lower denture, because the open tube, slightly wider than the bar, snaps over the latter. If mounted correctly, it gives the denture two freedoms of movement and thus allows for (a) vertical translation and (b) rotation around a sagittal resp. frontal axis. The harmful horizontal sliding movements are eliminated (guiding function). The longer the bar joint can be made, the more stable the foundation for the denture will be.

The bar joint for lower dentures offers various possibilities of preserving the remaining teeth and using them for better retention and improved function of the full lower denture. The patient has the confidence of wearing a stable appliance of good esthetics and the bar-joint denture is available to the patient of modest means. The bar joint is manufactured in three different qualities of alloy and in two sizes.

PHASES OF TECHNIQUE

(1) The abutments [in this case the lower (upper) two cuspids] are devitalized, the root canals filled. The crowns are cut down and the root stumps prepared to receive Richmond bases. Richmond bases are fitted to the abutments (fig. 210).

(2) First impression with impression compound, alginate or hydrocolloid. From the model, the individual tray (for lower dentures with retromolar extension) is made.

(3) Second impression with plaster and individual tray and with the Richmond bases in place. The roots are temporarily sealed.

(4) The bite, vertical height, midline are established, face bow registration, if necessary, is taken and the shade and size of teeth chosen. The border of the denture is marked on the master model.

(5) The teeth are then mounted in wax, with the anteriors as well as

Fig. 210 Two Richmond bases are splinted with the bar. The joint tube must fit exactly and without space between the bases.

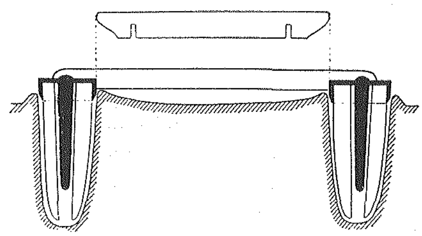
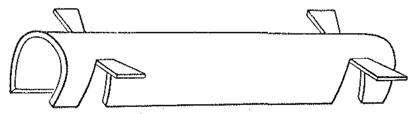


Fig. 211 Eight incisions are made laterally to obtain four flaps which are bent outward as retentions for the tube in the acrylic of the denture base.



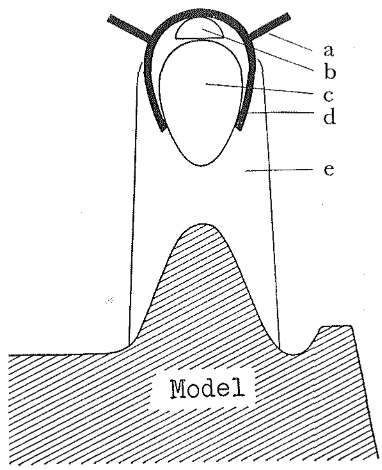
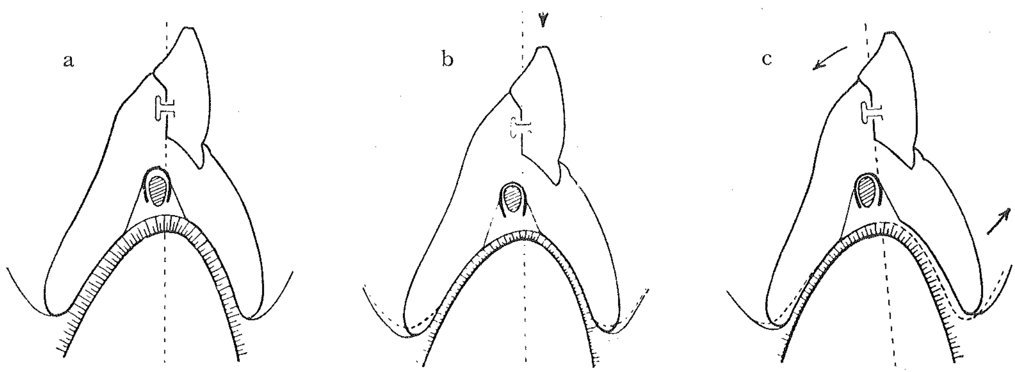


Fig. 212 Mounting of the tube.

a = retention flaps
b = auxiliary wire, vertical thickness 1 mm
c = bar
d = tube
e = plaster for correct fixation of the tube relative to the bar, and in order to keep the elastic ends of the tube free from acrylic.

Fig. 213

a = denture in rest position
b = denture under masticatory pressure, movement of vertical translation
c = distal part of the denture under masticatory pressure, movement of rotation around the bar.



possible above the alveolar ridge. They are tried in on the patient and checked for articulation and esthetics. A plaster key is taken of the anterior teeth.

(6) An adequate piece of bar is cut off. It is adapted on the Richmond caps so it is placed as near as possible to the alveolar ridge. In this position, it is soldered (fig. 217, 220).

(7) Preparation of the joint tube: With incisions into the margin, dove tailed flaps are bent upwards. These flaps serve as retention in the acrylic. No heat treatment is necessary (fig. 211). With the means of an auxiliary wire, the tube is placed in its correct rest position on the bar (fig. 210). The bar joint should be placed as nearly as possible between alveolar ridge and anterior teeth. The teeth are waxed up with the help of the plaster key.

(8) The denture is flasked, processed and polished. Sufficient space is left between the Richmond bases and the denture base (fig. 215).

(9) The splint is cemented on the cuspids (fig. 217).

(10) The denture is inserted: The flexible open tube snaps over the bar.

FUNCTION OF THE BAR JOINT

In rest position, the denture rests entirely on the mucous surface, because of the space between tube and bar. This space has been retained, when the tube was mounted with the aid of the auxiliary wire. Under masticatory stress, with a tissue resilience of around 1 mm, the tube settles on the bar and may transmit part of the stresses to the abutments (fig. 213).

Fig. 218 and 219 show a few examples for mounting the bar joint.

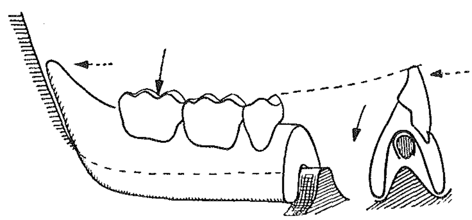


Fig. 214 Rotation in a sagittal plane. A horizonal translation towards the distal is arrested by the retromolar extension of the denture base.

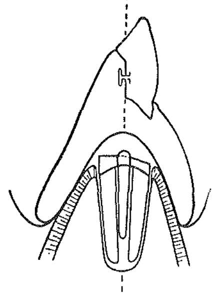


Fig. 215 Sagittal section through an abutment tooth under a bar-joint-denture.

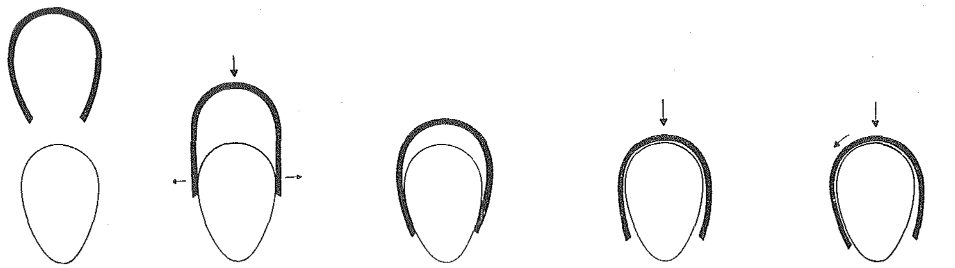


Fig. 216

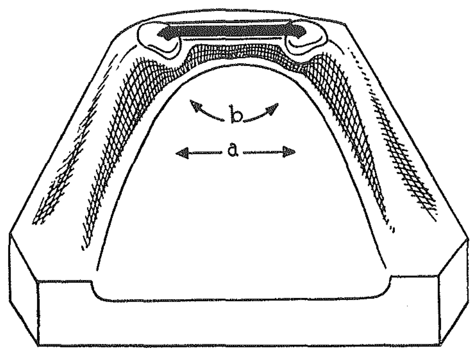


Fig. 217 The bar joint arrests any movement in the transversal plane (a), also, a rotation through a sagittal axis (b) is prevented.

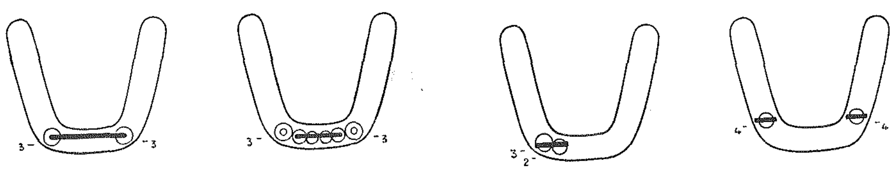


Fig. 218/219 A few examples for mounting the bar joint.

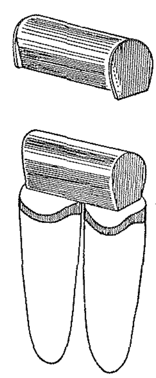


Fig. 220 Bar joint on two adjacent anterior teeth.

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INDEX