The Design, Construction & Use of Removable Orthodontic Appliances

5TH EDITION

C. PHILIP ADAMS

WRIGHT

The Design, Construction and Use of Removable Orthodontic Appliances

The Design, Construction and Use of Removable Orthodontic Appliances

By

C. PHILIP ADAMS
MDS, FDS, DOrth RCS Eng, FFD RCSI

Professor of Orthodontics, Queen's University, Belfast; Consultant in Orthodontics, Belfast Teaching Hospitals. Formerly Lecturer in Orthodontics, School of Dental Surgery, Liverpool; Lecturer in the Department of Orthodontics, Institute of Dental Surgery, British Postgraduate Medical Federation, University of London

5th Edition

WRIGHT

Bristol
1984

Published by:
John Wright & Sons Ltd,
823-825 Bath Road,
Bristol BS4 5NU, England.

First edition	1955
Reprinted	1956
Second edition	1957
Reprinted	1959
Reprinted	1961
Third edition	1964
Fourth edition	1970
Reprinted	1975
Reprinted	1977
Reprinted	1979
Reprinted	1983
Fifth edition	1984

Italian, Spanish, French and Japanese translations have also been made.

British Library Cataloguing in Publication Data **ISBN 0 7236 0713 3**

Adams, C. Philip
The design, construction and use of removable orthodontic appliances.—5th ed.
1. Orthodontic appliances. Removable
I. Title II. Adams, C. Philip. Design and construction of removable orthodontic appliances
617.6'43'0028 PR528.R45

Library of Congress
Catalog Card Number:
84-50009

Typeset and printed in Great Britain by
John Wright & Sons (Printing) Ltd at
The Stonebridge Press, Bristol BS4 5NU

Preface

This book was first published following a series of articles in the *Dental Practitioner* of thirty years ago and I have always felt that this origin led to a slight sense of discontinuity in the volume. While this has never discouraged readers in many parts of the world from making use of the text as new editions appeared, I have for some time felt that the book needed to be brought together into a more coherent form and that an effort to do this was overdue. While previous new editions mainly entailed the addition of new material as appeared necessary, the present edition has entailed a complete rearrangement of the volume and the re-writing of much of it.

Orthodontic treatment through the use of removable appliances constitutes a very large part of the needs of orthodontic management of any community today and removable orthodontic appliances, their design, construction and use must be based on the clearest, most unequivocal and comprehensible principles rather than on inspired ingenuity and inborn mechanical instinct.

It has been my aim throughout to base everything that is expounded in these pages as far as possible on anatomical, biological and mechanical scientific principles and laws rather than on rules of thumb or practices hallowed by tradition. The plan of the volume has been changed as it now deals with the principles of appliances, the elements of removable appliances, including functional appliances, and the use of appliances for various kinds of tooth movements and treatment situations.

The question of appliance construction is deferred to the later stages and is comprised in a chapter dealing with the fabrication of the wireform elements of appliances, clasps, baseplate, layout, and such laboratory procedures as the joining of wires and the preparation of record casts. Those who are familiar with the earlier editions of the book may miss material that has been deemed redundant and has been removed, but it is hoped that they will welcome the erasures of unnecessary material and the inclusion of what is new.

With very few exceptions, all the illustrations are new. All have been prepared over again for the benefit of reproduction processes in use today. When doing this, the opportunity has been taken to enlarge the subject material of interest to occupy the whole picture area in the belief that the knowledgeable who peruse the book do not need irrelevant surroundings to inform them of what the illustrations are about, and in this way to maximize the impact of the details of the subject matter. While some of the original photographs have simply been reprinted, excluding unnecessary background, many illustrations have been made from new appliances, and new drawings have been made for many of the line diagrams.

I wish to express my thanks to Hill Mercer for assistance with the preparation of appliances, to Carmel Dowd and Wendy James for help in putting the text together and to Maeve Adams, Sheena Sloan and Marlene Boe for their untiring efforts to complete the task of printing the photographs and for their help in making many of them.

I am very greatly indebted to my wife and family for their support and forbearance during the preparation of this new edition. Their cheerful acceptance of the disruptions caused by the stresses of composition and the proliferation of papers and photographic cuttings greatly eased the burdens of authorship.

I am most grateful to Miss Margaret Clennett, of the British Dental Association Library, for her kindness and help in checking the references.

C. P. A., March 1984.

Contents

Introduction

During the past thirty-five years the demand for orthodontic treatment has steadily increased and at the same time continuous efforts have been made to improve the standard of care, by every possible means.

The aims in treatment of Edward Angle have long been recognized as attainable for some subjects but not for such a large proportion as was at first hoped. Nevertheless, advances in the methods of manufacture have made elaborate and comprehensive fixed appliance treatment methods more readily available and the trend today is increasingly towards the use of such appliances.

Dental irregularity occurs in many forms and orthodontics has smoothed the path of the student by grouping and classifying the disorders of tooth alignment and even attempting to detail an appropriate answer to each category of treatment problem. Very often, however, one of the strongest impressions a student receives on first attending an outpatient clinic of orthodontic patients, representative of a population as a whole, is the discovery that most of them will not fit at all neatly into the classification he has been at such pains to learn. Add to this the finding that the owners of this gamut of irregularity are themselves very variable as regards age, condition, understanding and willingness to play their part in the carrying to fruition of any plan for their dental and orthodontic welfare that is finally placed before them. It then becomes clearer that problems in delivering an orthodontic service can exist.

Surprising as it may seem, it sometimes appears to be thought that orthodontics is comprised in treatment with appliances; that orthodontics is the appliance. Too often it seems to be overlooked that orthodontics is the management of the developing and the developed occlusion, with or without appliances, whichever is the more appropriate. The most obvious but often the least understood example of this principle is the decision not to interfere at all with a dentition by means of appliance treatment.

It follows, therefore, that if it is required to care for the whole spectrum of orthodontic problems in a community, it will be necessary to make available every possible kind of clinical management technique and this must at some time include the use of removable or functional appliances.

The removable appliance has always been part of orthodontics and it was the ineffectual devices of his day and the resort to extraction of teeth in orthodontic treatment that led Edward Angle to inveigh against all who did not strive to maintain the complete dentition and employ the most vigorous means to bring it into perfect arrangement (Angle, 1903-4).

The materials of today are a great advance in their physical properties for orthodontics on those of half a century ago but, apart from this, the greatest difficulty in making removable appliances effective has always been that of their accurate retention in position. Even the introduction of stainless steel was not the complete answer until the introduction of modern clasping methods reduced the problems of keeping removable appliances in place in young and immature dentitions. It is important, however, to realize that there is an end to the road in clasping teeth if they do not present undercut surfaces and, in the interest of the patient, it is better to turn to a more appropriate appliance discipline; to accept the fact that in certain cases fixed appliances must be used. With this ultimate limitation in mind, if the reader of the pages that follow will apply the clasping methods, as explained, to teeth that have the necessary potential for clasping, and adhere to simple, comprehensible spring-forming principles, there will still be a wide range of treatment problems which will become more easily manageable, with corresponding benefits to his patients.

Chapter 1

The Action of Orthodontic Appliances

Orthodontic appliances appear to the casual observer in a surprising variety of forms; the simple baseplate with two clasps, the complicated arrangement of arches and screens of the Fraenkel appliance or the filigree of fine wires, lockpins, bonded attachments and elastics of the Stage III Begg light wire treatment. All these devices, however, have one thing in common—they interfere in carefully considered ways with the pressure system which naturally controls the positions of the teeth.

The circumscribed nature, completeness and innocent appearance of an orthodontic appliance very often obscure what the appliance actually is and what it is doing when placed in a dentition. It is well, therefore, first to consider what is, in nature, happening within the dental arches and the occlusion as a whole and in the jaws and the face. A good starting point is to look upon the dental arches, jaws, the face and cranium as a complex pressure system.

The dentition is subjected to a continually varying set of forces which keeps the teeth in a state of movement during development of the occlusion. These are the forces of mastication, the pressures of the tongue and lips at rest and during speech, mastication and swallowing, and the forces of eruption of the teeth within the dental arches as a whole. The movements which result are rapid and extensive in the early years of life, while in later life the processes slow down so much as to become virtually imperceptible, although tooth movements continue while there are vitality of the tissues and functioning of the organism.

The action of an orthodontic appliance is to modify, in one way or another, the natural pressure systems of the dentition. An appliance may do this either by applying pressure to the teeth from a source within the appliance or by modifying and redirecting the natural pressures which occur within the dentition during the normal functional activities of the face and jaws.

Appliances which contain within themselves the means of creating and storing pressure are active appliances and these may be removable or fixed. Removable appliances may be taken from the mouth by the patient for cleaning or by the orthodontist for adjustment, while fixed appliances are cemented to the teeth for the duration of active treatment. Appliances which are placed between and about the teeth and in this way modify muscular activities and the way the dental arches meet together are functional appliances.

These three appliance types may be combined in some degree; a removable appliance may be used together with fixed attachments on some teeth, and a functional appliance may have a flexible element for the application of pressure to an individual tooth or a small group of teeth.

Removable appliances which are clasped to the teeth and contain an active component or pressure-generating device are in some countries referred to as fixed plates to distinguish them from functional appliances. Strictly speaking, both types are removable although they differ in their principles of action.

Again, fixed appliances, although

cemented to the teeth, can also differ in their principles of action and their potentialities as can be understood from a comparison of the labiolingual appliance with the twin-wire arch and other multiband types of appliance.

It is a law of mechanics that to every action there is an equal and opposite reaction and this is true for orthodontic appliances. When a pressure or action is generated and applied to a tooth by an appliance, the reaction to that pressure must be identified and dispersed so as not to produce any unwanted effect. This is done by spreading the load of the reaction over as large an area of tissue as possible so as to reduce the pressure in terms of grams per square millimetre to the smallest possible value. Anchorage may, however, be gained in a number of different ways, as follows.

1. *Simple anchorage*

This means that other teeth in the same arch are used as a base from which pressure is exerted. It will be obvious that anchorage teeth should outweigh the teeth being moved in number and size by as large a margin as possible so as to ensure that the anchorage teeth do not give way and move too. Such movement is undesirable, as a rule, and is known as 'anchorage slippage'.

2. *Reciprocal anchorage*

It is convenient if two equally sized teeth or groups of teeth are to be moved in opposite directions. Then both the action and reaction perform useful work. This is known as 'reciprocal anchorage'.

3. *Stationary anchorage*

The term 'stationary anchorage' refers to the stabilization of anchorage teeth so that they cannot tip or incline under pressure. Such teeth are, therefore, more resistant to movement and anchorage is increased. To term such anchorage 'stationary' is perhaps unduly optimistic as teeth can be moved bodily, although not as rapidly as by tilting.

Such 'stationary' anchorage is best achieved by multiband appliances, but the Sved bite plane provides stationary anchorage for removable appliances because the upper incisor teeth are prevented from inclining under pressure from the lingual aspect {*Fig.* 1.1).

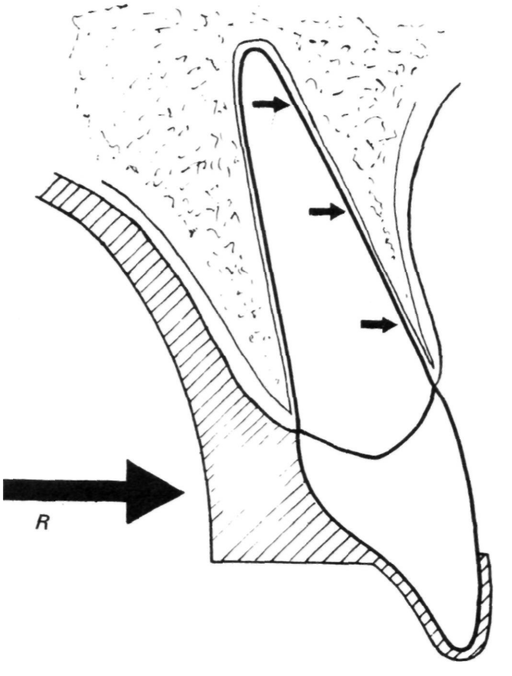


Fig. \.\. The Sved bite plate consists of an anterior bite plane, the baseplate material being carried over the incisal edges of the anterior teeth. As a result, the incisors cannot incline forwards. If a pressure used in the appliance has a forward reaction, /?, this is distributed evenly along the labial wall of the incisor tooth sockets and these teeth are, as a result, more resistant to forward movement. This effect is termed 'stationary anchorage'.

4. *Intermaxillary anchorage*

When traction is exerted between the upper dental arch and the lower, the force on the two arches is equal and opposite and the effects on the arches as a whole are about equal and opposite. This arrangement of force distribution is attributed to Baker (1904) and was formerly known as 'Baker anchorage'. It is possible with sophisticated multiband appliances, combined with extraction of teeth in either one or both arches, to produce highly effective rearrangements of the teeth in each arch and corrections of occlusal relationships.

5. *Extra-oral anchorage*

Extra-oral anchorage makes use of headcaps and neck straps to reach anchorage bases at the back of the head and neck from which pressure can be exerted on the dental arches. The necessary connection is made through wire extensions of the intra-oral part of the appliance or by curved hooks attached to elastics incorporated in the headgear.

It is possible to exert extra-oral traction in a forward direction by the use of an anterior extension of the headgear to gain an anchorage point out in front of the patient's face. Extra-oral anchorage is, in practice, stationary anchorage because effects due to the reaction of the pressures used do not give cause for concern as a rule.

A CONSIDERATION OF THE VARIOUS TYPES OF ORTHODONTIC APPLIANCES

Clasped Removal Appliances

These appliances consist of an active part, or pressure- source, which is activated on placing the appliance in the mouth thereby exerting pressure on a tooth or group of teeth. Such a pressure source is held in place by being fixed to a baseplate which in turn is held securely in position by clasps.

A clasped removable appliance, therefore, consists of a baseplate or framework which is held in position on the dental arch by clasps and which serves to support a pressure component which acts upon teeth which are to be moved. The baseplate also serves the purpose of transmitting the reaction from the active component to the teeth and tissues against which the baseplate is fitted. These latter teeth and tissues constitute the anchorage of the appliance system or foundation from which pressure is exerted on the teeth which are to be moved. A clasped removable appliance from the mechanical point of view is a pressure acting on teeth to be moved and an equal and opposite reaction to the pressure which is distributed to the source of anchorage. In order that the required teeth shall move and the anchorage teeth shall not, the anchorage teeth must be as much greater in number and size than the teeth to be moved as is possible in the circumstances of the case.

Pressure may be produced in clasped removable appliances by springs, by elastic bands or by a controlled wedging action making use of screws.

Springs

The simplest of all springs is the cantilever spring, or piece of straight, flexible wire fixed at one end and free to move at the other or free end. Within the elastic limit of the material, such a spring may be deflected by a pressure *P* at the free end over a distance *D* (*Fig.* 1.2). If the length of the spring is *L* and the thickness *T*, then for a round wire the deflection of the spring is directly proportional to the pressure exerted on it; to the third power of the length and inversely proportional to the fourth power of the thickness. The relationship is summarized by the formula $D \propto (PL^3/T^4)$ (Fig. 1.2, D). For any given spring, to double the pressure on it would double the deflection produced at the free end (Fig. 1.2, A), to double the length would increase the deflection eight times for the same pressure (Fig. 1.2, B), and to halve the thickness would increase the deflection sixteen times for the same pressure (Fig. 1.2, C).

In practice the requirements of a spring for an orthodontic appliance are that the spring should deliver an amount of pressure that is appropriate to the number and size of the teeth to be moved, and that the action of

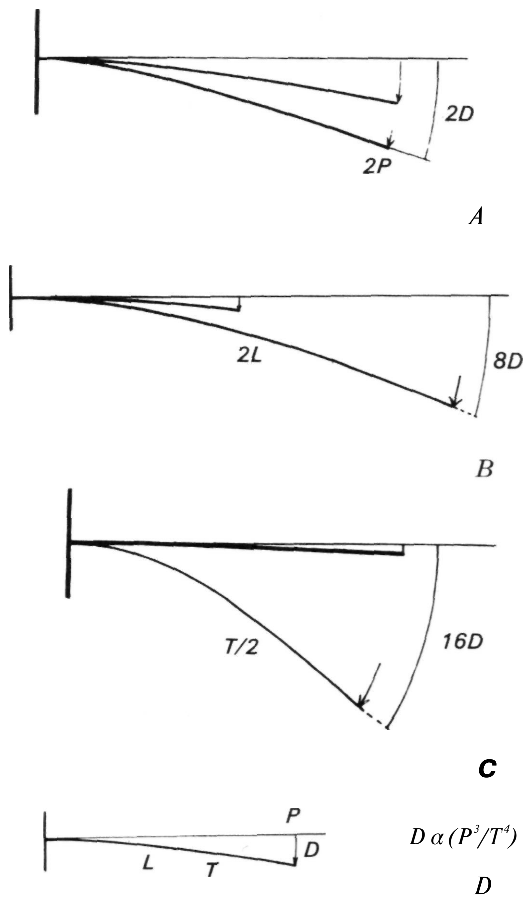


Fig. 1.2. A cantilever spring is fixed at one end and free to move at the other which deflects under pressure and delivers a gradually diminishing pressure in returning to its original form. *A,* The degree of pressure is proportional to the degree of deflection produced. *B,* If the length of the spring is doubled the degree of deflection comes eight times as great for the same amount of pressure. *C,* If the thickness of the spring is reduced to one-half, the amount of deflection becomes sixteen times as great for the same amount of pressure. *D,* Deflection, pressure, length and thickness are related by the formula: $D\alpha\ (PL^3/T^4)$.

the spring should take place over an adequate distance. These objects are achieved by using a metal wire which has a high degree of elasticity and by selecting an appropriate combination of length and thickness to achieve the optimum degrees of pressure and range of action in the spring.

Elastics

Latex, rubber bands or plastic rings, collectively known as 'elastics', when stretched are used to develop pressures in orthodontic appliances. To do this the elastic is looped onto suitable hooks and in this way produces a pull. This pull may be applied to a single tooth by attaching a stud or hook to the tooth and looping the elastic to such an attachment and to a hook on a baseplate. Elastic traction is applied to groups of teeth by applying elastics to hooks on a baseplate or to an archwire, anchorage being derived from the opposing dental arch or from a source outside the mouth altogether. Elastic force produces pressure effects the same as those caused by any other pressure source.

Elastic bands are available in a wide variety of lengths and thicknesses. For some applications elastics supplied by stationers are satisfactory but purpose-made orthodontic elastics of fine gauges and down to short lengths are available from specialist suppliers.

Screws

Screw appliances consist of two parts connected by a screw which has left- and right-

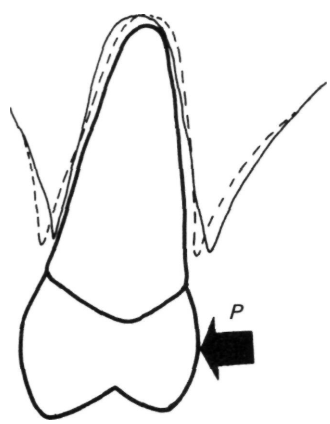


Fig. 1.3. A tooth can be moved immediately by a small amount due to the elasticity of the supporting tissues. If held in the new position the alveolar bone adapts itself to the new position of the root. A pressure *(p)* produced by a screw plate causes movement of a tooth over a very short distance.

handed threads at opposite ends, the centre of the screw being formed into a boss or plain section which is perforated so that the screw can be turned by means of a pin or wrench. In this way the two parts of the appliance are separated and when placed in the dental arch produce a pressure on the teeth which is accommodated by the slight natural mobility that occurs in teeth (*Fig.* 1.3). In this way teeth are immediately moved or wedged apart by very small amounts and in the days subsequent to the placing of the appliance, remodelling of the surrounding bone tissues takes place. Subsequent further screw adjustments are made to build up a total degree of movement such as may be required by the treatment plan.

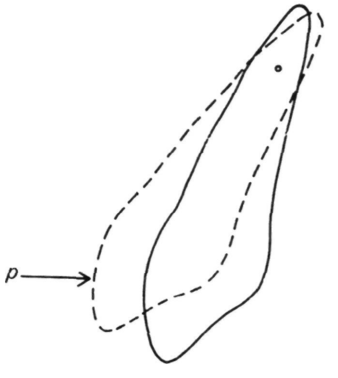


Fig. 1.4. A tooth which is inclined tips about a point slightly below the apex (above in the case of lower teeth). It is believed that the gentler the pressure, the nearer to the apex is the point about which the tooth tips and vice versa.

Effects produced by clasped removable appliances

A spring which is the active part of a clasped removable appliance acts by pressing on the surface of a tooth and a tooth so pressed on moves by tilting in some degree. It is believed that the tilting so produced occurs not about the tip of the root, if the tooth is single-rooted, but about a point a short distance along the root from the apex (*Fig.* 1.4). Multiple-rooted teeth behave in a more complicated manner but tilting can be seen in such teeth also when so moved.

It is important in treatment planning and management to take into account any tilting that may be expected to occur. Teeth which are unfavourably inclined may be improved and teeth which are well positioned may become unfavourably tilted. Inclinations produced by treatment frequently improve

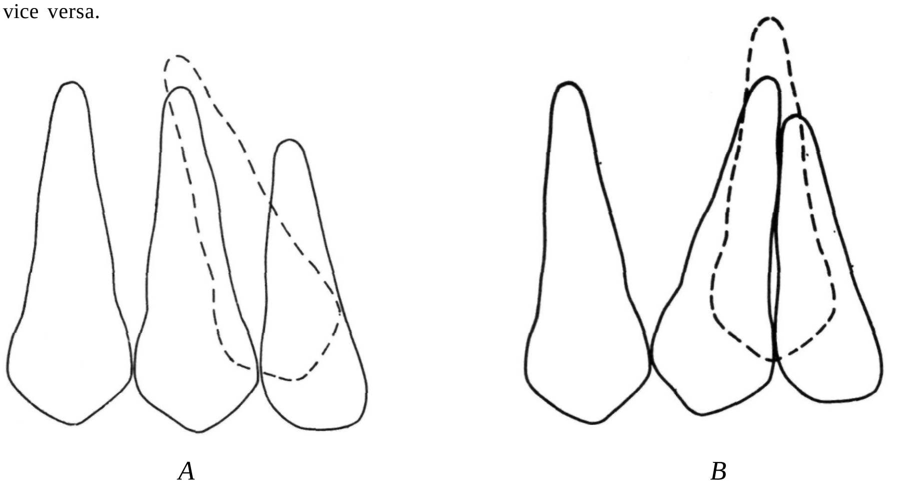


Fig. 1.5. Favourable and unfavourable tipping of a tooth can be illustrated by the retroclination of a canine tooth. *A*, The canine apex is placed distally and the tooth, when tipped distally, lies favourably in the space available. *B*, The canine apex is mesially placed and moving the tooth into the space available increases an already unfavourable inclination. Broken line: before movement. Continuous line: after movement.

spontaneously in time and the earlier a tooth is moved, the less tilting occurs and the more such tilting resolves spontaneously (*Fig.* 1.5).

An important aspect of pressing on a tooth with a spring is that the pressure is only effective at a single point and the direction of pressure is at right angles to a tangent at that point. Removable appliance springs cannot grasp a tooth so that the point of application of a spring to a tooth is critical if a pressure in the correct direction is to be achieved (*Fig.* 1.6). The same considerations are true of any appliance by which pressure is exerted on surfaces of teeth as, for instance, with traction or expansion appliances where much of the pressure is applied through a baseplate at the points and surfaces at which the baseplate fits against the teeth. In some situations the tilting effect, often regarded as characteristic of removable appliances, can be avoided and in some instances a root movement or torquing effect produced by appropriate design of the appliance. Removable appliances can be used to produce some root movements and rotations and thus can be useful because of the simplicity with which the result is obtained. The effects are produced either by means of two forces acting as a couple or by causing a force to act about a fixed point so producing rotation (*Fig.* 1.7). Rotation may also be produced by using a fixed/removable appliance with a small spring attached to the tooth by means of a box bonded or banded to the tooth.

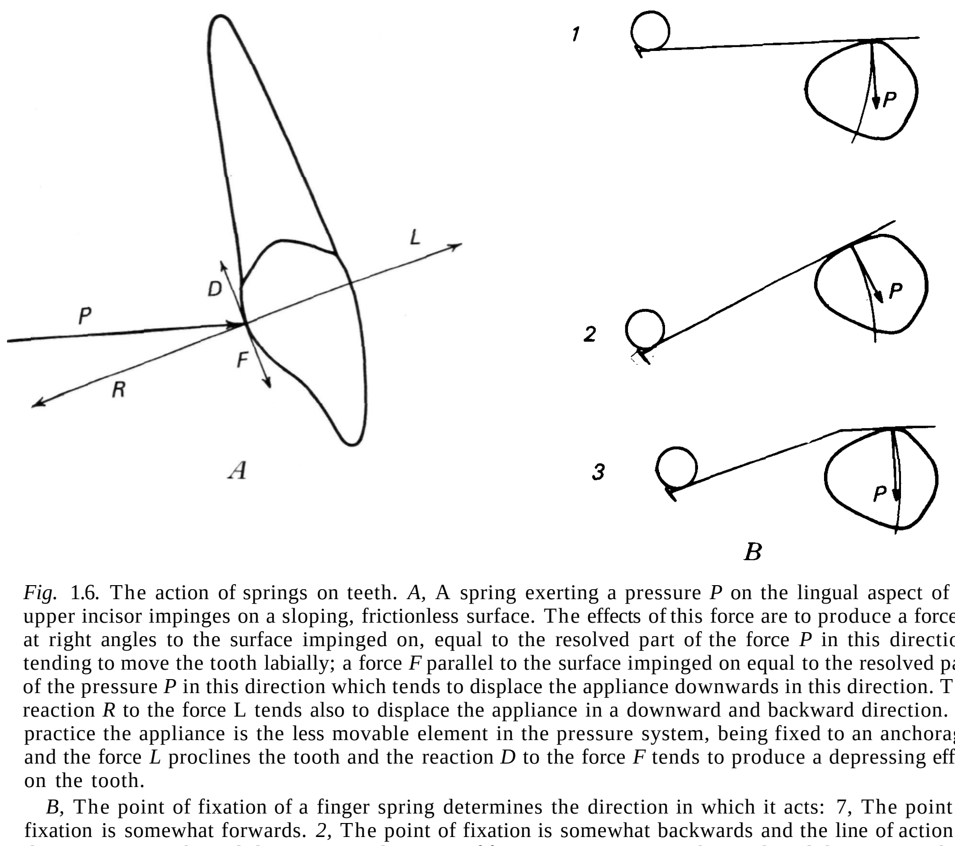
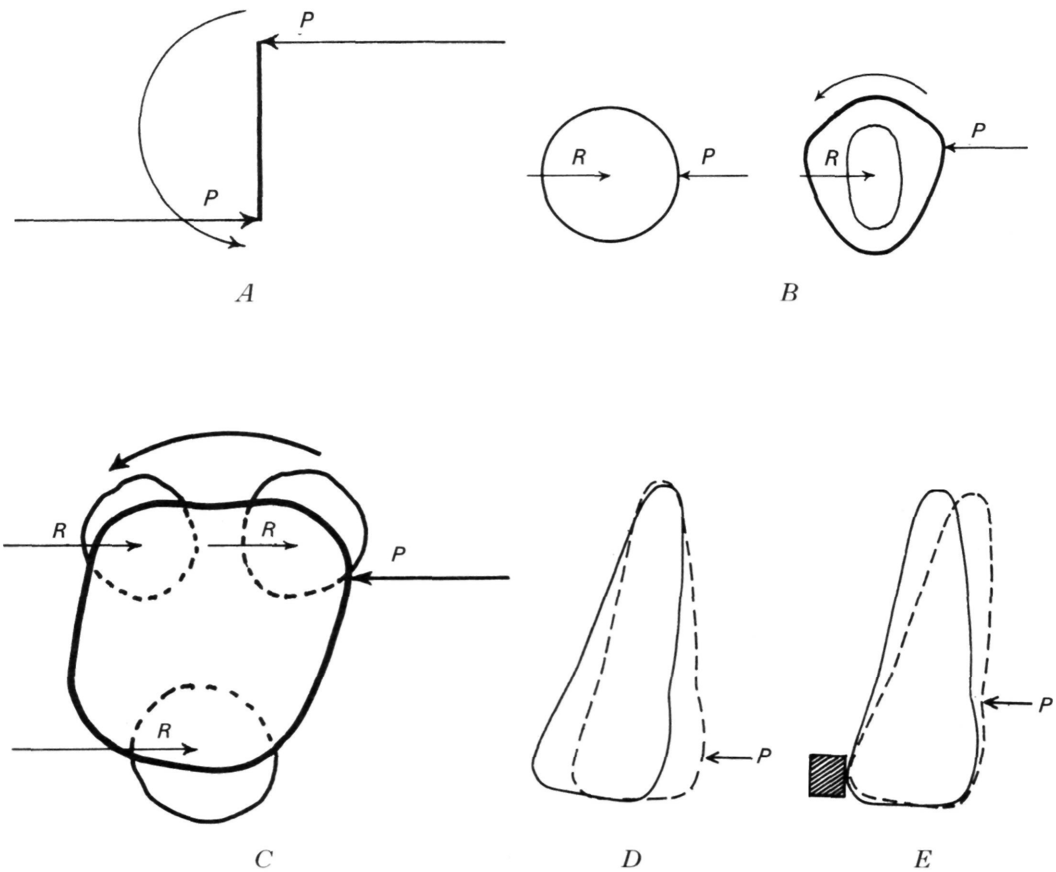


Fig. 1.6. The action of springs on teeth. *A,* A spring exerting a pressure *P* on the lingual aspect of an upper incisor impinges on a sloping, frictionless surface. The effects of this force are to produce a force *L* at right angles to the surface impinged on, equal to the resolved part of the force *P* in this direction, tending to move the tooth labially; a force *F* parallel to the surface impinged on equal to the resolved part of the pressure *P* in this direction which tends to displace the appliance downwards in this direction. The reaction *R* to the force L tends also to displace the appliance in a downward and backward direction. In practice the appliance is the less movable element in the pressure system, being fixed to an anchorage, and the force *L* proclines the tooth and the reaction *D* to the force *F* tends to produce a depressing effect on the tooth.

B, The point of fixation of a finger spring determines the direction in which it acts: 7, The point of fixation is somewhat forwards. *2,* The point of fixation is somewhat backwards and the line of action of the spring is in a buccal direction. J, The point of fixation is opposite to the tooth and the spring is bent to make the point of application of pressure on the mesial surface.



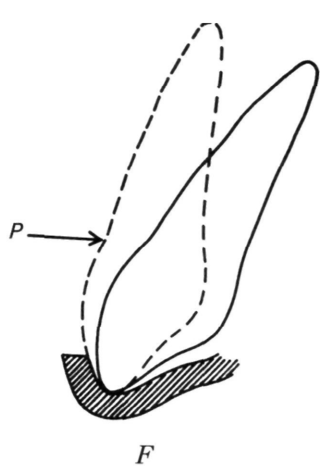


Fig. 1.7. Rotation and root movement. *A,* The mechanical couple. Equal and opposite pressures which are not in line produce rotation. *B,* Moment of a force about a point. (P is the line of application of pressure. *R* is the centre of resistance.) If the resistance is in line with the pressure, no rotation takes place. If the resistance is not opposed to the pressure, rotation will take place. Pressing on the slightly buccally placed contact point of a premolar will produce rotation. C, In the case of an upper first molar, pressure on the mesial surface will produce rotation around the large palatal root.

D, Pressure (P) at the distal surface of an incisor that is free to move will produce mesial tipping. *E,* Pressure (P) in a mesial direction at the distal gum margin of an incisor, which is blocked at the mesial aspect of the incisal edge, will produce mesial tipping of the root. F, Pressure (P) at the labial gum margin of an incisor which is prevented from tipping at the incisal edge will produce root movement in a lingual direction.

Functional Appliances

Functional appliances, as their name suggests, act through the functional activities of the face, jaws and dental arches by modifying or redirecting naturally-occurring forces in order to promote movements of teeth and, by some it is believed, to produce beneficial changes in the growth pattern of the face and jaws and, by others, improvements in respiratory function and general physical development.

There is no field of orthodontics so rich in theory and hypothesis, special technical terminology and speculation as that of the functional appliance. The names of the appliances and appliance systems are many and various and the list includes such names as monobloc, twin-block, duo-block, bionator and propulsor. Others simply bear the names of their originators such as Andresen, Bimler, Fraenkel and Harvold. A further aspect is the claims that are made for an appliance's efficacy in stimulating facial growth of a clinically significant degree. This topic is a minefield, full of traps for the unwary and inexperienced; how often are hopes raised, later to be dashed.

It is sometimes suggested that the meanings of 'function' and 'functional' are not properly understood and should not be used in connection with orthodontic appliances. Clinical orthodontists, however, do use appliances which they term 'functional' and malocclusions are corrected by such appliances whatever may be the theoretical objections.

Functional appliances operate either through the muscles of mastication, which move the mandible, or through the activities of the musculature of the tongue, lips and cheeks and their immediately adjacent tissues, often loosely referred to as the soft tissues. The two systems are not mutually exclusive but, broadly speaking, functional appliances are designed in some cases to produce precise active pressures on teeth to cause them to move, and in others to withhold some of the pressures that would ordinarily maintain stability of the teeth and to permit other naturally-occurring forces to produce tooth movement.

Functional appliances also modify the maxillo-mandibular relationship during function and may thereby produce changes in the growth pattern of the face itself and the positions of some of the soft tissues during respiration.

Effects produced by functional appliances

A number of effects can be discerned after the use of functional appliances. In the teeth, there may be found alterations in axial inclinations of individual teeth or groups of teeth and expansion and changes in occlusal relationship of the dental arches as a whole. In the facial structures there may be changes in size and shape of the jaws and in the posture and function of the soft tissues. The determination of how far such changes may have been produced by the appliance and how far by growth is not easy. Experience shows that the use of functional appliances during the growth years produces more effect than if used after growth has ceased.

Fixed Appliances

Fixed appliances have co-existed with other types for many years and at first differed but little from clasped removable appliances in principle, operating as they did through the medium of screws and springs attached to heavy archwires or frameworks fixed to anchor teeth by means of bands clamped onto the teeth by screws.

Labiolingual appliances

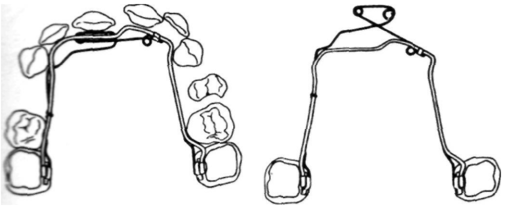
The last generation of these appliances was the ultimate refinement of the labiolingual appliance described by Oliver et al. (1940) and designed in stainless steel by Friel and McKeag (1939), using plain bands and heavy archwires welded to the bands and bearing a variety of fine and flexible springs for the movement of teeth {*Fig.* 1.8). These appliances had the merits of being efiicient, durable and needing little attention once correctly installed. The pressures exerted were gentle and over a long range of action. The kinds of movements possible were not greatly different from those produced by modern removable appliances. In their time, however, labiolingual appliances were more efficient than the removable appliances then available, but the principles of the two systems were the same, that is to say, an anchorage base, a solid framework and a source of pressure in a spring or in elastics to move teeth.

Multiband appliances

In due course the idea emerged that by placing bands on all the teeth and attaching a fine archwire, formed to a predetermined correct shape, to the bands by means of clips or brackets soldered to the bands, deforming the archwire in the process, the archwire as it returned to its original shape would draw the teeth into a correct arch form.

In such a system the determination of which teeth are anchor teeth and which are teeth in movement can become a highly complicated analysis as there is, at first sight, no framework and no base from which pressure is to be exerted. The active part of the appliance is the slender archwire attached to and potentially moving all the teeth at once.

The new possibilities were quickly perceived and a variety of archwire types were evolved, and even combinations of the former labiolingual appliance together with the new labial multiband appliance were used, as in the Johnson twin wire arch method (1938,1941), together with a heavy lingual or palatal archwire.



F:g. 1.8. A typical labiolingual appliance consisting of molar bands with a heavy lingual arch and a fine spring to procline 1|. (*Reproduced by kind permission of the European Orthodontic Society.)*

The variations in the pure multiband appliance that were introduced were of two kinds; different kinds of archwires and different kinds of attachment brackets. The main variations in archwires were in the kind of archwire, that is to say, differences in the cross-section of wire, which could be a plain round wire; a flat section laid flat against the teeth and known as the 'ribbon arch'; a rectangular or flat section laid edgewise against the tooth and known as the edgewise arch; and multistrand archwires which have very great flexibility but are restricted in the uses to which they can be put.

The characteristics of the metal of the archwire varied considerably. The early kinds of gold alloy had limited elasticity, while modern stainless steel wires are available in a number of grades of hardness, and special alloy archwires are now available such as Elgiloy, which can be heat hardened, and Nitinol, which is coated with a white disguising skin. Every specialist supply house today offers archwires bearing its own name and specification of physical properties.

The attachment brackets are the second and important component of the flexible arch type of fixed appliance. Attachment of an archwire to a tooth can be effected as simply as by ligaturing and in certain situations this attachment can still be used. Better control is obtained by a bracket, channel or tube fixed to a band which is cemented to the tooth or bonded directly to the tooth by one of the composite materials.

The variety of brackets available is now very great and all are designed to exploit some mechanical principle as applied and embodied in the particular archwire material and also the way in which the arch is constructed. There are, however, two basic principles in that the tooth movements may be effected by the construction and activation of the archwire alone, and suitable formation of the elastic archwire itself can effect a great variety of tooth movements.

Also, however, additional springs and elastics can be used to increase and enhance the variety of detail movements. These are truly auxiliary springs which add further potential to the basic spring mechanism of the archwire and produce special movements not easily obtained by archwires alone.

While bracket attachments and archwires are made in a variety of forms, there are a few basic types which illustrate the ways in which forces are applied to the teeth by multiband appliances.

The twin wire arch. One of the simplest attachments and one which was used for a variety of purposes for many years is the ripple bracket which was devised for use with twin wire arch appliances. This bracket consists of a short length of stainless steel tape formed in a press into an M shape. The bracket is welded to a band and in use the active archwire or twin wire arch lies in the central channel and is held in by a ligature which passes through the tunnels on either side. When this attachment is used with a

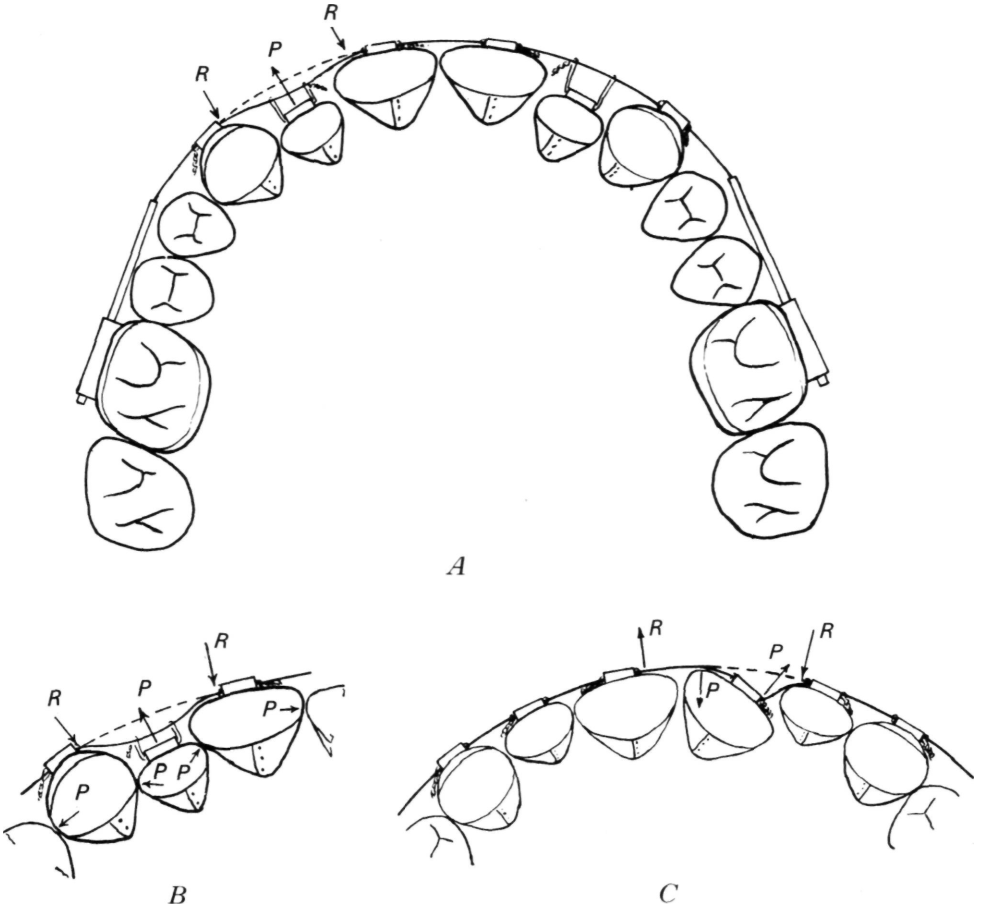
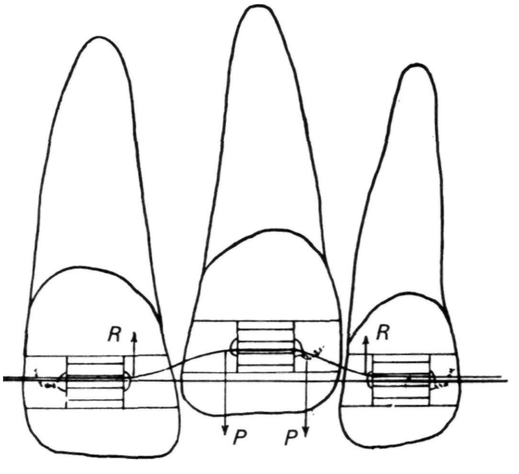


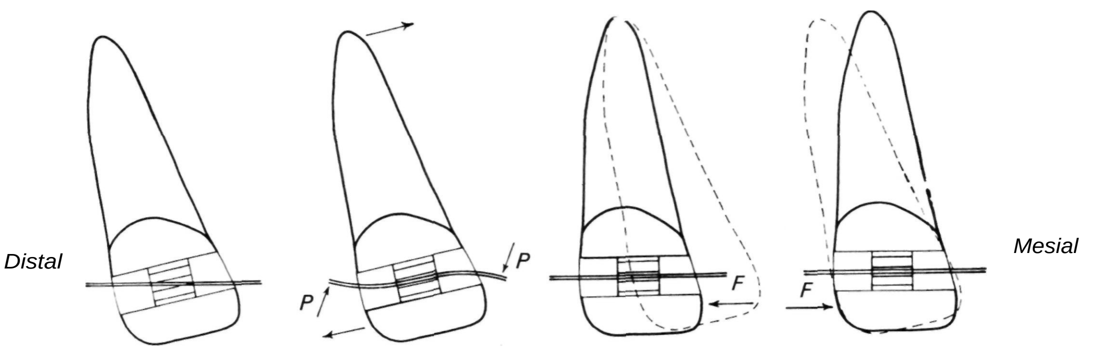
Fig. 1.9. *A,* Labial movement with twin wire arch. P, pressure on 2|; *R,* reaction. The reaction is borne mainly by the adjoining teeth. The ligature on |2 has not been tightened. *B,* When the incisors are imbricated the full pressure, *P,* of the twin wire arch is not taken by the single displaced tooth. The reaction, *RR,* remains the same on the adjoining teeth, but the pressure, *P,* is dispersed against their sloping lingual surfaces, forcing them apart, and hence against the next two teeth in the row. *C,* Rotation of incisor with twin wire arch.

flexible archwire the teeth are drawn into line with the archwire and teeth which are rotated are drawn into good ahgnment {*Fig.* 1.9).

The edgewise appliance. The ripple bracket is also used with a solid light wire arch where only simple tooth alignments are required. The edgewise bracket resembles the ripple bracket in that there is a horizontal channel into which the archwire fits, but there the resemblance ceases as the edgewise bracket is cut from the solid and is machined to a high degree of accuracy. The brackets are usually used with a rectangular archwire which fits the channels precisely, and the combination makes possible the accurate control of tooth position and requires corresponding care and accuracy in the placing of the attachments and the adjustment of the archwire. The appliance was introduced by Edward Angle (1929) under the title: 'The latest and best in orthodontic mechanisms'.



D



E *F* *G* *H*

D, Elongation of tooth with twin wire arch. Light pressure is used; the reaction is unlikely to upset the adjoining teeth. *E*, Arch passive. *F*, Arch must be deformed to get into the bracket. The resulting pressures tend to move root mesially, crown distally. *G*, If crown is assisted by force, movement will be mostly at the crown. *H*, If crown is stabilized with force, movement will take place entirely at the apex.

Edgewise attachments are formed with lugs above and below the channel for the archwire, which is held into the channel by a ligature which is simply looped over the lugs or, as is more common today, a firm tough ring of plastic material is drawn over the lugs.

In use, the edgewise arch is shaped into an ideal arch form and seated and held in the brackets. The dental arches are aligned in perfect arrangement and the occlusal relationship corrected by means of intermaxillary and extra-oral traction.

Mesiodistal and labiolingual inclination of the teeth can be adjusted by second- and third-order bends which are formed by placing steps in the archwire and small twists which torque the roots labiolingually and mesiodistally. In conjunction with intermaxillary traction, virtually complete control of tooth positioning can be achieved, and by using these means, Edward Angle maintained that all the teeth could be brought into perfect occlusion {*Fig.* 1.10).

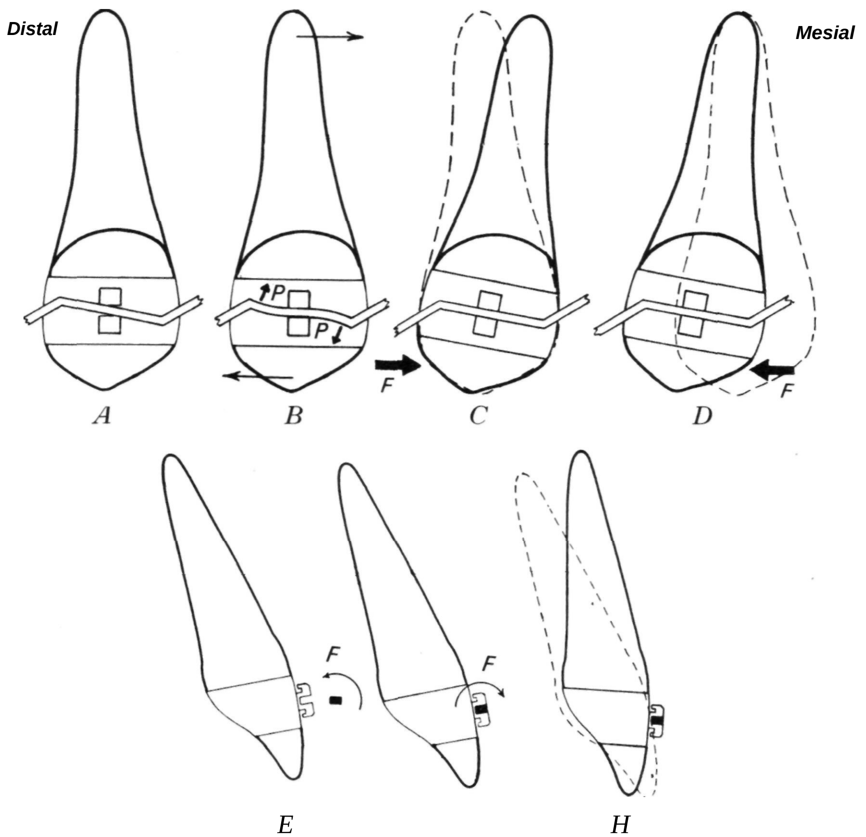


Fig. 1.10. The edgewise arch; second-order bends. *A,* The passive arch crosses the bracket at an angle. *B,* The archwire is deformed in order to get it into the channel and the resulting pressures, *PP,* tend to tilt the apex mesially, the crown distally. *C,* If the crown is stabilized with a force, *F,* movement takes place at the apex. *D,* If the crown is assisted to move by force, *F,* main movement will take place at the crown and not at the apex. *E,* Torque force applied to an incisor using the edgewise arch for labial root movement. The arch must be twisted with a force, *F,* to align it with the channel in the bracket and permit insertion. G, The arch then exerts force, *F,* tipping the apex of the tooth labially. The amount of pressure exerted on the labial plate of bone is difficult to assess clinically. *H,* Movement produced by torque force.

These notes are a considerable simplification of the edgewise system of appliance treatment which has endured since its introduction to orthodontics. There have been modifications in detail over the years but in essence the appliance is still the same today.

The round arch appliance. For many years a plain, round-section light archwire has been used in multiband appliances with brackets of various kinds, from ripple brackets to edgewise brackets, the archwire fitting the channels with varying degrees of precision and held in place usually by ligatures. The kinds of movements that could be achieved depended to a great degree on the ingenuity of the orthodontist and his skill and experience. By forming loops in the arch, great flexibility could be built in and small sections of the arch could be aligned in various ways opposite individual teeth to produce individual rotations and mesiodistal tippings. Intermaxillary and extra-oral traction could be applied.

In theory, a bodily movement of teeth can be effected by the use of a fixed appliance which employs an attachment having a channel or tube which slides accurately along a closely-fitting archwire. In practice, a channel or tube which fits an archwire accurately enough to prevent any tilting would not slide freely and, furthermore, archwires cannot be so completely rigid as to prevent tilting absolutely. As a result, some tilting occurs and it is the purpose of such fixed appliance treatment methods to minimize tilting and to correct tilting by root movement after crown position has been established.

The problems of axial tilting were clearly perceived by Begg (1965) who made it a principle to correct crown position first of all, regardless of tiltings, and then to correct axial inclinations by root movement, where necessary, as a separate stage of treatment.

The Begg light-wire appliance. A system based on the use of a light round wire arch was formalized and defined by Begg (1965) and this system is now widely used. The system makes use of a bracket which is derived from one of the very earliest bracket types, the ribbon arch bracket. This bracket is narrow mesiodistally and has a vertical slot close to the tooth surface approached from the gingival aspect. Into this slot the ribbon arch is inserted and ligatured, thereafter drawing the teeth into good arch form. The Begg round arch is also laid in the vertical slot but is held by means of a hooked pin, the bracket being pressed up from sheet metal and having a socket through which the pin passes and is held in when the tip projects through the socket and is bent over {*Fig.* 1.11).

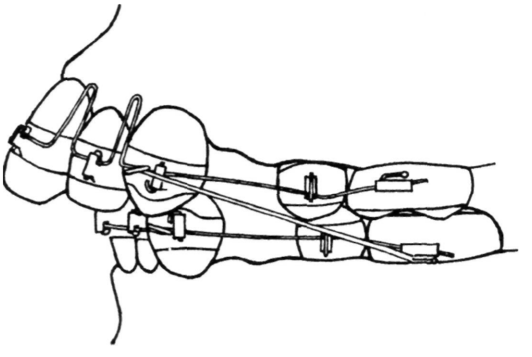


Fig. 1.11. A typical Begg appliance for alignment of the anterior segments, reduction of overbite and closure of extraction sites by lingual movement of upper labial segments and mesial movement of lower molars and second premolars. (*Reproduced by kind permission of G. G. T. Fletcher and John Wright & Sons Ltd, Bristol.)*

The features of this bracket are, first, that it is narrow and no attempt is made to restrict tipping of the tooth in any direction. Secondly, the archwire slides freely through the slot even when the pin is locked in. This gets over the problem of binding of the bracket on the archwire which impedes mesiodistal movement. The principle of the use of the archwire with this appliance is to bring the crowns of the teeth into correct alignment and the dental arches into correct occlusion in the first place. If teeth have been extracted, the extraction sites are closed in a predetermined manner even though teeth are tipped in the process.

In the final stage, the axial alignments of the teeth are corrected mesiodistally and labiolingually by using auxiliary springs additional to the archwires (*Fig.* 1.12). These

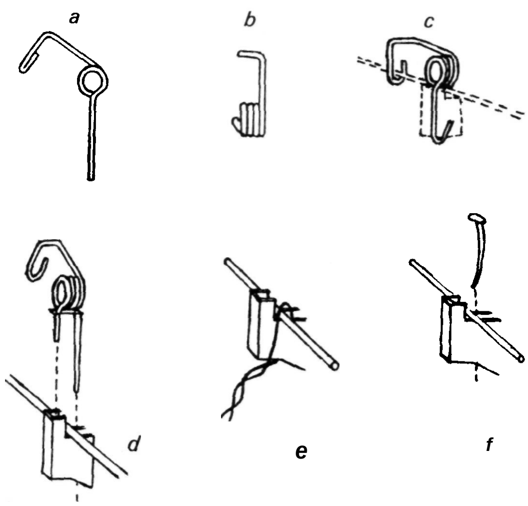


Fig. L12. Auxiliaries for the Begg appliance. Shown is a root torquing auxiliary, *a, b, c, d;* ligature and lockpin with unipoint bracket, *e, f. (Reproduced by kind permission of G. G. T. Fletcher and John Wright & Sons Ltd, Bristol.)*

springs are true auxiliaries and perform movements that cannot be performed by the archwire because the connection between the archwire and the tooth is through a single free-sliding point. It is for this reason that the brackets are called unipoint brackets. It is, however, this freedom of the tooth to tilt that makes possible its root movement by an auxiliary spring as a final stage of treatment.

This outline of the Begg light wire appliance is a condensation of the detailed discussion of the nature of malocclusion in modern man and the systematic approach to the appraisal of individual problems and their treatment, which is part of the Begg philosophy as a whole. The mechanical principles which underlie the methods used in this treatment scheme have been mentioned, but the subtleties of the manipulation of the archwire itself are many and must be considered in connection with the anchorage requirements, the distribution of forces and the control of vertical relationships and axial inclinations of the teeth.

The developement of force between an archwire and a bracket can be effected by forming the archwire so that it is out of alignment with the bracket channel and then drawing the wire into the bracket. An alternative method is to leave the archwire fiat but curved to the required correct arch form and to produce torquing and tipping actions by placing the bracket attachments at various angles and misalignments with the archwire. When the archwire is put into the channels in the brackets, various kinds and degrees of activity are introduced into the system and corresponding planned tooth movements take place.

This necessitates placing the attachments with great precision as, if this is not done, it is then necessary to adjust the archwire, and it might seem that it would have been better to have placed the brackets uniformly and to develop the pressure by archwire adjustment in the first place.

Combined fixed / removable appliances. There are some small-scale tooth movements for which a fixed appliance is necessary but involving only a single tooth, for instance, and a full-scale fixed appliance may seem unjustified. In such cases, it is possible to attach a spring to a tooth using a box, socket or tube and to hook the free end of the spring onto a clasp or other wire placed for the purpose on a baseplate and so generate a tipping or rotatory force on a tooth. The spring is not fixed to the baseplate but is hooked on and the patient can unhook the spring to remove the plate for cleaning and re-hook it, so activating the spring.

It is important that the attachment of the spring to the tooth should be firm and accurate and the best method is by a precision box. For some years the box attributed to Friel and McKeag (1939), and used by Watkin (1933), for a pin-and-tube appliance was used for whip springs, but a scaled-down and stronger type of box is more practical and effective *(see* Chapter 5).

SUMMARY

The clasped removable appliance and the labiolingual appliance work in the same way, that is to say, there is a solid framework on which the active part or pressure source is placed, that is, the baseplate or the labial or lingual archwire, or to which the force is applied where intermaxillary and extra-oral traction are used. The two appliance systems apply pressure to the crowns of teeth causing movement to take place and this movement is in the main of a tilting nature. Finally the framework distributes the reaction of the force to the anchorage base. Clasped removable appliances and labiolingual appliances have to be designed with the particular tooth movements that are called for in mind, and it may be that the treatment plan needs to be broken down into stages of tooth movements, each one of which is carried out by a slightly different appliance. Clasped removable appliances perform most, if not all, of the functions of labiolingual appliances. This is not to say that the clasped removable appliance replaces the labiolingual appliance entirely; there are situations in which labiolingual appliances can still have a part to play.

Functional appliances make use of existing pressure sources within the dentofacial complex. These forces may be redirected precisely onto the teeth or may be caused to change the existing pressure environment of the jaws and face as a whole. Functional appliances are particularly useful during active growing periods and in the treatment of malocclusions in which occlusal discrepancies are major problems.

Multiband appliances, through attachments fixed to the teeth, give control of every aspect of crown and root position. The same attachments are used throughout and, as treatment proceeds, archwires are changed and replaced and auxiliary springs added for detail effects.

Chapter 2

The Design of Removable Appliances

The components of removable appliances consist of the energy or pressure source, the clasping system and the baseplate or framework of the appliance. The pressure source may be a metal spring or an elastic band or, alternatively, the elasticity of the periodontal structures may be used to store the energy produced by the movement of the teeth by a rigid screw. The clasping or appliance-retaining system secures the appliance to the dental arch. The baseplate is the framework of the appliance which supports the pressure system and distributes the reaction of the pressure to the anchorage. Clasped removable appliances may also have additional attachments to make use of anchorage from the head and neck through the use of headcaps or collars.

ENERGY SOURCES

Orthodontic Springs

Orthodontic springs on removable appliances today are almost universally made of 18/8 stainless steel or nickel/chrome wire. Before the introduction of stainless steel wires for orthodontic purposes, platinized gold wires were used but this material had rather a small elastic limit so that the range of action of the springs made from it was fairly short. Stainless steel is more elastic and this makes possible the construction of springs with an adequately long range of action.

The amount of pressure exerted on a tooth has to be considered as the pressure being applied per unit of root area. Root area varies between larger and smaller teeth. It was suggested by Schwarz (1931) that a pressure of $20 g/cm^2$ of root area was suitable for producing tooth movement. In practice, this is a pressure of not more than 20g per single-rooted tooth. Larger teeth, such as the molars and upper canines, will accept higher pressures because of their larger root areas.

Excessive pressure will, however, produce interference with the capillary blood flow and in this way interfere with or prevent bone changes which are necessary for tooth movement. The patient's reaction to pressure on the teeth must be considered carefully. Patients vary in their reaction to pressure in the sense that some find that pressure, especially in the initial stages, produces discomfort and pain and complain accordingly. Apart from any warning signal that such pain might be, discomfort may be a disincentive to co-operation in treatment. Orthodontic treatment should be carried out without discomfort to the patient and this can be achieved by proper adjustment of the appliance (*Table* 2.1).

It is, therefore, necessary to have the pressures exerted by orthodontic appliances under control in that the amount of pressure and the distance over which the pressure acts are carefully regulated. From the point of view of practical management of treatment, visits for adjustment should be spaced at intervals of about 4 weeks and appliances should continue to act as uniformly as possible over such a period of time. This can be achieved by a suitable design of orthodontic springs as regards length, thickness, amount of deflection and pressure exerted.

Table 2.1. Table of pressures of springs

Spring type	*Length (mm)*	*Thickness (mm)*	*No. of coils*	*Inner diameter of coils (mm)*	*Deflection for 20 g pressure (mm)*
Apron	12	0·3	4	1·0	9·0
Finger	18	0·5	1	2·5	3·0
Self-supporting	10	0·7	1	3·5	0·3
	15	0·7	1	4·0	0·6

The design of springs

It is important to appreciate that any stainless steel wire of the ranges and thicknesses available today is flexible in some degree and may be used in appropriate circumstances for the construction of a spring.

The finer gauges of wire appear more flexible and the thicker gauges less flexible, and the degree of flexibility and the amount of pressure exerted are determined by the length and thickness of wire that is used, whether part of the length is formed into coils or not. The length of a spring that can be used in an orthodontic appliance is restricted by the dimensions of the dental arch and the limits imposed by the size of the oral cavity.

Fine wires of about 0.3mm thickness need usually to be supported on a thicker wire or archwire and added length can be incorporated in coils wound upon the supporting wire. The free end of the wire can be brought back to the supporting wire and wound once or twice round it to make the arm or limb of the spring into a U, a V or a rectangular shape. The resulting spring is robust but at the same time flexible. Thicker wires, about 0.5mm gauge, need only be supported at the point of origin. This may be by embedding in a baseplate or by welding or soldering to a heavier archwire. A single coil is usually incorporated and the limb of the spring usually needs to be guided by a suitable guiding wire and, in some situations, can be protected by the baseplate of the appliance. There are disadvantages in this latter arrangement which will be discussed later.

Heavier springs, of 0.7 mm upwards, do not usually need to be guided or guarded but can sometimes be made more effective by being stabilized. Springs in this group have rather short ranges of action but are nonetheless eflfective in generating pressures on teeth and are used with great success in the circumstances to which they are adapted. In all circumstances, the cantilever form of spring in which a point of attachment and a

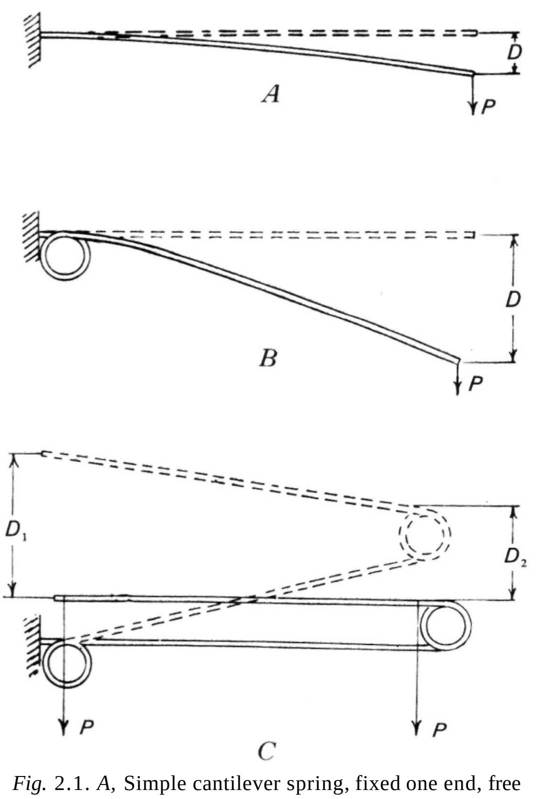


Fig. 2.1. *A,* Simple cantilever spring, fixed one end, free to move at the other. *B,* Cantilever spring with coil at point of attachment. C, Double cantilever spring which will move two, three or four teeth an equal amount in the same direction. Pressure (*p*) produces deflections *D*, D_1 and D_2.

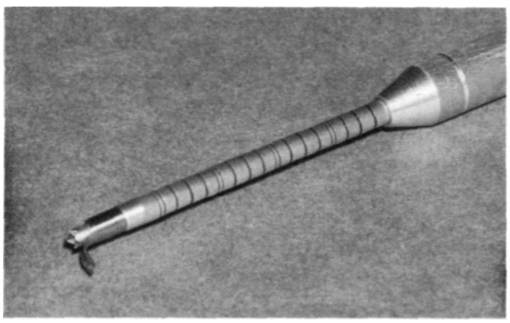
direction of movement at the free end are identifiable is the most satisfactory. Where a number of teeth are to be moved as in the proclination of two to four incisors, a double cantilever spring is effective, but a miniaturized double cantilever made on the scale of a single tooth and used for a single tooth movement is much less effective than a plain single cantilever, which is always to be preferred {*Fig.* 2.1).

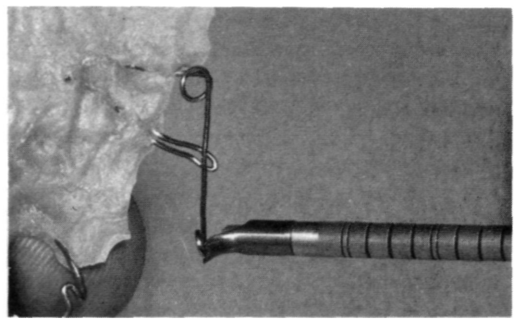
A special form of a very heavy spring is the Coffin spring made of 1.25 mm wire. This is used in the Coffin expansion appliance and is highly effective in expanding or contracting the upper or lower arches in a lateral direction (*see Figs* 6.2, 6.6).

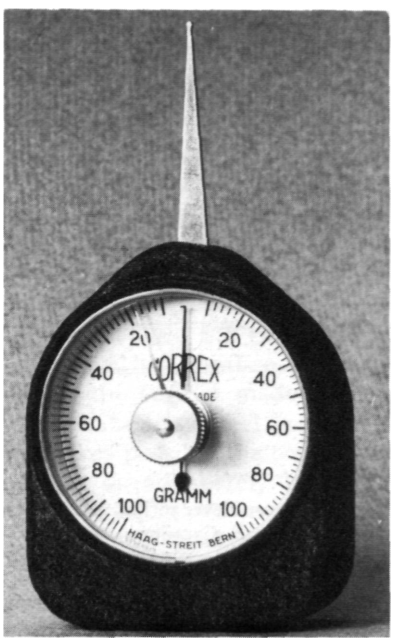
As a guide to the amount of pressure that springs made from round stainless steel wire exert. *Table* 2.1 lists the results of measurement of the deflection produced by a 20-g pressure on a number of springs that are routinely used in removable orthodontic appliances.

Fig. 2.2 shows the use of gauges to measure spring pressure.

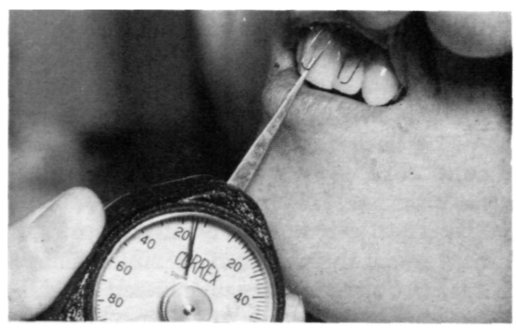
Fig. 2.3 shows a representative group of springs attached for demonstration to a strong wire support. The short thick spring







C



D

Fig. 2.2. The use of pressure gauges. *A*, A plunger type of gauge calibrated in ounces. At the opposite end there is a hook which makes it possible to measure elastic tensions. *B*, Measuring the pressure of a cantilever spring. *C*, The Correx pressure gauge calibrated in grammes. *D*, Measuring the pressure of an apron spring.

(Fig. 23, A) at the *top left* is of 0.9 mm wire and can be used in special situations although its range of action is small. The spring at the *top right* is the standard canine retractor of 0.7 mm thickness. This is a self-supporting spring. The spring on the *bottom left* is a single cantilever spring of 0.5mm thickness with one coil. This spring needs to be guarded and supported. The spring on the *bottom right* is an apron spring of 0.3 mm thickness with three or four coils. *Fig. 2.3(B)* shows a group of finger springs of 0.5 mm wire with guides for mesiodistal and labiolingual movement of teeth. *Fig.* 2.3(C) shows detail of a link which holds a finger spring against its guide wire and so protects the spring from distortion while permitting free movement along its line of action.

The Torque Spring

This spring derives its elasticity from the twisting of a section of wire in the same way as torque bars of high tensile steel are used for suspension systems in road vehicles.

Fig. 2.4(7) shows diagrammatically the layout of a torque spring. The springs shown are symmetrical and the sections *A*, *B* and *A'*, *B'* are fixed firmly, in the case of orthodontic springs, in the baseplate of the appliance. The sections *B*, *C* and B', C are the torque bars and the sections C, *D*, C, *D'* and D, *D'* make up an apron spring.

Such apron springs derive their main flexibility from the twisting of the sections mentioned and the length of the torque bars, and in consequence their flexibility can be increased as shown in *Fig.* 2.4 (2) and *(3).* Torque springs are very robust and at the same time flexible and easy to construct, position and adjust. They are also neat and inconspicuous.

Examples are shown in *Figs. 3.25E* and 5.4.

Elastics

Elastic bands have for many years been used to store energy in orthodontic appliances. Those bands supplied by stationers and used for many domestic and office needs are suitable for some appliance purposes in orthodontics.

The larger sizes of bands can be used for extra-oral traction; such elastics are not standardized and experience or measurement will determine the amount of pull that they are allowed to generate. For intra-oral use, smaller elastics are needed. The thickness of the elastics is usually about 1 mm square and the sizes are numbered. These elastics were widely used in the past, but today purpose-made elastics are made by the specialist manufacturers and these come in sizes from 1/8in. to 5/16in. in diameter and in two strengths according to their thickness *(Fig.* 2.5).

Elastics have a considerable range of action and produce a very suitable degree of force application to a tooth or to teeth due to the ease with which they are applied, and the fact that the patient can renew the elastics at regular intervals and thereby maintain an even degree of pressure on the tooth or teeth that are being moved.

The attachment of a fine elastic to a single tooth can be made to a stud or hook bonded to the tooth with composite material. A tooth that has been exposed surgically may have a hook attached at operation and traction can then be applied by an elastic stretched between the hook on the tooth and a hook on a fixed or removable appliance. The hook on the appliance may be attached at any desired point on the baseplate or to a hook welded to an archwire or a clasp.

Rubber or elastic material can also be used in compression in the form of small pegs, pads or blocks. Such pegs, pads or blocks are pulled or jammed into holes drilled in thickened areas in baseplates and in this way become compressed when the appliance is inserted. The amount of movement that can be produced with such a device is obviously small and the appliance type cannot be considered very efficient. However, it is sometimes necessary to make quite small movements and the rubber plug can often be added to an existing baseplate.

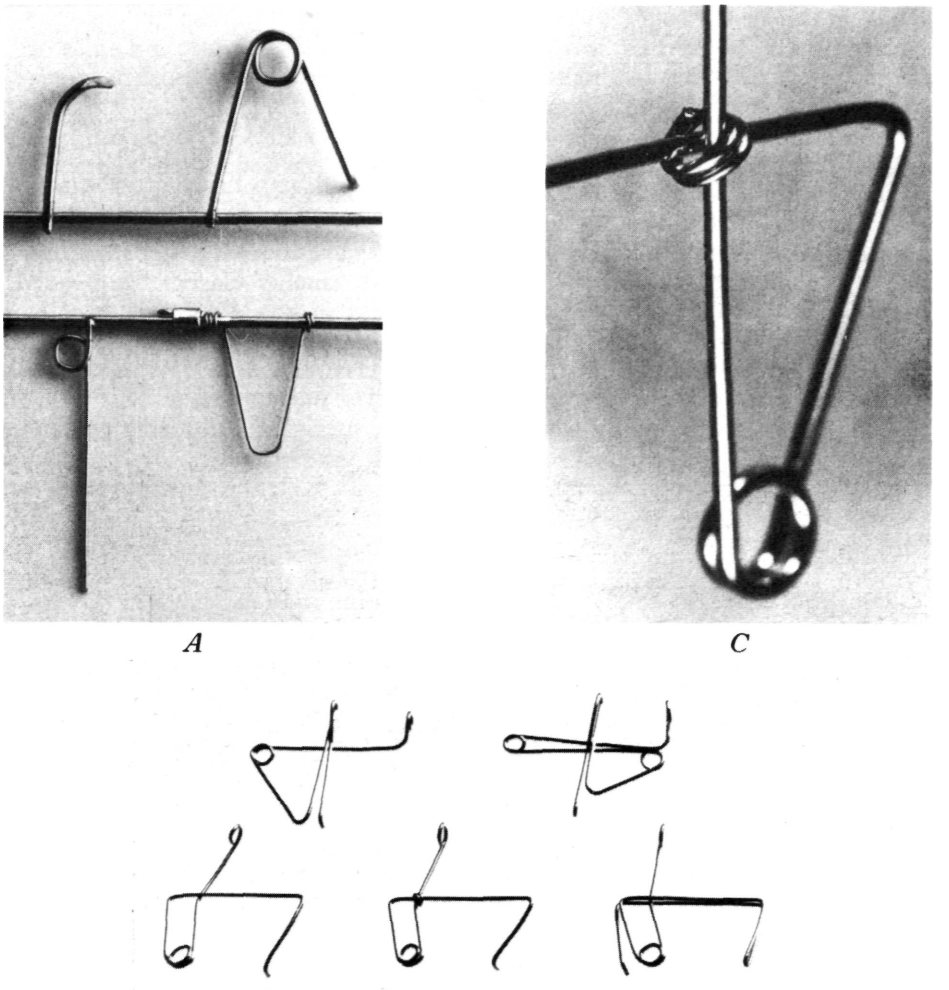


Fig. 2.3. *A,* **A** representative group of springs fixed to a heavy support. *Top left,* a spring of 09 mm wire. *Top right,* a standard canine retractor spring of 0.7 mm wire. *Bottom left, a* finger spring of 0.5 mm wire. *Bottom right,* an apron spring of 03 mm wire wound on the heavy support arch. *B,* A group of cantilever springs with guards. *Upper row,* a single and a double cantilever spring with a guard to keep the spring applied to the tooth. *Bottom row,* a single cantilever spring for retraction of teeth in the buccal segment. *Left,* a plain spring and guard; *Centre,* spring with a wire link holding the spring to the guard; *Right,* spring with a double guide to prevent distortion of the spring by the patient. *C,* Detail of a link wound round the guard and guide wire to stop the patient lifting the spring away from the guard. A link is made of 0.3 mm wire wound round twice, cut off and loosened with a probe.

Screws

The doyen of screw devices was the Badcock screw which was a screw threaded into a tubular housing. The screw at its free end had a short collar which revolved on the head of the screw when the screw was rotated by means of a key or wrench, the two parts of the appliance in which the screw was embedded separated and pressed against the teeth to which the appliance was clasped.

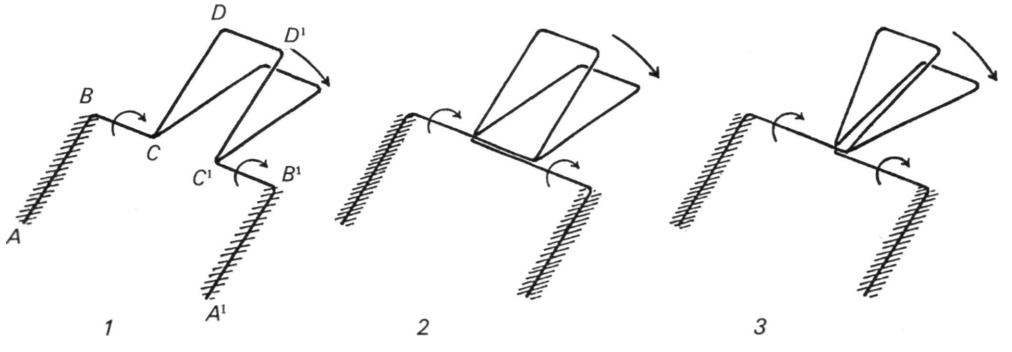


Fig. 2.4. Diagrammatic layout of a torque spring. *See text* for explanation of letters *A,B,C,D* and *A',B',C, D'.*

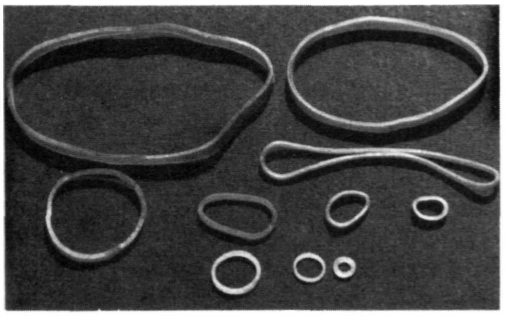


Fig. 2.5. A selection of elastics. These range from the ordinary elastics available from stationers down to the specialist elastics obtainable from orthodontic suppliers seen in the bottom row. The smallest of the three circular elastics is 1/8 in. in diameter.

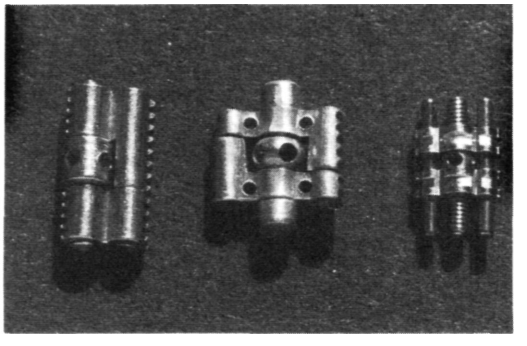


Fig. 2.6. Screws for orthodontic appliances. *Left,* a single screw with a single guide. *Centre* and *right,* double-ended screws with double guides. The screw on the right measures 11 mm in length.

A screw of this kind is rigid so that when the parts of the appliance are separated, the only way in which the appHance can then be placed on the dental arch is by pressing the teeth slightly apart due to the fact that the periodontal support allows this to happen.

The movement of the teeth that takes place is due first of all to the fact that the periodontal membrane slings the tooth in the alveolar process and the membrane is compressed on one side and placed under tension on the other side. There is probably also a slight amount of flexibility in the cementum and the adjoining alveolar bone. The effect is that these elastic tissues store the pressure produced by the slight movement of the teeth. Teeth moved in this way must be allowed a period during which bone remodelling can take place and, as bone remodels, slight additional movements are carried out by adjustment of the plate until the desired complete amount of movement has been achieved.

Screws are sometimes used as a means of expanding the entire dental arch. It is, however, possible by means of suitable design of the baseplate to move quite small groups of teeth when required. This development has been due mainly to the manufacture of smaller sizes of screws. A further refinement is that modern screws are double-ended with left- and right-hand threads at opposite ends so that, as the screw rotates, the nuts or collars into which the threaded ends are placed move apart in equal and opposite directions. Today there are many types of screws being manufactured and these offer various possibilities for the reciprocal movement of segments of baseplate appliances {*Fig.* 2.6). Some screws have coil springs

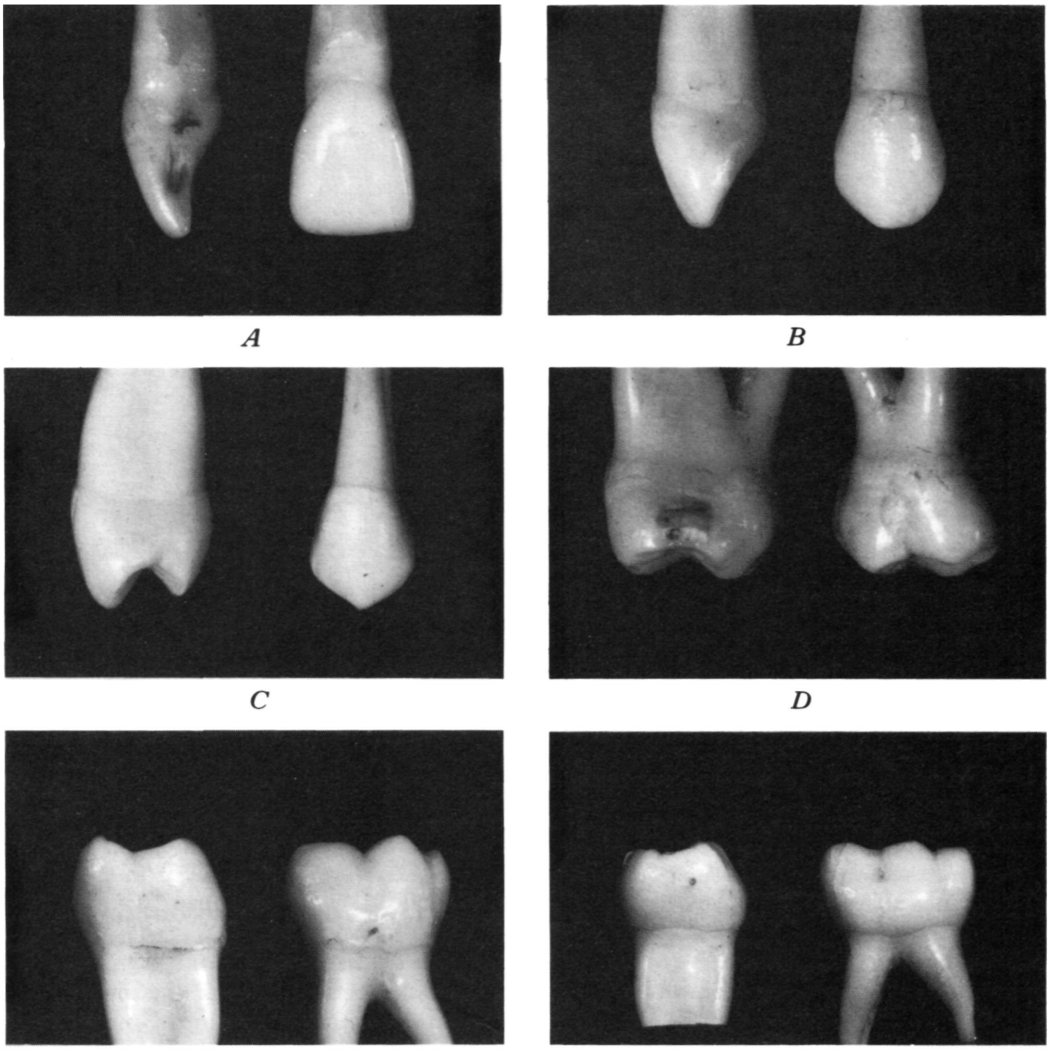


Fig. 2.7. These illustrations show the mesial and the labial or buccal views of the incisor, canine, premolar and molar teeth; also the lower second deciduous molar. *A,* Upper central incisor. *B,* Permanent upper canine. *C,* An upper premolar. *D,* The upper first permanent molar. *E,* The lower first permanent molar. *F,* The lower second deciduous molar. These illustrations show clearly the extensive mesial and distal undercuts on all these teeth which make them suitable for orthodontic clasping purposes.

inside them so that the screw becomes a means of adjusting the tension on the coil spring which then exerts the required pressure.

Orthodontic Clasps

Clasps depend for their action on the presence of surfaces which slope inwards towards the anatomical neck of a tooth below its maximum diameter. These inward slopes, usually called undercuts or retentive surfaces, vary in extent and degree of inclination. Clasps, fitted into these undercuts, retain a baseplate or appliance in position.

It might be thought that the longer and deeper the undercuts, the more effective clasps would be. This is not so because orthodontic clasps must be capable of retaining appliances on teeth which are not fully erupted and on which the full extent of undercuts has not emerged from the gum tissues. Orthodontic clasps must, therefore, be designed to work effectively on the smallest and shallowest undercut, and where a tooth is fully erupted or there is gingival recession, only a small part of the available undercut should be used.

The undercuts that are available for use as clasping surfaces are to be found buccally and lingually, mesially and distally on the deciduous molars and on the permanent molars, premolars, canines and even on incisors {*Fig.* 2.7).

The upper first permanent molar illustrates the available retentive surfaces of a tooth *(Fig.* 2.8). The buccal and lingual undercuts can be seen from the mesial aspect of the tooth *(A).* The buccal surface of the molar is flat, but just at the cervical margin there is a small undercut. The lingual surface is bulbous, and at the anatomical neck of the tooth there is a distinct undercut. Both the undercuts are most marked at the anatomical neck of the tooth and are not usable for retention purposes until the tooth is fully erupted.

The mesial and distal undercuts are visible from the buccal aspect of the molar

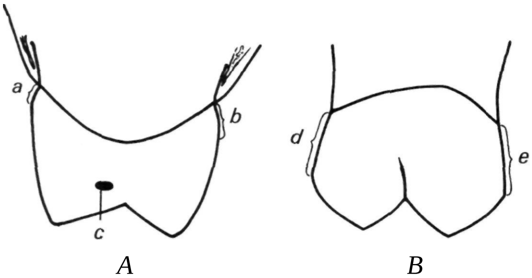


Fig. 2.8. The mesial and buccal views of the upper first permanent molar. *A,* The mesial view shows small undercuts at the buccal and lingual sides when the tooth is fully erupted *(a, b). B,* The undercuts mesially and distally below the contact points (c) are much more extensive and much more readily available for clasping purposes at an early stage of eruption (*d, e).*

(B). The widest mesiodistal diameter of the tooth is at the level of the contact points and the mesial and distal surfaces of the tooth below these points slope inwards to the neck of the tooth. These undercuts are more extensive than those on the buccal and lingual surfaces and they begin nearer to the occlusal surface of the tooth and are accessible when the tooth is at an earlier stage of eruption than are the buccal and lingual undercuts. The mesial and distal undercuts extend buccally and lingually and are, therefore, accessible from the buccal aspect for clasping purposes. Mesial and distal undercuts are found on all teeth, deciduous and

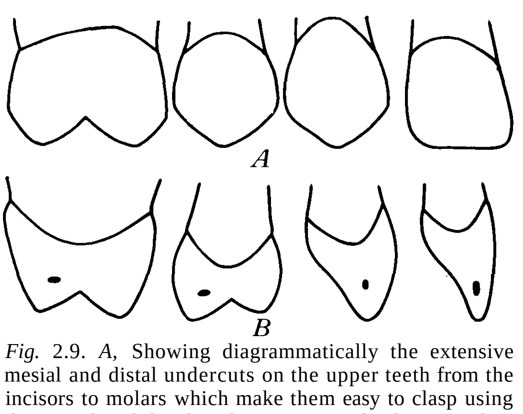


Fig. 2.9. *A,* Showing diagrammatically the extensive mesial and distal undercuts on the upper teeth from the incisors to molars which make them easy to clasp using the mesial and distal undercuts. *B,* Only the premolars and molars have undercuts buccally and lingually which make them claspable, but these undercuts are only available when the teeth are fully erupted.

permanent molars and on premolars, canines and incisors (*Fig.* 2.9). A clasp designed to make use of the mesial and distal undercuts is more effective than one which uses the buccal and lingual undercuts because it will clasp semi-erupted teeth.

The evolution of the orthodontic clasp

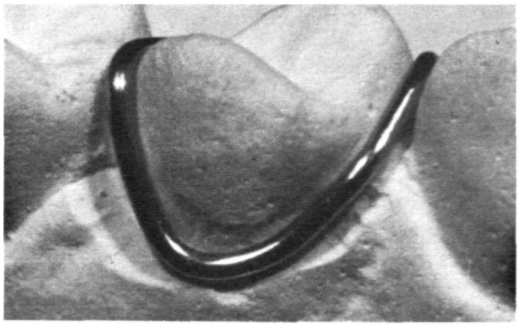
The orthodontic clasp seems traditionally to have been in the form of a loop of wire with both ends embedded in the baseplate. The loop itself has been either quite plain or of more or less complexity depending on the way in which it was intended to work. The term 'crib' is sometimes used loosely as meaning an orthodontic clasp (*Fig.* 2.10,A).

A plain loop of wire, arched over the contact points of a tooth and fitted to the buccal gum margin, can be sprung a little towards the baseplate so causing the clasp to pinch the tooth against the baseplate. If the clasp and the baseplate fit against buccal and lingual undercuts, the clasp will hold the baseplate in position (*Fig.* 2.10,5).

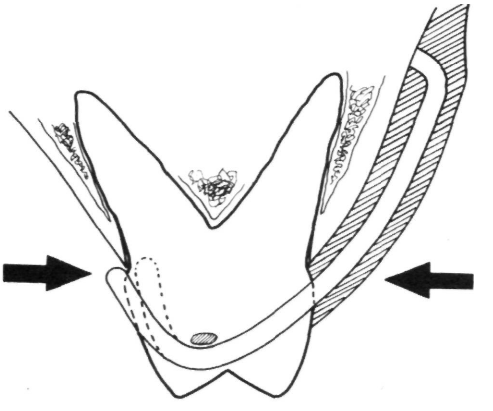
It has always been difficult to retain orthodontic appliances in position using the simple orthodontic clasp or crib because of the fact that in the child patient the buccal and lingual undercuts on the teeth are not usually exposed to view at the time at which orthodontic treatment is being done. As a result, therefore, the problem of retaining orthodontic appliances by means of clasps has led to various attempts to use the mesial and distal undercuts.

The Jackson clasp illustrates this point as the clasp is squared mesially and distally so that it makes contact to some degree with the mesial and distal undercuts {*Fig.* 2.11).

The Crozat clasp works in the same way except that an additional piece of wire is



A



B

Fig. 2.10. *A,* The plain orthodontic clasp sometimes called'the 'crib' clasp. *B,* When the clasp is activated towards the plate and the tooth is fully erupted, the tooth can be gripped by the clasp.

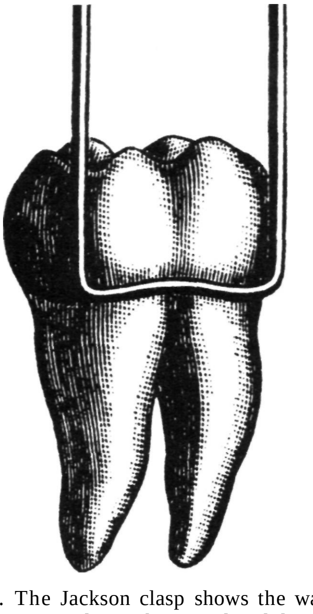


Fig. 2.11. The Jackson clasp shows the way in which the clasp is squared into the mesial and distal undercuts to increase the possibility of clasping the tooth.

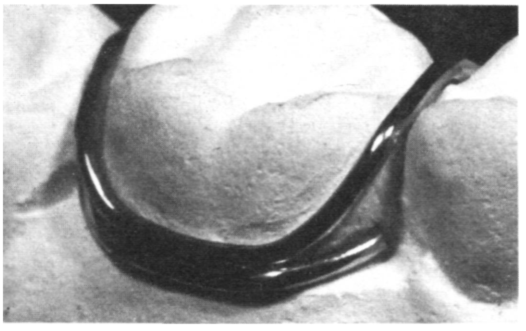


Fig. 2.12. The Crozat clasp. This clasp has, in addition to the ordinary orthodontic loop, an additional piece welded or soldered which runs into the mesial and distal undercuts.

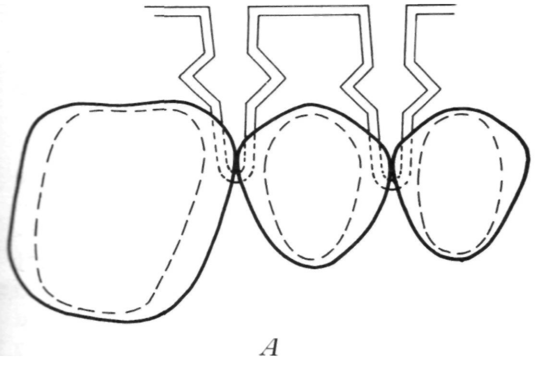
soldered or welded to a plain clasp and the tips of the extra wire are made to fit the mesial and distal undercuts (*Fig.* 2.12).

The arrowhead clasp designed by Schwarz makes use of the undercut area below the contact point of two teeth. The arrowhead is formed by special pliers and two and sometimes three arrowheads are placed on three or four teeth in a buccal segment (*Fig.* 2.13).

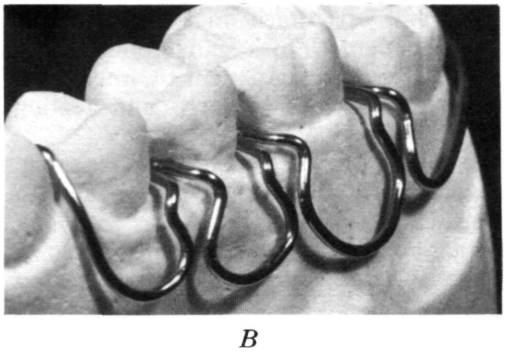
There are other clasps available today which use either the recess below the contact point between two teeth or the mesial and distal undercuts on individual teeth. One such clasp is commercially made and has a small sphere of metal on the end of the tag. This ball is placed below the contact point of two teeth to gain retention or impinges on the mesial and distal undercuts of a tooth.

The Adams clasp {*Fig.* 2.14) is preferred today by many workers for the retention of orthodontic appliances. This clasp is made to fit a single tooth, whether in approximal contact with the adjoining teeth or standing in isolation. The points of the clasp do not fit beneath the contact point of two adjoining teeth but make contact with the mesial and distal undercuts only on the tooth which is being clasped. The advantages of this arrangement are that a single tooth may be clasped whether as part of a complete arch or not. The clasp also has the following advantages:

1. The clasp is small, neat and unob trusive. It takes up a minimum of space in the buccal sulcus and in the baseplate.
2. The clasp may be used on any tooth, deciduous or permanent.
3. A tooth in a state of semi-eruption may be clasped.
4. The clasp is strong, but resilient enough to give a firm grip for every retention purpose. A single short piece of wire is used so resisting the distorting and displacing forces of mastication.
5. No specialized pliers are required for constructing the clasp.



A



B

Fig. 2.13. *A,* The Schwarz arrowhead clasp. The arrowheads fit under the contact point between two adjoining teeth. *B,* The clinical appearance of the Schwarz arrowhead clasp.

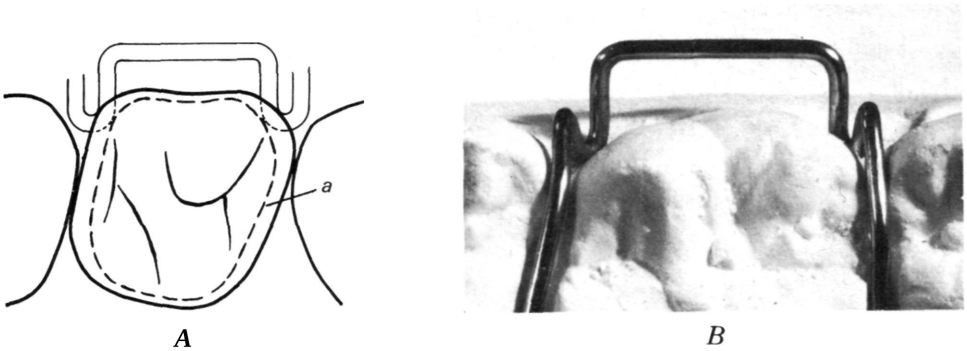


Fig. 2.14. *A,* The Adams clasp which fits on a single tooth and makes use of the mesial and distal undercuts. *B,* The clinical appearance of the Adams clasp. The dotted line *a* represents the smaller circumference of the tooth below the level of the contact points.

Baseplates

The baseplate of an appliance serves two important functions. The first is to provide a point of attachment for a spring or number of springs and, secondly, the baseplate fits accurately against the other teeth in the dental arch and distributes the reaction of the pressure which is being applied to the teeth to be moved.

The tags of springs, clasps and arches or bows are embedded in the baseplate and must be securely held. To ensure that such tags do not become loose the baseplate must be built up a little over the tags. Baseplates need be only 1-2 mm thick and should not be built up all over their area in order to hold tags which can be held safely by a little local thickening. Thin baseplates are adequately strong and are much more comfortable for the patient. Thick and clumsy baseplates discourage the patient by interfering unnecessarily with speech and eating (*Fig.* 2.15).

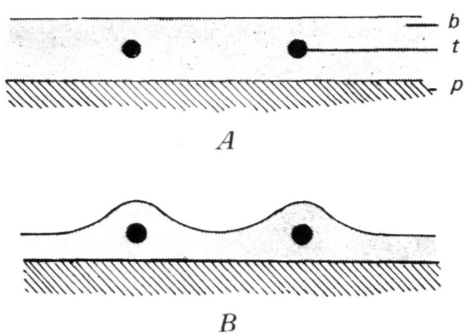


Fig. 2.15. Baseplates should not be made unduly thick. A baseplate need not be thickened all over *(A)* to ensure adequate retention of tags. To do so fills up the mouth and interferes with speech, *b,* baseplate; *t,* tag; *p,* plaster of working model. *B,* A single thickness of wax should be used and the plate thickened over tags only. This is quite as strong and much more comfortable for the patient than *(A).*

Baseplates must be extended as far as may be necessary to obtain anchorage and to ensure stability under the forces to which they are subjected.

In the lower arch, the deep undercuts below the lingual aspect of the molar teeth should be dealt with by filling in the undercuts with plaster on the working cast or by leaving the baseplate thick enough to make it possible to ease the baseplate back from the fitting surface below the teeth. Tags in this area need to be carefully arranged to make this possible. The baseplate should not be trimmed from below as this narrows the depth of the appliance and creates difiiculties in the attachment of clasps and springs (*Fig.* 2.16).

Baseplates should be contoured to follow the lingual gum margin of the teeth.

While baseplates serve as the framework of a removable- appliance, supporting the

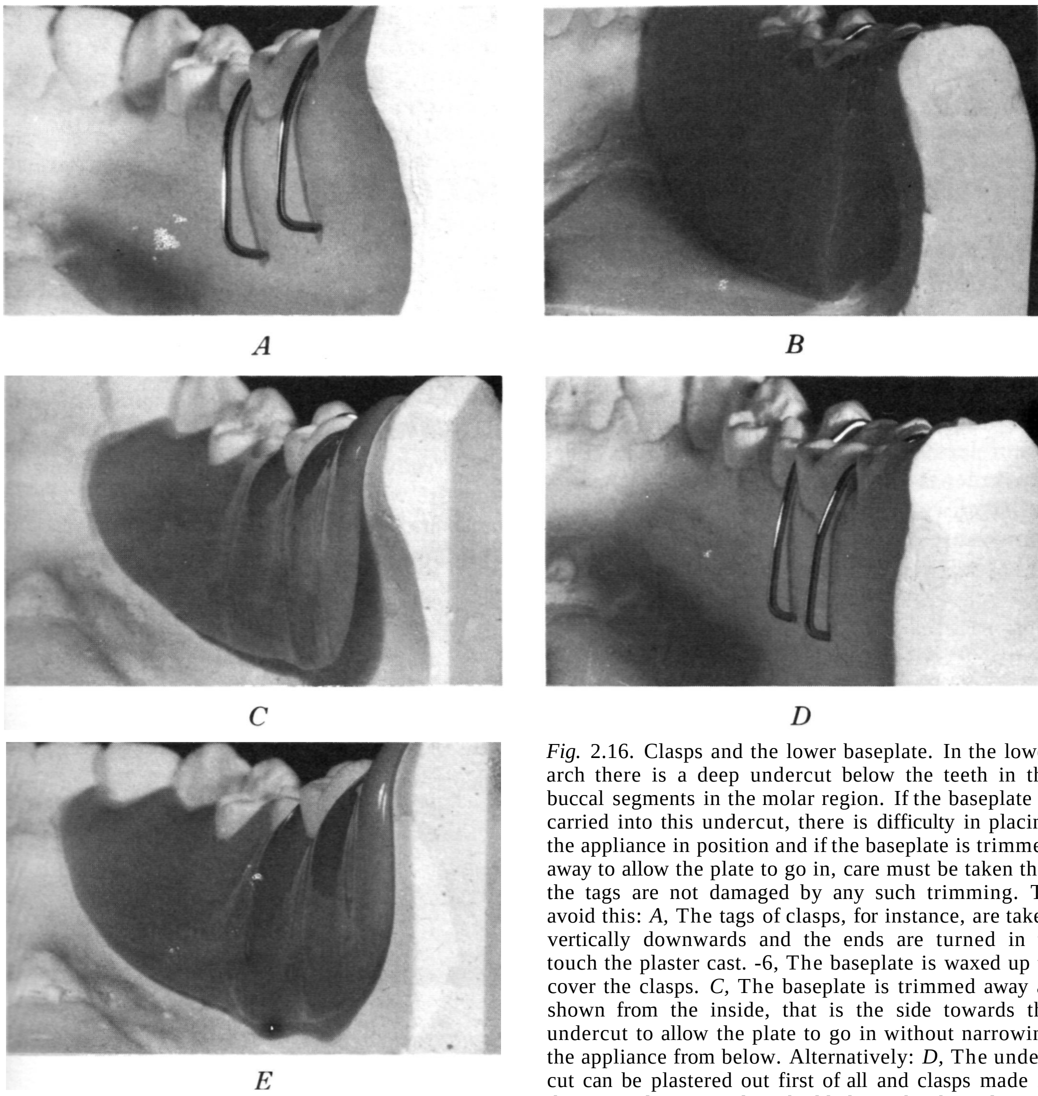


Fig. 2.16. Clasps and the lower baseplate. In the lower arch there is a deep undercut below the teeth in the buccal segments in the molar region. If the baseplate is carried into this undercut, there is difficulty in placing the appliance in position and if the baseplate is trimmed away to allow the plate to go in, care must be taken that the tags are not damaged by any such trimming. To avoid this: *A*, The tags of clasps, for instance, are taken vertically downwards and the ends are turned in to touch the plaster cast. -6, The baseplate is waxed up to cover the clasps. *C*, The baseplate is trimmed away as shown from the inside, that is the side towards the undercut to allow the plate to go in without narrowing the appliance from below. Alternatively: *D*, The undercut can be plastered out first of all and clasps made in the normal way and embedded in the baseplate as shown at (E).

active element and transmitting the reaction to the anchorage, baseplates may sometimes be extended also to act as bite planes or to provide an inclined plane.

This additional use of baseplates brings them into the group of functional appliances and it is sufficient to mention here that a temporary propping of the bite by a bite plane may be necessary to permit movement, by a spring, of a tooth or number of teeth otherwise locked in place by the occlusion (*see Fig.* 3.11).

Chapter 3

Labiolingual and Buccolingual Movement of Teeth

The term 'labiolingual movement' applies to the anterior teeth, the incisors and canines, and buccolingual movement applies to the premolars and molars. In performing these movements an inclining effect is usually satisfactory and this can be performed by removable appliances in the great majority of cases.

LABIAL AND BUCCAL MOVEMENT OF TEETH

Labial Movement of Incisors

This movement is called proclination of incisors while a similar movement of canine teeth and the teeth farther back is referred to as a labial and buccal movement.

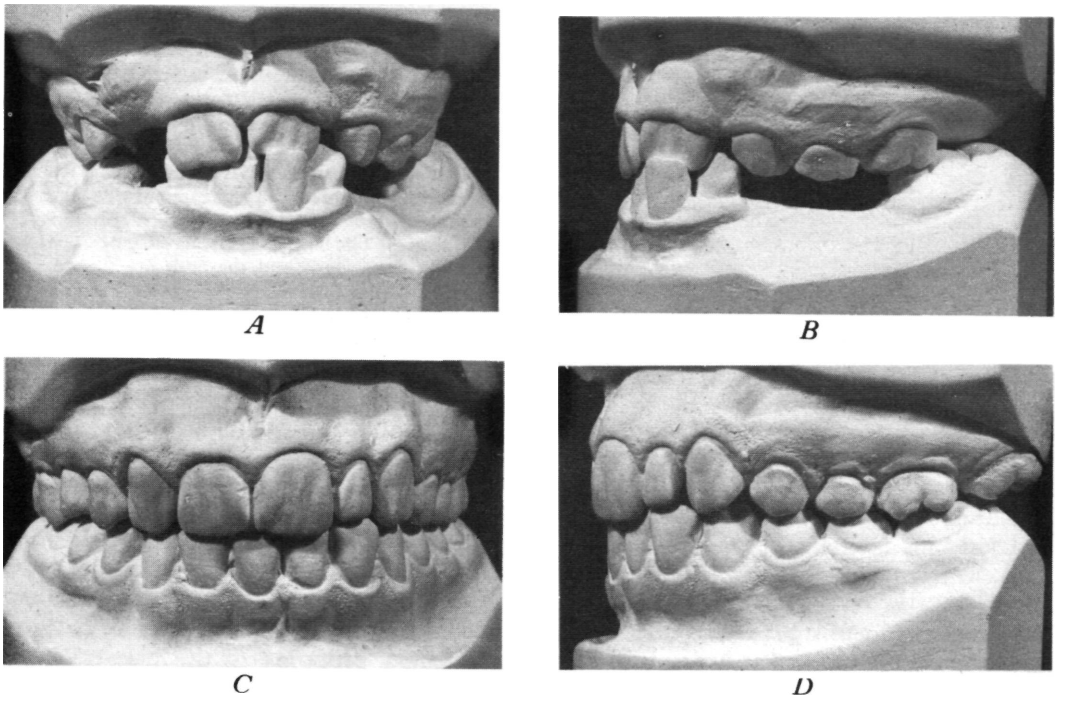


Fig. 3.1. *A, B,* Front and side views of a patient aged 6 years with a single incisor caught behind the lower incisors. *C,D,* After proclination of |1, the dentition developed to an excellent arrangement apart from congenital absence of 2|.

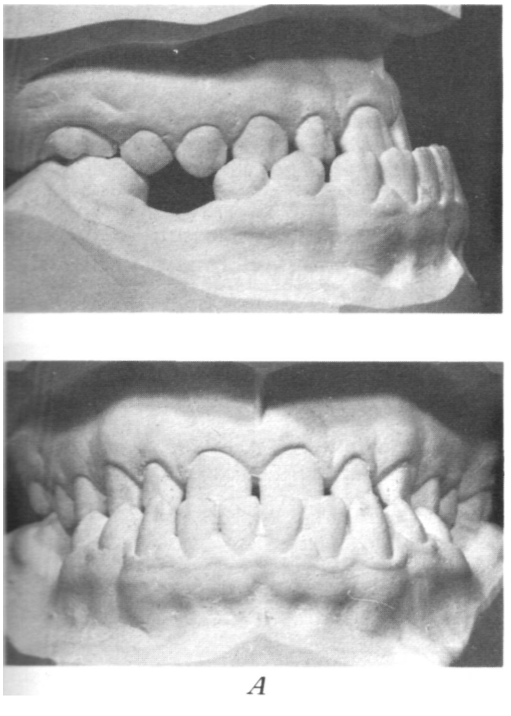
Upper incisors may need to be proclined because of their biting lingually to the lower incisors; the fault may lie equally with the upper and with the lower teeth or may be mainly in the upper or in the lower teeth. It is important to assess and distinguish where the problem lies and to plan tooth movements so as to produce the necessary correction or improvement.

Lingual Occlusion of Upper Incisors

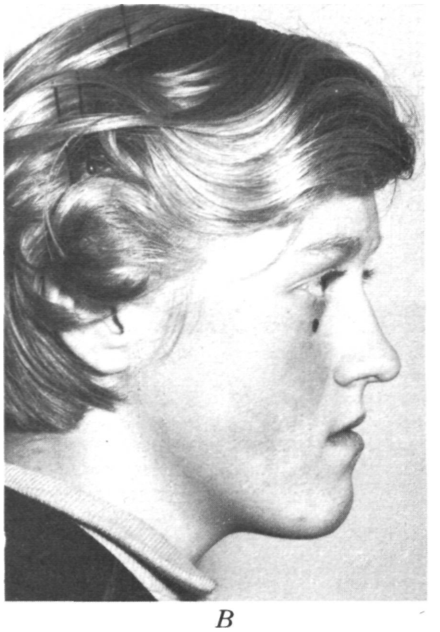
The details of any case in point may vary considerably as shown in *Figs.* 3.1 and 3.2 illustrating two strongly contrasting instances. In the first case *(Fig.* 3.1) there is a well-arranged dentition apart from the detail that one upper incisor is biting lingually to the lower incisors, overbite and overjet of the other anterior teeth being normal. In the second case *(Fig.* 3.2) the lower labial segment, as a whole, occludes mesially to the upper and all the upper incisors bite lingually to the lower incisors. The differences between the two cases are of nature and degree. The second case contains problems of face size and shape that are not present in the first, and the discrepancy in the relationship of the incisor teeth is of a more severe degree in the second case than in the first. These are two extreme examples of upper incisors biting lingually to lower incisors and between them lie shades of discrepancy ranging from the mild to the extrem'e.

Factors which influence the correction of lingual occlusion of upper incisors to lower incisors are:

1. Space conditions—if the upper anterior teeth are crowded, there may not



A



B

Fig. 3.2. *A,* The upper incisors bite lingually to the lower incisors and so also do the canines; the underjet is 5 mm. This is a Class III malocclusion and in no way can incisor relation be corrected by purely orthodontic measures. *B,* This patient was treated by mandibular resection.

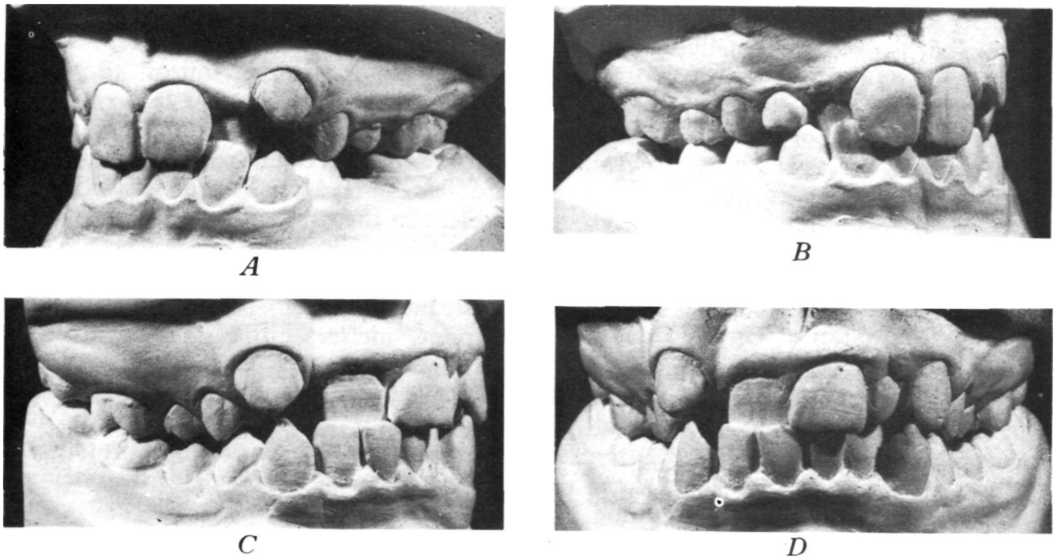
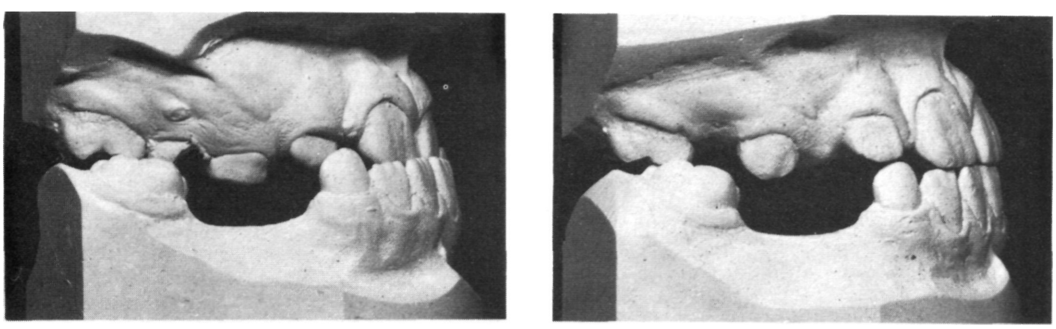


Fig. 3.3. *A,B,* Right and left views of the patient with normal overbite and overjet of 1|1. The upper lateral incisors bite lingually to the lower incisors, but there is not sufficient space to correct the lateral incisor position. *C,D,* A similar case except that 2l| bite lingually to the lower incisors and there is insufficient space for correction of the lateral incisor.

be space to procline a lingually occluding upper tooth into line {*Fig.* 3.3,A,B,C,D*)*.

2. Degree of overbite—if there is little overbite, upper incisors, when proclined, may not remain stable as overbite is further reduced by the movement of proclination *(Fig.* 3.4).
3. Upper incisor inclination—if the upper incisors are. already inclined forwards, proclination may further reduce overbite and leave the upper incisors in a traumatogenic position *(Fig.* 3.5).
4. Dental base relationship—if there is a tendency to prenormality in the dental



A B

Fig. 3.4. In this case the upper incisors have very little overbite *(A)* and after proclination *(B)* the overbite had disappeared completely and the upper incisors are in an unstable position. Retroclination of the lower incisors might help but would not be easy in the absence of space between the incisors or the extraction of the lower premolars as these are not yet erupted.

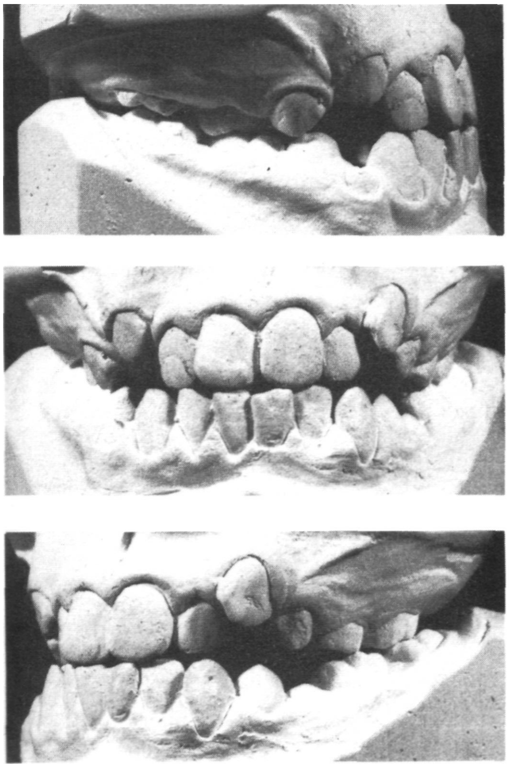


Fig. 3.5. This patient has not only crowding but also no overbite so that correction of 2|2 requires space. It can be seen that the lower incisors appear retroclined so that there is not a good prospect for producing an overbite relationship. This patient would probably, in due course, require surgical treatment.

Fig. 3.6. This patient has some degree of overbite, but the dental base discrepancy suggests that the question of stability of the upper incisors after correction might be in doubt. Note that the buccal segment relationship is markedly prenormal.

base relationship, there may be difficulty in achieving a correct incisor relationship by orthodontic means (*Fig.* 3.6).

5. Where an upper incisor or a number of upper incisors bite lingually to the lower incisors, the possibility of there being a forward deviation, displacement or posturing of the mandible on closing from the rest position to occlusion should be looked for. If there is such a displacement forwards and the patient can bring the lower incisors edge-to-edge with the upper incisor or incisors, treatment of the case may be simplified as part of the correction will be produced by the mandible's closing to occlusion without shifting forwards from the abnormal or premature contact of the incisor teeth (*Fig.* 3.7).

Dental base discrepancy and inadequate overbite relationship produce the greatest problems in the stability of corrected incisor relationship.

The following case histories illustrate some of the problems encountered in correcting upper incisors which bite lingually the lower incisors.

Fig. 3.8 shows a developing normal dentition apart from the lingual occlusion of a single incisor. Arch form was excellent; space conditions were adequate; overbite and overjet normal. Treatment was to procline the affected tooth with an appliance using a single finger spring of 0.5 mm, guarded to hold the spring down against the tooth. The presence of a space betweeen the central incisors made possible the placing of the guard in a vertical position and projecting adequately to cover the full range of action of the spring. Even though there was little overbite, bite planes were placed over the posterior teeth while the incisor tooth was being moved.

Figs. 3.9 and 3.10 show 2 cases of single central incisor teeth caught behind the bite in patients of 10 and 13 years of age. The dentitions were otherwise normal and there were no problems of space, overbite relationship or dental base discrepancy.

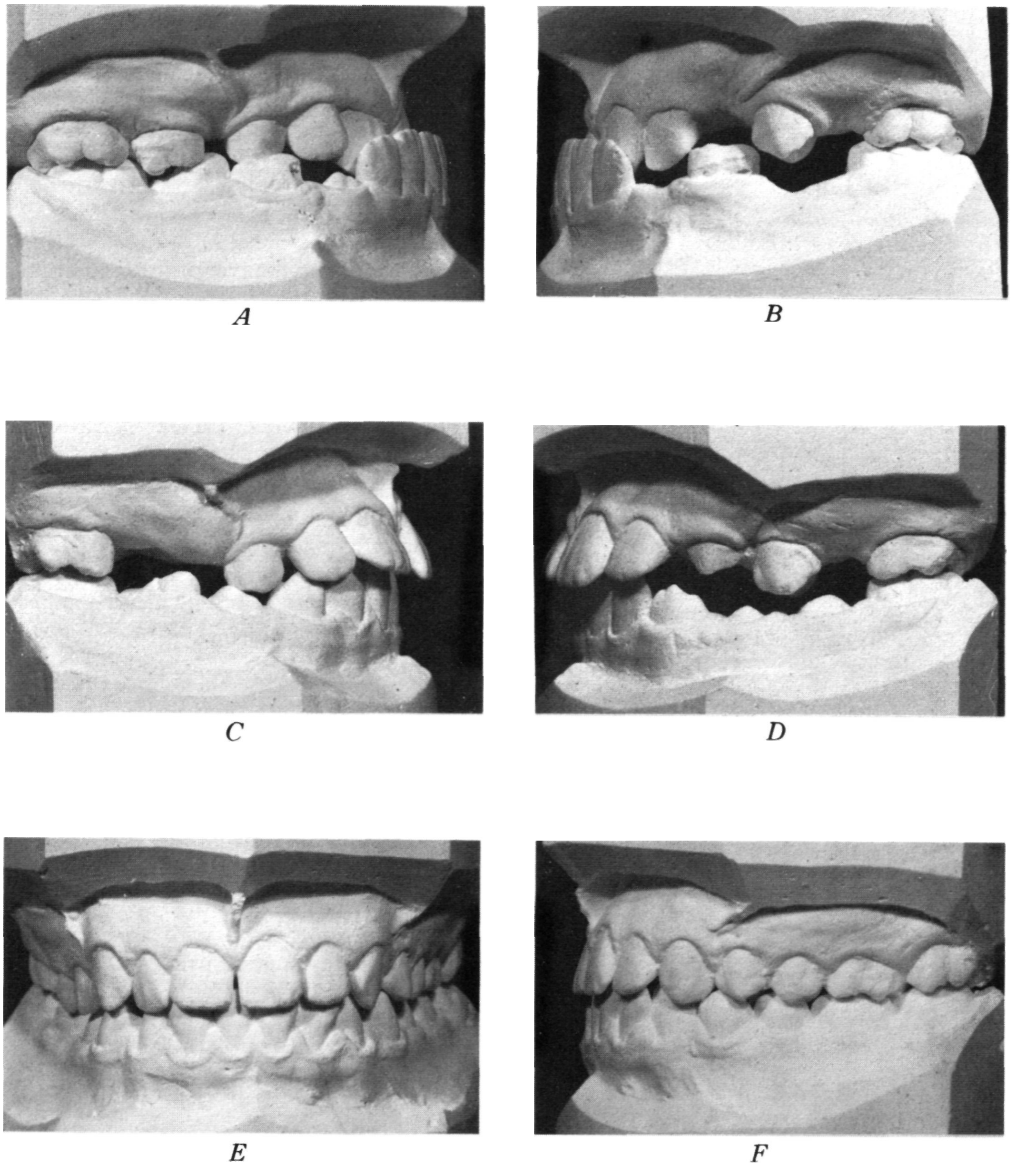
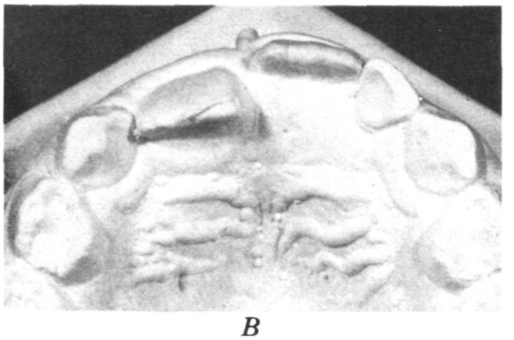
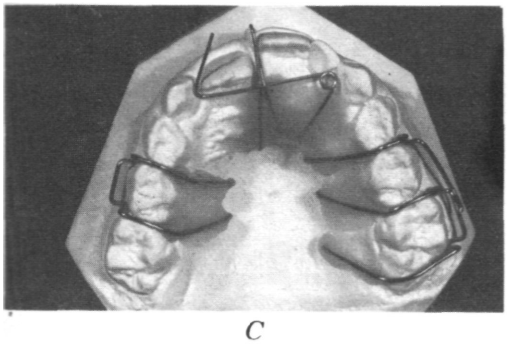


Fig. 3.7. This patient has, apparently, a fairly severe dental base discrepancy but note that at *(A, B)* the molar relationship is normal. After correction of the incisor relationship by proclination of the upper incisors (C, *D),* note the change in the molar relation indicating that there has been a postural element in the incisor discrepancy. At *(E, F)* the occlusion has developed normally and there has been improvement in the upper incisor inclination.

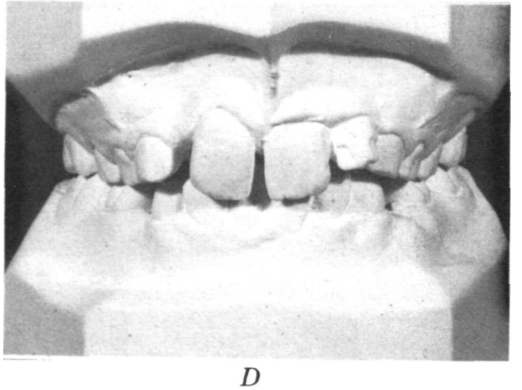
A



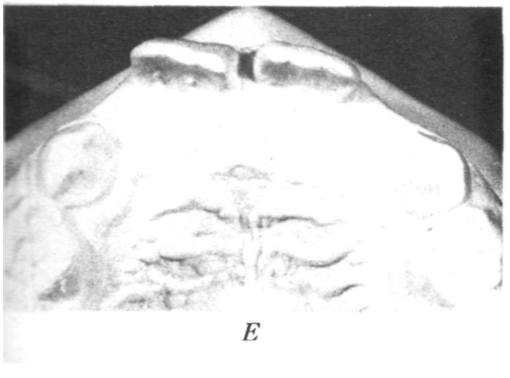
B



C



D



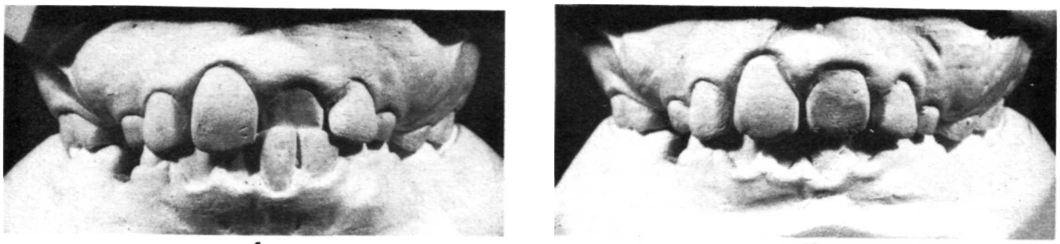
E

Fig. 3.8. A child aged 7 years with a single incisor biting lingually to the lowers. *A,B,* This tooth was proclined using a finger spring. Note the guard which projects between the central incisors giving very good control of the action of the spring. *C,* The end of the finger spring was turned into a loop at the time of fitting the appliance. Note the accessory clasp which gives excellent antero-posterior stability of the appliance. Posterior bite planes were, of course, used in this appliance. *D,E,* Note the improvement in overbite relation after correction of 1|.

Single cantilever springs were used in each case (*Fig.* 3.11), the bite being propped temporarily on bite planes covering the back teeth. There was no problem of stability of the treated result.

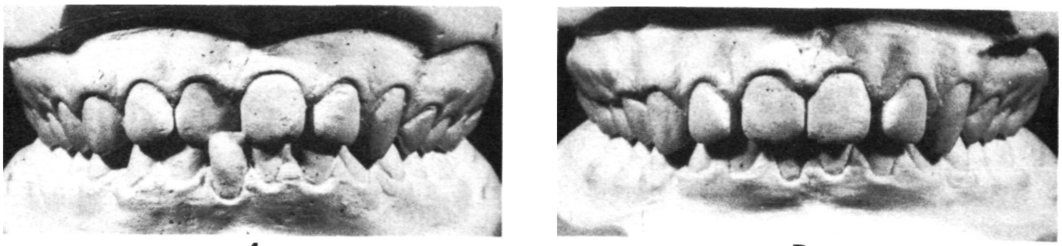
It is interesting to observe the faceting on the lingually placed upper incisors. The wear can be seen on careful examination of the photographs.

In *Fig.* 3.12 are seen the casts of a young patient with crowding of the incisors, the lateral incisors being caught behind the bite of the lower incisors. In this case, the deciduous canine tooth on the patient's right



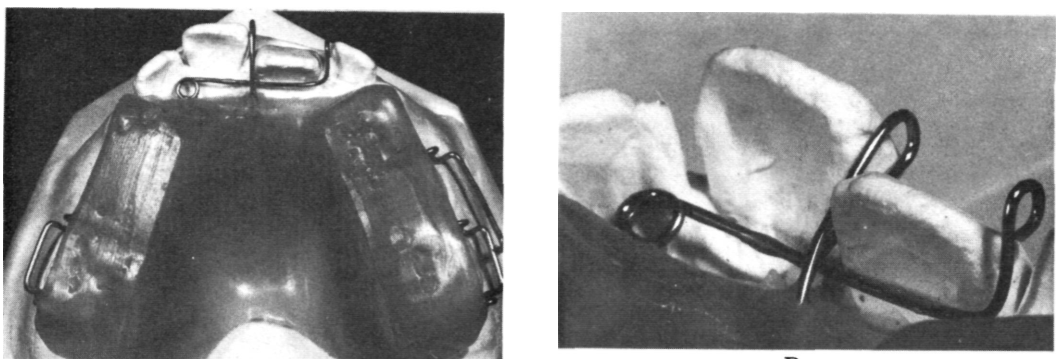
A B

Fig. 3.9. *A,* An excellent occlusion with one incisor caught behind the bite in a patient aged 9 years. *B,* The incisor was corrected by means of a finger spring on an appliance clasped as shown with posterior bite planes. The presence of a space between the incisors permitted the use of a guard which came forwards between the teeth giving excellent control of the spring's action.

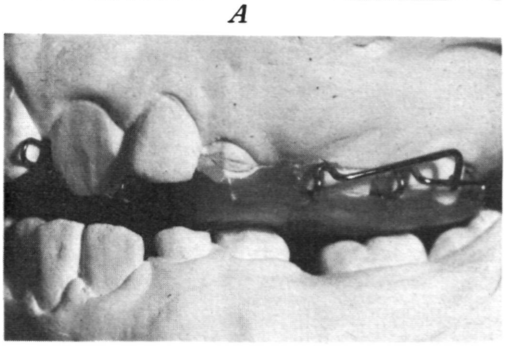


A B

Fig. 3.10. A, Another somewhat older patient having 1| caught lingually to 1|. B, The bite was propped on the posterior teeth and the offending incisor proclined sufficiently to correct the malocclusion.

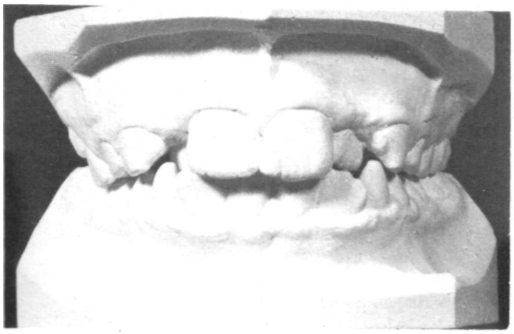


A B

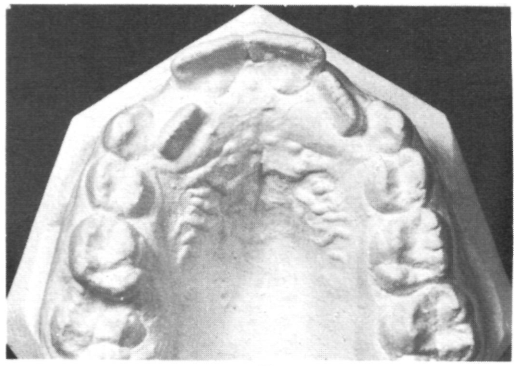


C

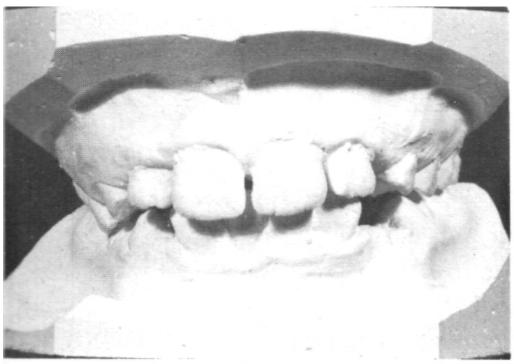
Fig. 3.11. The appliance which was used in treating the patient in *Fig.* 3.10. A, The layout of the spring, clasps and biting planes. Note that the guard passes forwards between the central incisors thereby controlling the action of the spring. *B,* Close-up of the spring. Note the looped end of the spring and how it does not interfere with the adjoining tooth. C, The bite planes are curved to fit the line of the upper occlusal plane. Note the accessory arrowhead for antero-posterior stability.



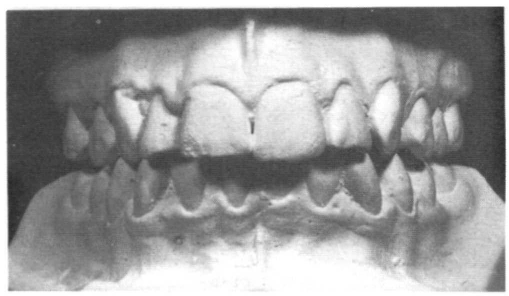
A



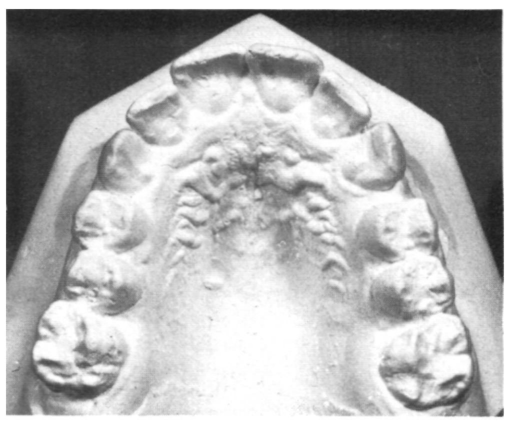
B



C



D



E

Fig. 3.12. *A,B,* A young patient aged 8 years in whom 2|2 were biting lingually to the lower incisors. This patient had an underlying crowding problem and there was not room to procline the upper lateral incisors. C, Treatment necessitated removal of C|C followed by proclination of the lateral incisors. The crowding problem was treated by removal of first permanent molars which had very large fillings. *D, E,* Result at 14 years of age.

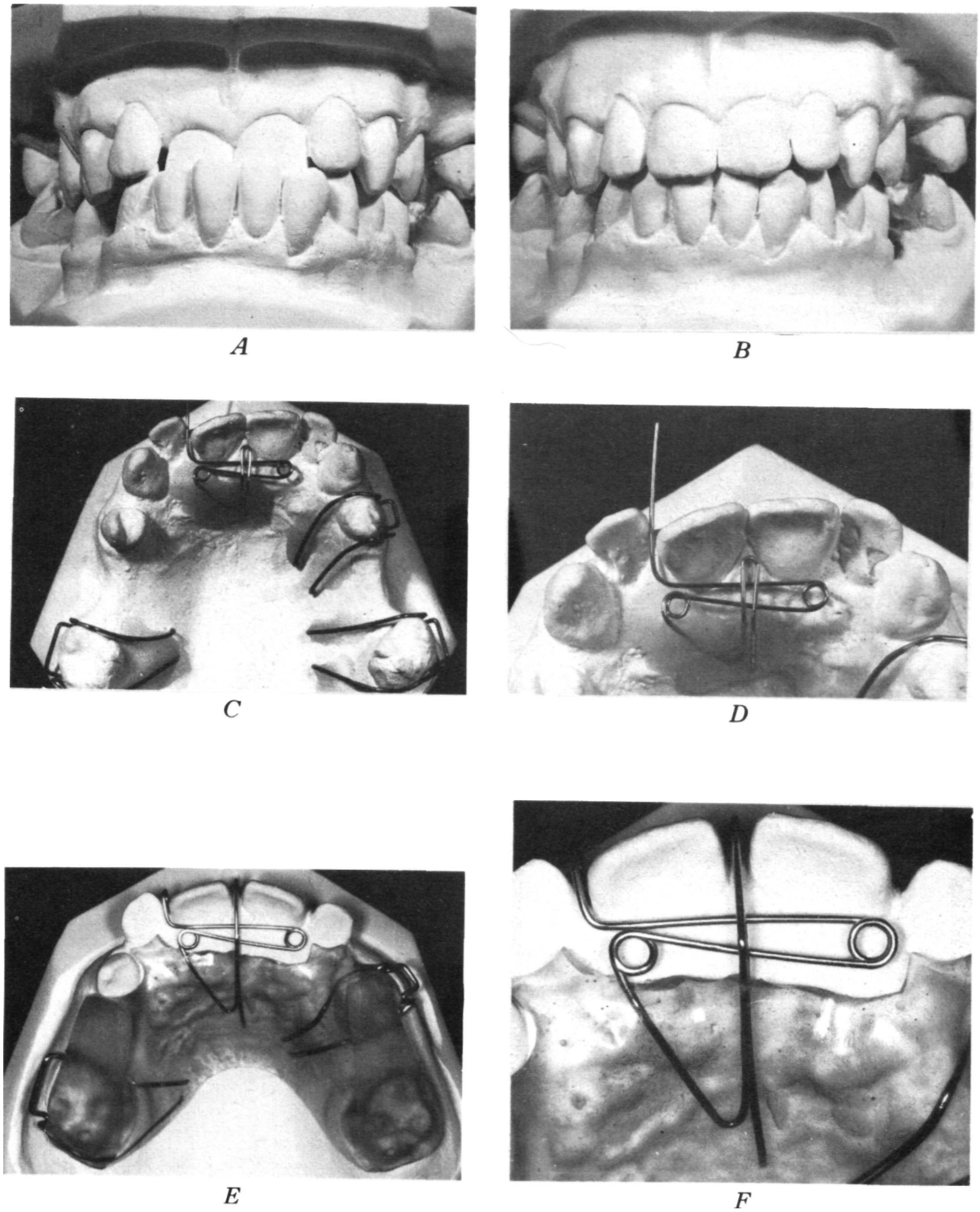


Fig. 3.13. *A,* This is an older patient aged about 45 who, surprisingly, did not have 1|1 corrected in childhood. Before the construction of prostheses, 1|1 were corrected with a double cantilever spring (C,D). The end of the spring was turned into a loop at the time of fitting the appliance. Posterior bite planes were used. *B,* Shows the completed orthodontic result. Where the incisors are spaced, the guard controlling the spring can be brought between the teeth so obtaining better control of the spring *{E,F).*

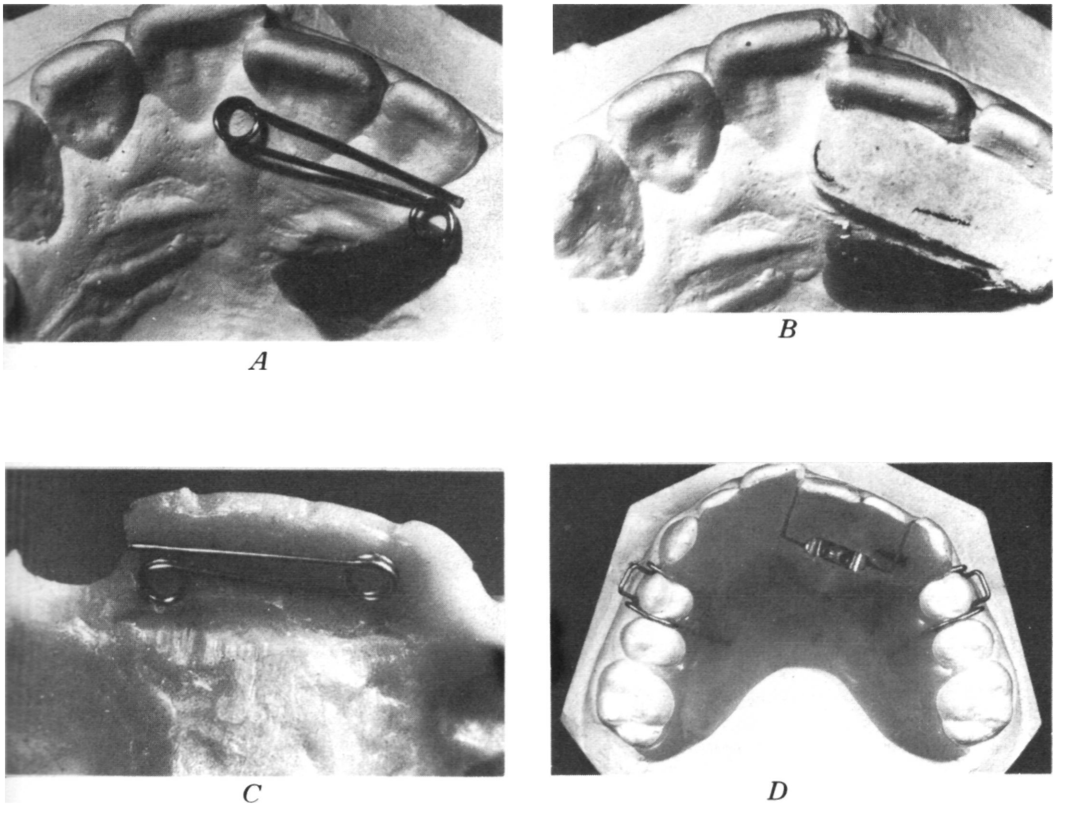


Fig. 3.14. Some alternative ways of proclining upper incisors. *A,* A double cantilever spring which is boxed in. *B,* The spring is encased in plaster and a flat surface formed on top of it. The baseplate is then brought over the spring as shown in (C). *D,* A screw is sometimes convenient as it can be activated by the patient.

side was removed before correcting the lateral incisors because of the lack of space.

The older patient should not despair of treatment of misplaced incisor teeth. The patient illustrated in *Fig.* 3.13 was 45 years of age and was referred for advice prior to the construction of prostheses to replace posterior teeth. The misplaced upper central incisors were moved without difficulty into stable positions by means of a double cantilever spring in conjunction with bite planes on the teeth in the buccal segments. Similar appliances for performing such a movement are shown in *Fig.* 3.14.

In the case shown in *Fig.* 3.15 it was necessary to procline four upper incisors into correct relationship with the lower incisors. Here again, the space conditions were adequate and overjet and overbite were normal. As the teeth were not spaced, it was not possible to carry the guide for the spring forwards beyond the teeth. If the spring shows a tendency to slip down and under the incisors, the spring may be activated a little upwards as well as forwards, as this counteracts any tendency for the spring to slip out of contact with the teeth. *Fig.* 3.16 shows a similar case.

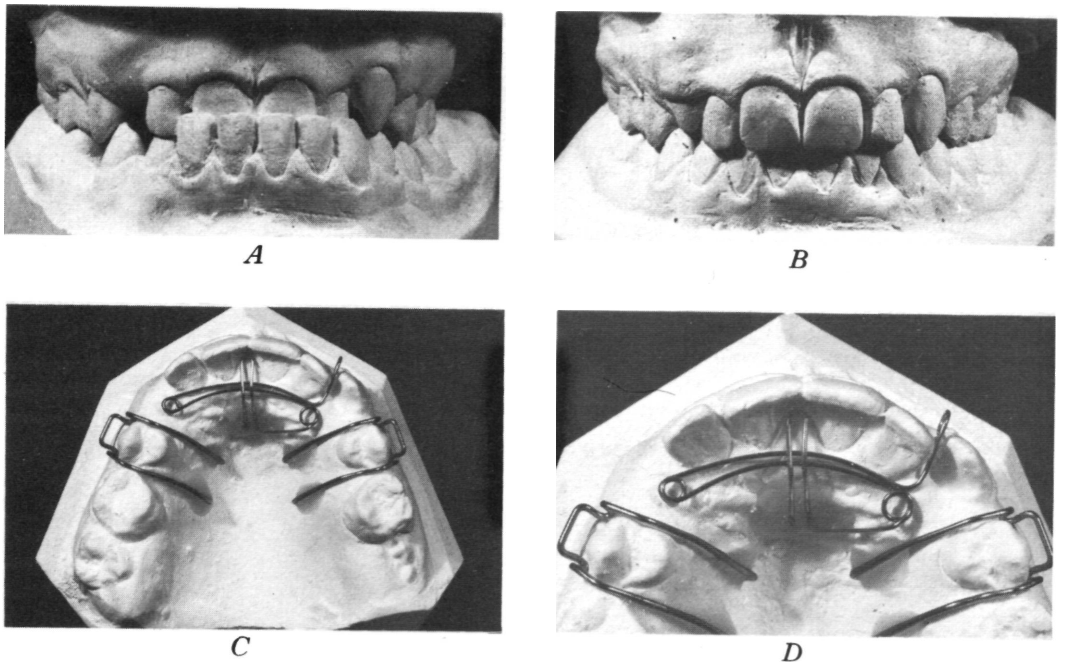
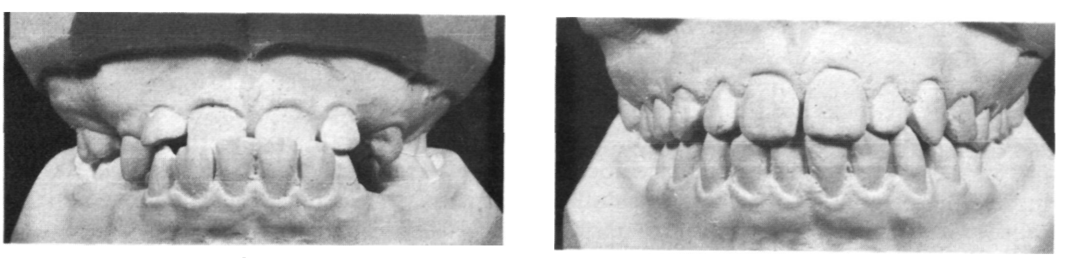


Fig. 3.15. A patient aged 12 in whom $\underline{21|12}$ occluded lingually to the lower incisors. The bite was propped on posterior bite planes and a double cantilever spring (*C,D)* was used to procline all four teeth simultaneously. *A,* Before treatment. *B,* After treatment.



A ***B***

Fig. 3.16. *A,* A similar case to the previous one involving three incisors. *B,* In this case, the right upper canine had to be removed but the right upper first premolar resembles the canine sufficiently.

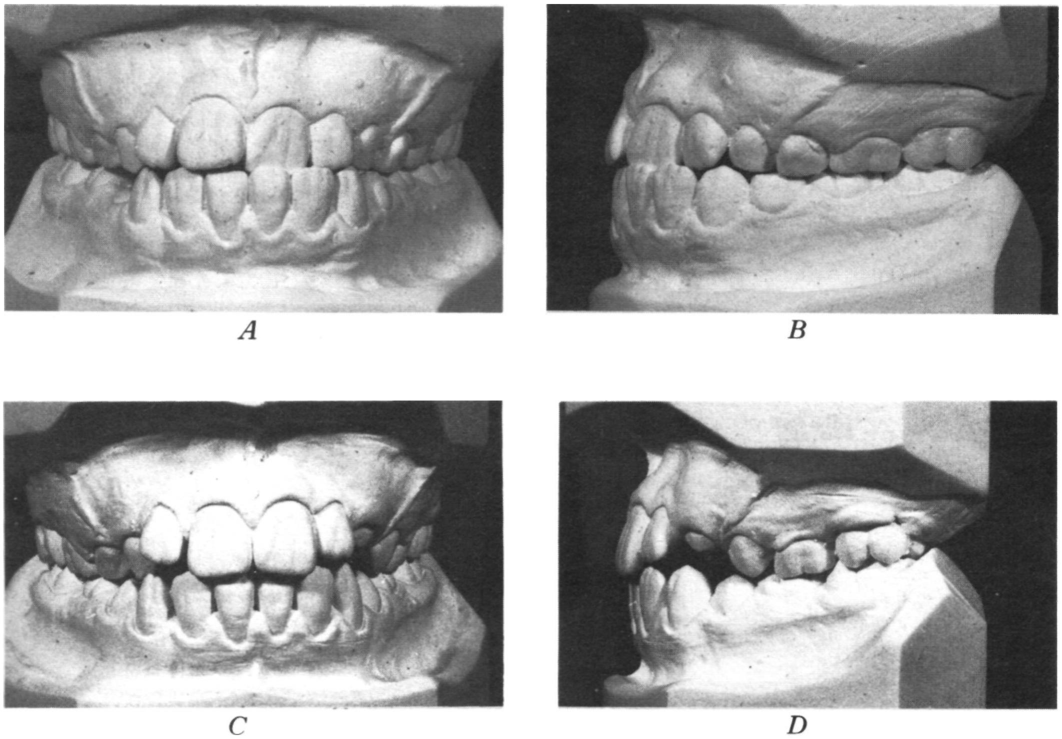


Fig. 3.17. *A,B,* A-patient aged 8 years in whom 21| occluded normally with an absolute minimum of overbite and |12 bite lingually to the lower incisors. *C, D,* |12 were proclined slightly and match 21| exactly. It is possible that the overbite has improved very slightly but the ultimate stability of the anterior labial segment will remain to be seen.

Fig. 3.17 shows a young patient with normal buccal occlusion but minimal overbite. When |12 were proclined, they matched 21| which were already in normal occlusion, although having little or no overbite relation with the lower incisors.

The patient shown in *Fig.* 3.18 was older, being 26 years of age, and when ill were proclined into correct occlusion, the overbite was reduced but adequate to maintain correct incisor relationship.

The last 2 cases in this category show how surprising results are achieved in apparently unpromising cases.

Fig. 3.19 shows the dentition of a child of 8 years of age just as the upper incisors are beginning to erupt. First, the centrals were proclined into correct relationship to the lower incisors and the lateral incisors had also to be corrected shortly after eruption. The dentition then proceeded to develop normally.

Fig. 3.20 shows a girl of 7 years of age in whom a very unpromising incisor relationship improved spontaneously, and as the lower incisors were slightly spaced, correction of the incisor relationship was effected by slightly proclining the upper incisors

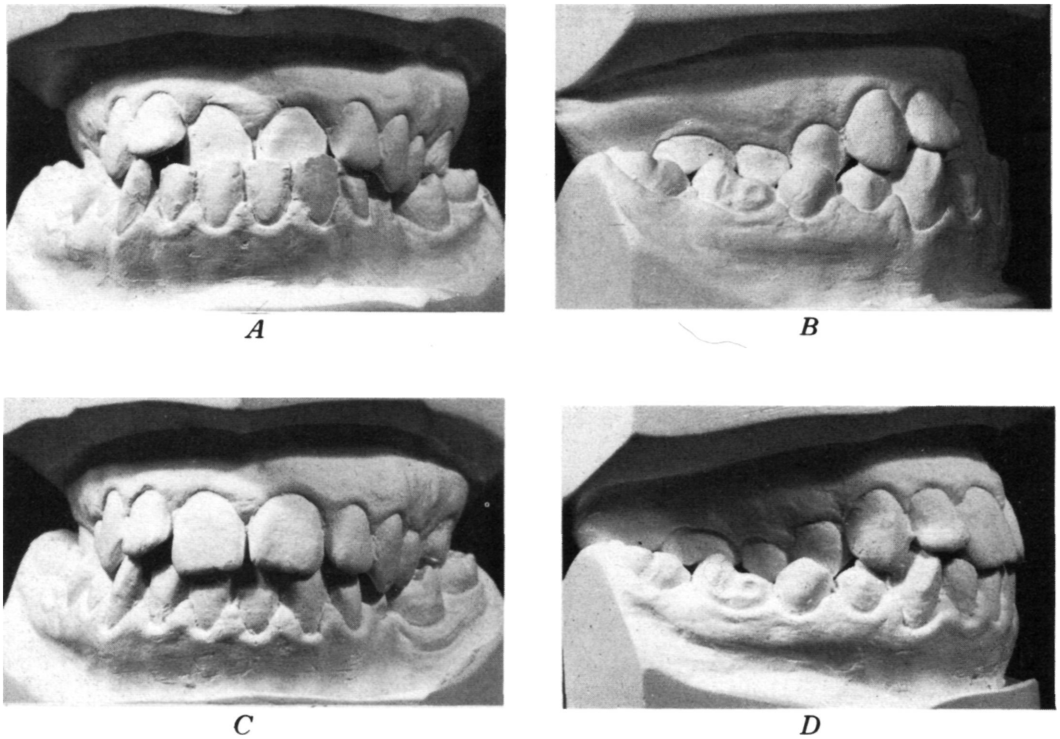
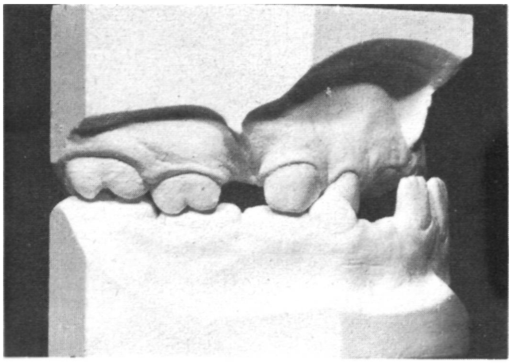


Fig. 3.18. *A, B,* An older patient in whom 1|1 bite lingually to the lower incisors and when corrected the overbite on the teeth which had been moved was markedly reduced. C, *D,* It does seem, however, that overbite will be sufficient to maintain stability of the corrected incisor relationship.

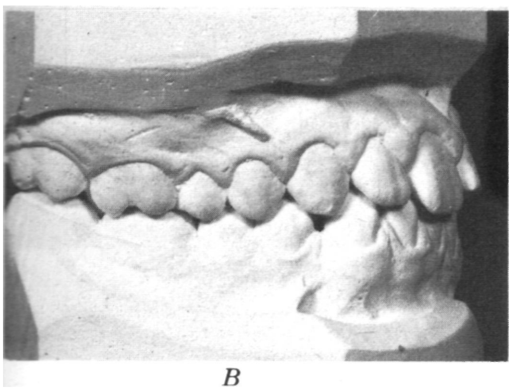
and retroclining the lower incisors. The dentition thereafter developed normally.

Labial Movement of Lower Incisors

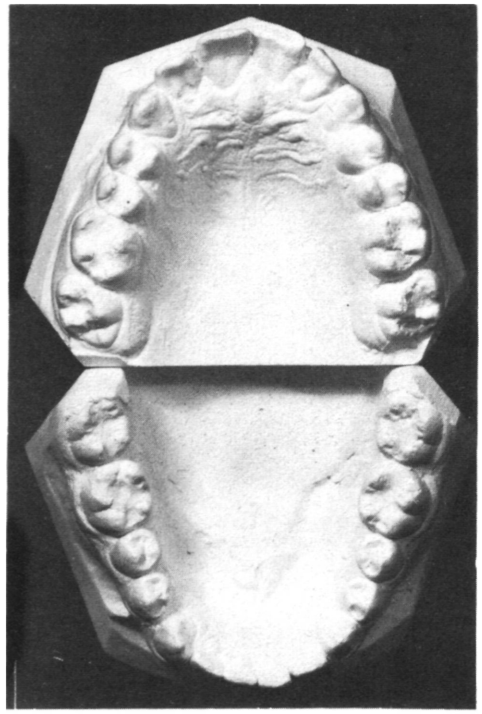
Proclination of lower incisors is a movement which today is undertaken very much less than formerly. Indeed, such are often felt to be the later disadvantages of proclining lower incisors that it may be felt that this movement is totally undesirable. There may, however, occasionally be circumstances in which this movement is required and it is possible to produce it using a removable appliance. The recommended removable appliance resembles the fixed lower lingual arch with apron springs which was formerly used to produce this tooth movement. The removable appliance consists of a lingual arch with apron springs attached by welding a tape loop or held by an attachment embedded in the baseplate (*Fig.* 3.21).



A



B



C

Fig. 3.19. *A,* A boy aged 8 years in whom 1|1 are just beginning to erupt. *A,* The incisor relation seems most unpromising but 1|1 and subsequently 2|2 were proclined leading to the development of a normal occlusion at 12 years of age. |1 was fractured in a bicycle accident. *B, C,* Lateral and occlusal view at 14 years of age.

Labial Movement of Upper Canine Teeth

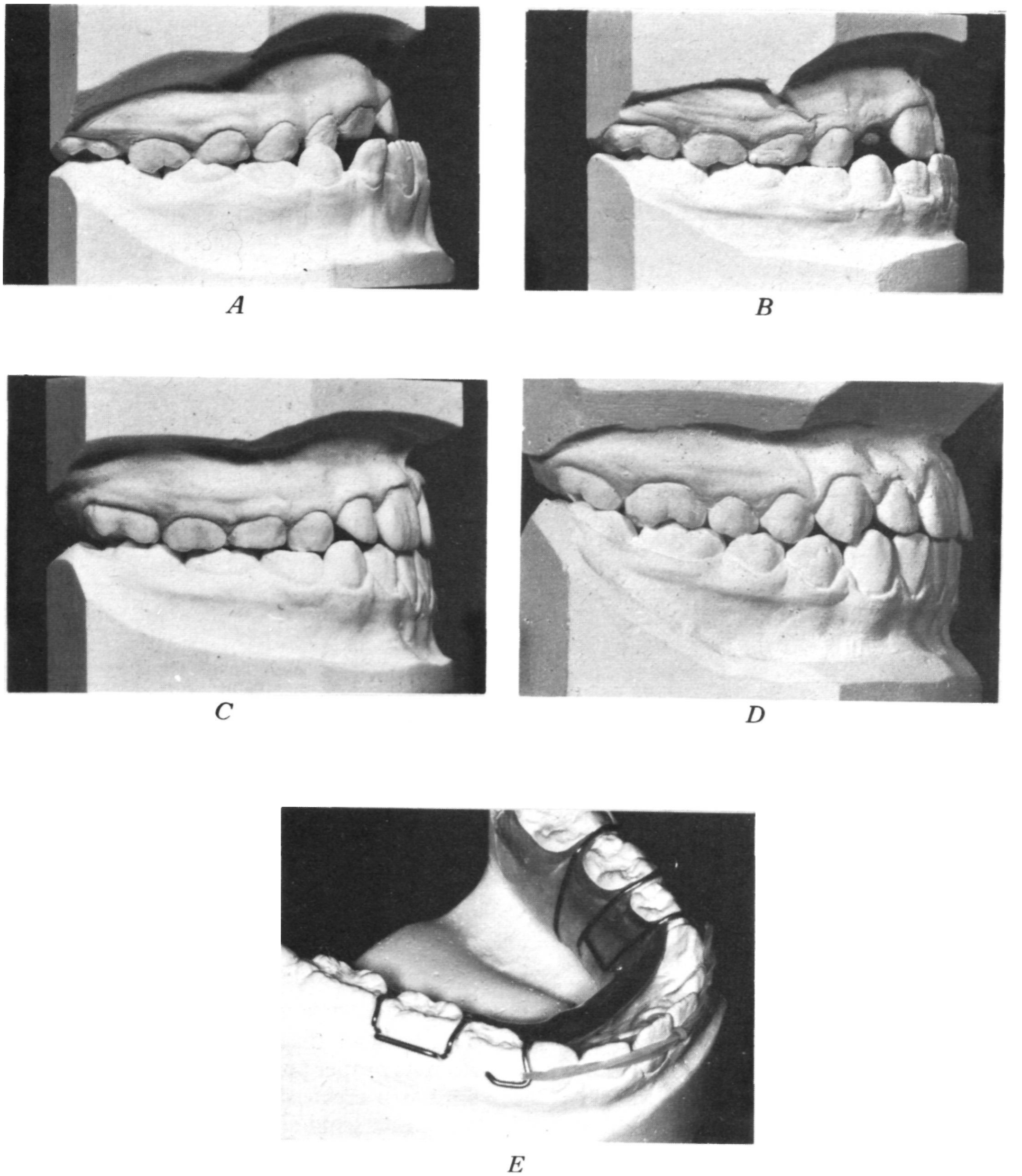
The treatment of the palatally inclined upper canine tooth can be satisfactory if the position of the apex of the tooth is normal and the tooth only requires to be inclined in a labial direction. Misplacement of the permanent upper canine tooth is a complex subject and it is only possible here to outline the nature of the problems connected with management of such cases. Accurate assessment of the ectopic upper canine is important as a number of factors can create difficulties in treatment.

1. *Misplacement of the apex*

The apex of the canine may be displaced from its proper position as well as the crown. This will create difficulties in bringing the tooth into good alignment.

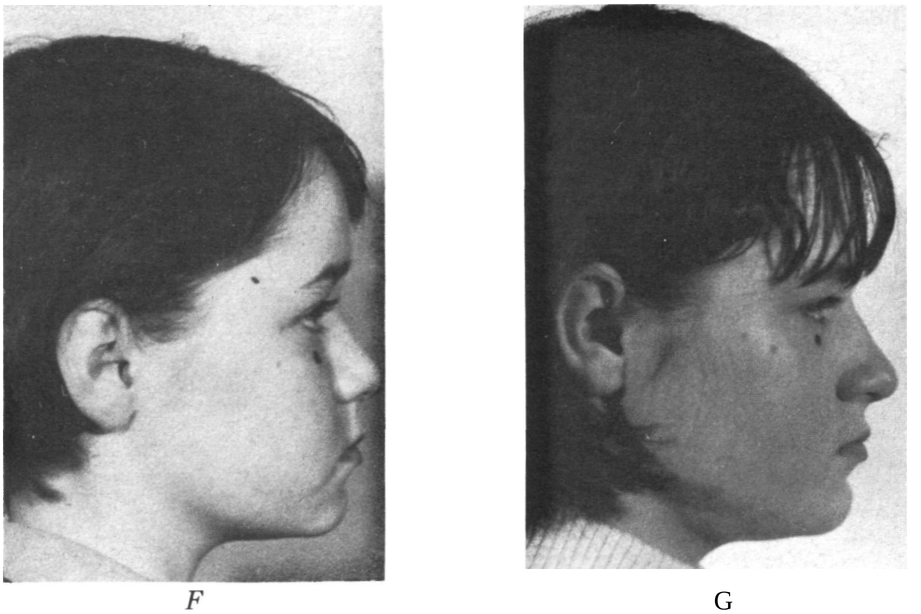
2. *Space conditions in the dental arch*

There may be delay in eruption of the permanent canine and in bringing it into alignment. In the meantime, the deciduous canine is smaller than the permanent canine and cannot maintain the amount of space needed for a permanent tooth.



A B C D E

Fig. 3.20. *A,* A girl aged 7 years in whom the occlusal relation tended markedly to prenormality. *B,* After a period of observation, the incisor relation had improved considerably, and at this stage the upper incisors were proclined a little and the lower incisors retroclined, using an elastic stretched between hooks, and the incisor relation became corrected (C).D, The occlusion developed to normal with a slight prenormal tendency. *E,* The lower appliance.



F G

Fig. 3.20 (cont.) *F,G,* Show the appearance in profile at 8 and 18 years of age.

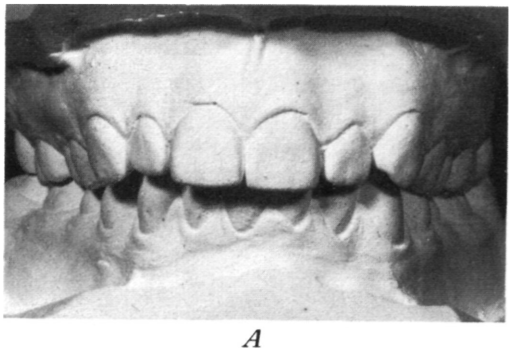
3. *Rotation of the permanent canine*

Displaced canines may be rotated more or less severely, adding an extra dimension to the treatment procedure.

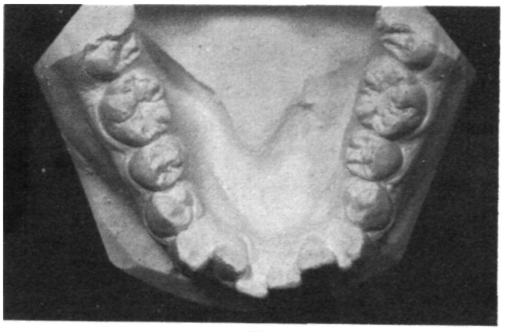
4. *Failure of eruption*

A buried canine which does not erupt at the proper time may fail in the end to erupt fully to the occlusal level of the other teeth. The longer treatment is delayed, the greater the possibility that the canine will lose its capacity for eruption.

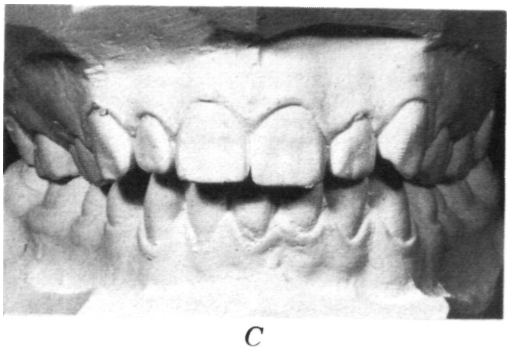
The lingually placed canine, after exposure, may be moved in a labial direction using a clasped removable appliance. It is necessary to envisage the path which the canine crown is to move along and to arrange the point of fixation of the spring and the point of application of pressure with great care. If the canine crown is much displaced, it may not be necessary to prop the bite until the tooth has actually been moved and comes into contact with the lower teeth. When this point arrives, the bite should be propped to allow the canine tooth to move easily across the bite of the lower teeth. As already mentioned, such teeth are frequently rotated and the rotation of the tooth into correct alignment (a procedure sometimes referred to as 'derotation') can be



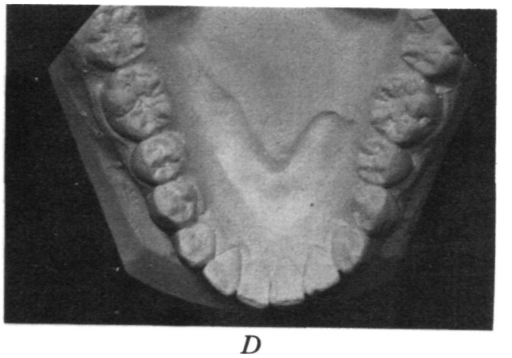
A



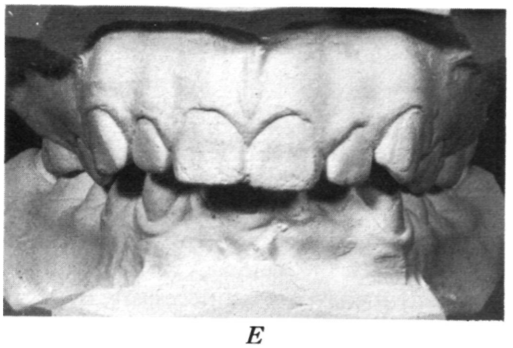
B



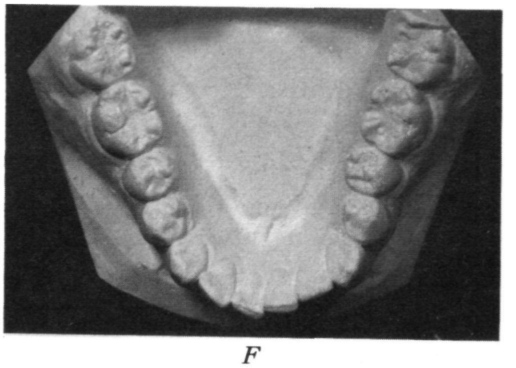
C



D

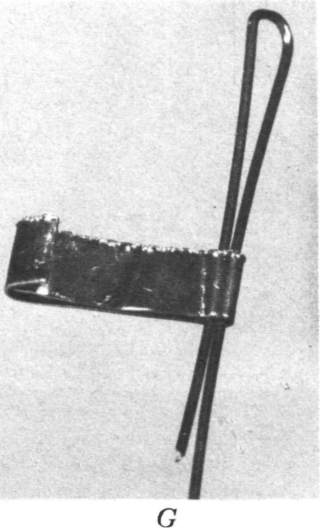


E

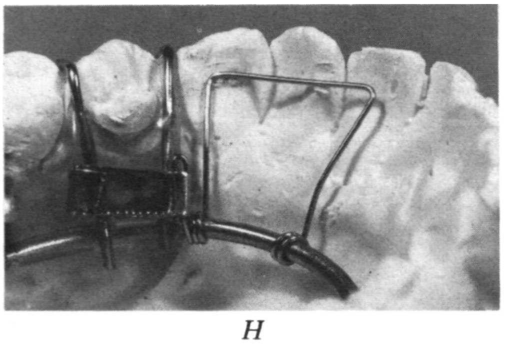


F

Fig. 3.21. *A,B,* This patient aged 12 years had an excellent upper arch and crowding in the lower labial segment. *C, D,* The bite was opened using a Sved bite plane and the lower incisors aligned using apron springs on a lower removable lingual arch. *E, F,* The new incisor relationship settled well and lower third molars were removed. Upper third molars were congenitally absent.



G

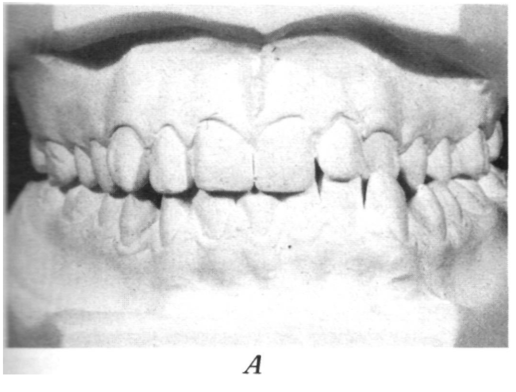


H

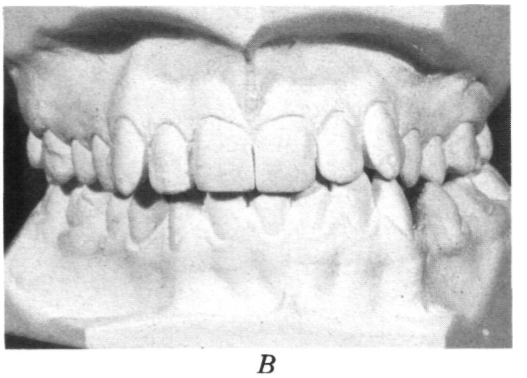
Fig. 3.21 (cont.) G, *H,* The lower appliance. The spring wire was held with a tape loop embedded in the baseplate.

done by means of a fixed/removable appliance combination using an attachment bonded to the canine tooth.

One of the important aspects of the treatability of such cases is the vertical position of the tooth in relation to the adjoining teeth. The position of the crown of the tooth may be short of the occlusal plane owing to the tooth having formed completely before being moved into position and therefore not, in the end, erupting fully. Orthodontic elongation of such a tooth is a procedure to be undertaken with circumspection *(Figs.* 3.22, 3.23, 3.24).



A



B

Fig. 3.22. Correction of |3/|3 by lingual movement of |3 and labial movement of |3. The patient has a lower midline shift to the left and overbite of |3/|3 is minimal, but the condition proved stable and considerably enhanced the patient's appearance. *A,* Before treatment; *B,* After.

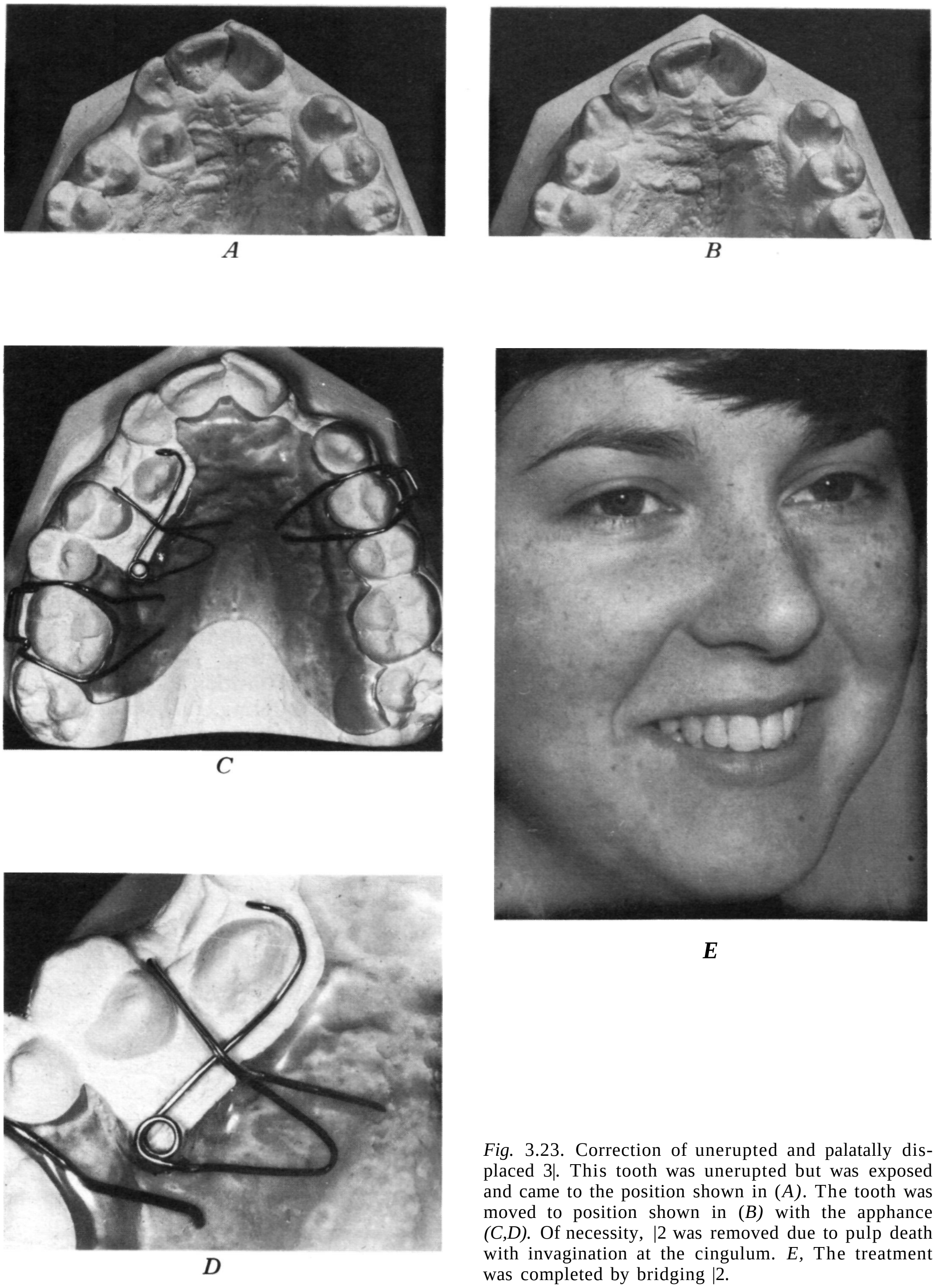


Fig. 3.23. Correction of unerupted and palatally displaced 3|. This tooth was unerupted but was exposed and came to the position shown in (*A*). The tooth was moved to position shown in (*B)* with the apphance *(C,D).* Of necessity, |2 was removed due to pulp death with invagination at the cingulum. *E,* The treatment was completed by bridging |2.

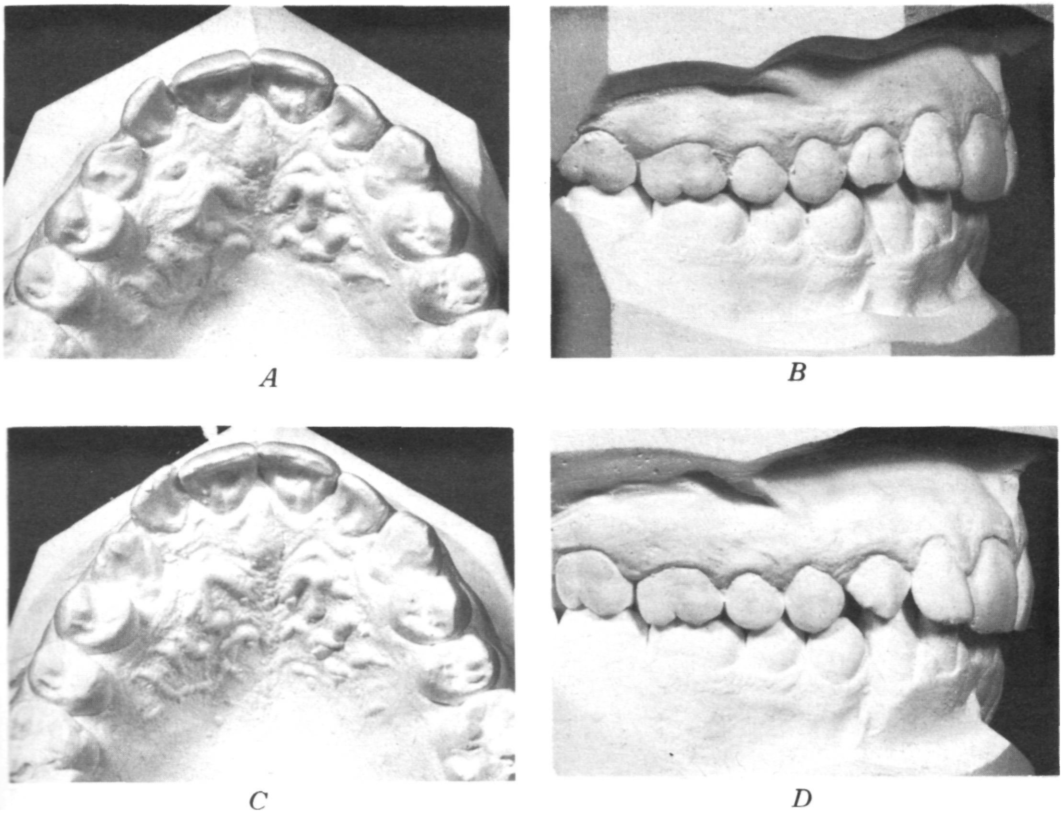


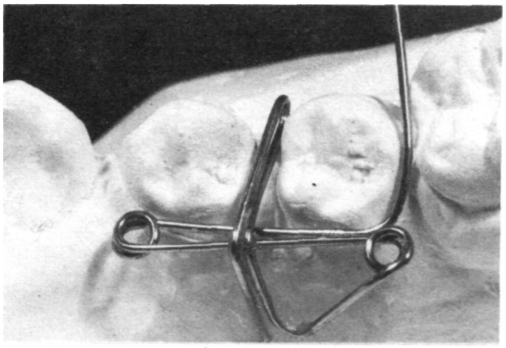
Fig. 3.24. *A, B,* Correction of 3| which had recently erupted in a 25-year-old patient. *C, D,* 3| was moved into line following extraction of C|, replacing the deciduous with a permanent tooth.

Labial Movement of Lower Canines

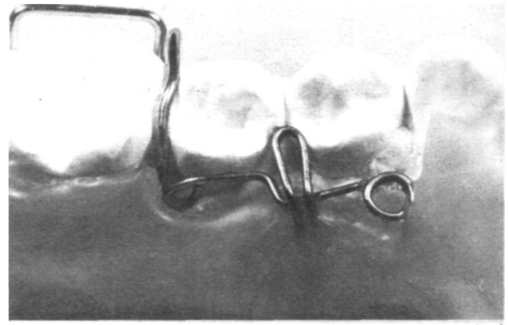
This movement is not often needed as a single tooth movement but if necessary can be done with an apron spring attached to a lingual arch or by means of a finger spring.

Buccal Movements of Upper and Lower Premolars and Molars

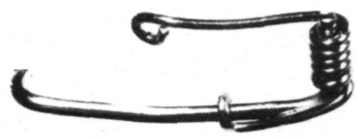
These movements can be done quite effectively using clasped removable appliances by means of finger springs and double cantilever springs. Because of the close proximity of the tongue to the buccal teeth, springs in this region must be very neatly made with small coils so that the tongue does not bulge into the area of the spring and become caught. Such springs are sometimes boxed in by the baseplate to avoid this possible source of trouble, but in turn this creates difficulties which outweigh any possible advantages; that is to say the cavities beneath the plate act as food traps and the covering up of the spring renders its manipulation and adjustment unduly difficult. The more open the spring can be, the more



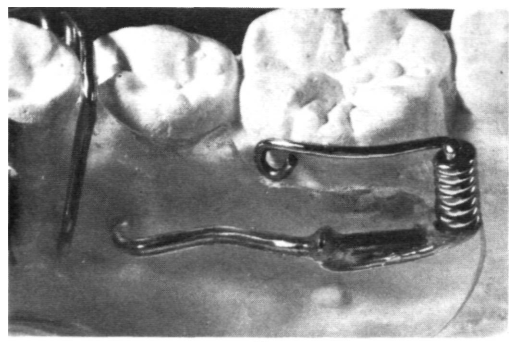
A



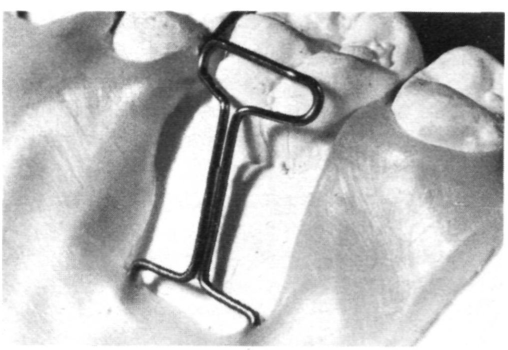
B



C



D



E

Fig. 3.25. Buccal movement of premolars and molars. *A,* Double cantilever spring to move |45 labially. Note that there is space between the teeth to carry the guard well outwards to control the spring. When fitting the appliance, the end of the spring is turned into a loop. *B,* A single cantilever spring to move |5 buccally. Note that the spring is cranked as it was not possible to carry the guard between the teeth and cranking the spring keeps it better under the guard. *C,D,* A supported spring to move a lower molar buccally. The spring is of 0.6 mm wire wound on a support 10 mm thick. The spring is soldered or welded to the support and then wound. Note the rounded end of the spring. *E,* A torque spring to move an upper molar buccally. The transverse sections act as torque springs giving the spring considerable flexibility. This spring is boxed in order to make the baseplate adequately strong but is shown here before plastering and boxing.

easy it is to keep clean and to adjust *(Fig. 3.25, A, B).*

In the lower arch, a cantilever spring of 0.6 mm wire wound on a support is very effective for buccal movement of single teeth *(Fig. 3.25, CD).*

There is one useful spring which it is necessary to cover up in the way described with the disadvantages being accepted. This is a spring known as a 'T' spring or 'club' spring which is efficient in buccal movement of upper molars and premolars *(Fig.* 3.25 *E).* This spring is covered by the baseplate but its adjustment is done by lifting the spring away from the baseplate. Cleanliness must be carefully attended to.

The buccolingual movement of molars and premolars must be undertaken with due regard to their ultimate stability, and here the width dimensions of the upper and lower arches and the sharpness and interdigitations of the cusps of the teeth are factors which influence the treatability of the condition *(Figs.* 3.26-28).

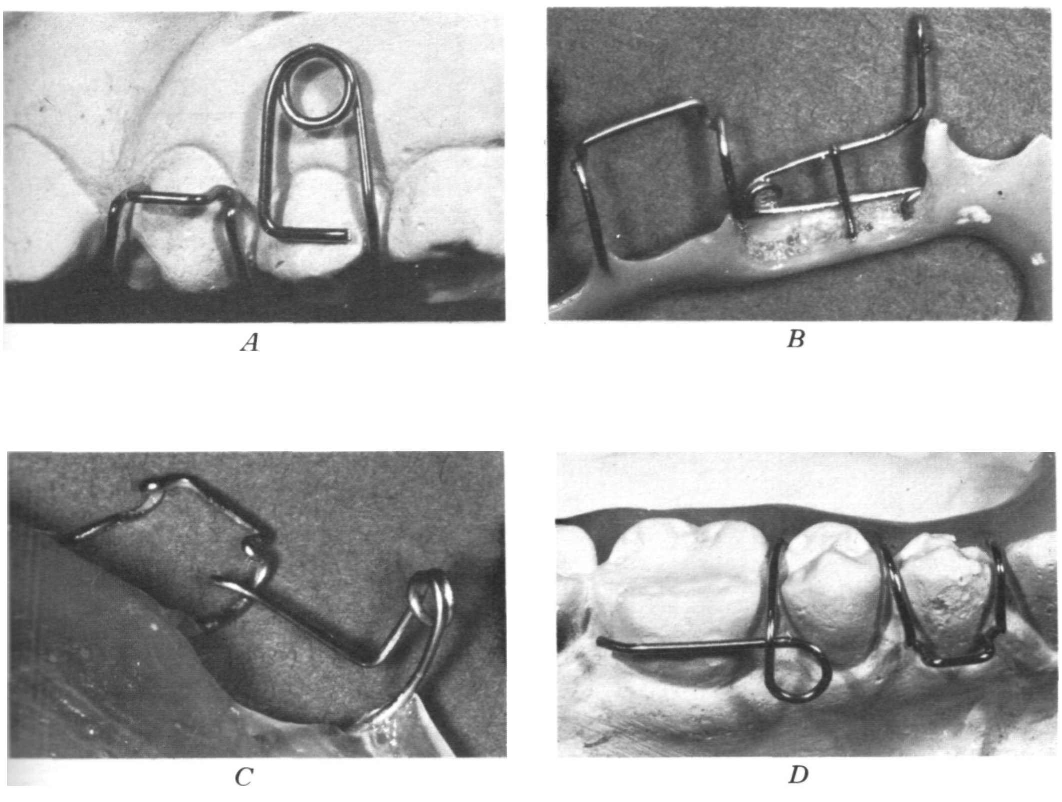


Fig. 3.26. Buccolingual movement of premolars and molars. *A,* Self-supporting spring for lingual movement of premolar. *B,* Double cantilever spring for buccal movement of two premolars. *C,* Self-supporting spring for lingual movement of two premolars. *D,* Self-supporting spring for lingual movement of molar.

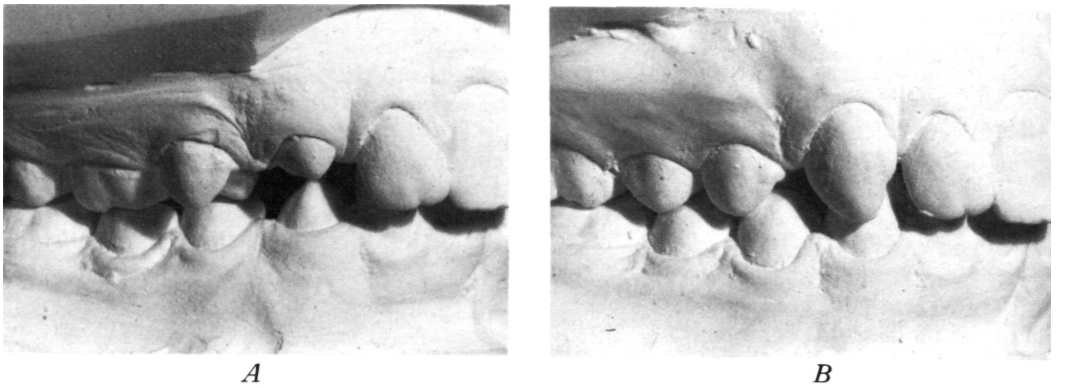


Fig. 3.27. Buccolingual correction of first premolars. *A,* Before correction; *B,* After.

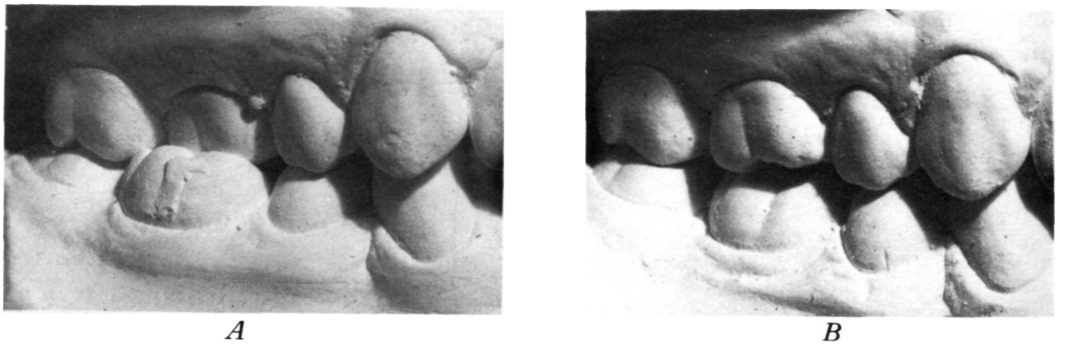


Fig. 3.28. Buccolingual correction of first molars. *A,* Before correction; *B,* After.

Buccolingual adjustment of one or two teeth will involve consideration of the alignment of the buccal segments as a whole, from which it may appear that one or two teeth are, in fact, displaced buccally or lingually and are, therefore, amenable to permanent correction in the alignment of the arch. The question of the buccolingual movement of entire dental arches is properly considered under the heading of arch expansion which will be dealt with in due course (*see* Chapter 6).

It frequently happens that when a tooth in the buccal segments needs to be corrected buccolingually, an opposing tooth also needs to be moved as part of the correction. (*See below* Lingual movement of molars and premolars.)

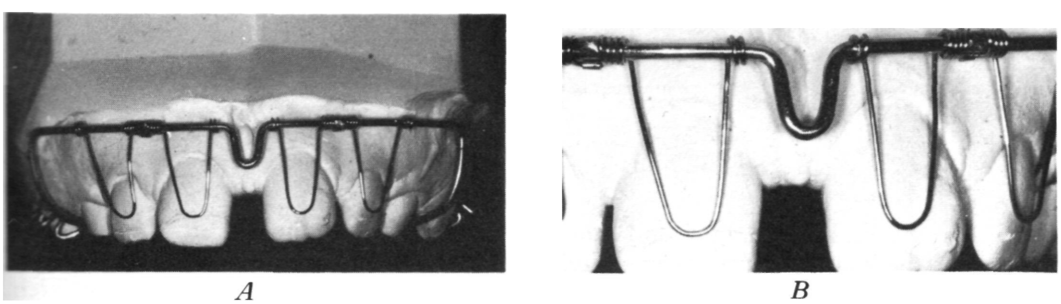
LINGUAL MOVEMENT OF TEETH

Upper Incisors

Retroclination of upper incisors is frequently called for and can be carried out in a number of ways. It is important to consider the relationship of these teeth to the lower incisors and also to the adjoining tissues of the lips and tongue as well as considering the dental base relationship.

In a straightforward case, the dental base relationship and soft tissue morphology are normal and retroclination of the upper incisors will produce a normal relationship of the crowns of the upper and lower incisors. The soft tissues of the lips and tongue will then adapt themselves in such a way as to maintain the stability of the relationship of the incisor teeth at the end of treatment.

One of the traditional methods for applying pressure on the labial surfaces of the upper incisors is by means of apron springs wound on a high labial archwire made of heavy gauge wire which is attached to a baseplate. The archwire is an extension of the baseplate and contributes little to the flexibility of the system. The apron springs are of fine gauge wire (0.3 mm) having three or four coils which give a very flexible spring but, at the same time, a spring which resists interferences from the lips and from food during eating. The baseplate is clasped usually to the first molar teeth and can have, if necessary, auxiliary clasps on the second premolars (*Fig.* 3.29). Apron springs of this kind have the great advantage that they can be adjusted to produce different effects on the individual teeth but if required, such an apron spring can be made wide enough to act on two teeth. By placing a coil system at each end of an apron spring of this kind, the



A *B*

Fig. 3.29. *A*, Appliance for lingual movement of upper incisors with 10 mm archwire and apron springs. *B*, The springs are attached by taping to the archwire. (*See* Welding.) It is also possible to attach the springs by soldering.

spring can be made wide enough to act on three or four teeth.

The Roberts retraction appliance for the upper anterior teeth (Roberts, 1956; *Fig.* 3.30) is unobtrusive and effective.The appHance acts on the whole labial segment and effects on individual teeth are not easy to obtain.

use a self-supporting spring which is brought from a distal point, a little farther back on the arch, and is formed into a loop at the active end which lies against the tooth which is to be retroclined. Such a spring is unobtrusive and easy to wear and adjust and produces a very satisfactory movement of the tooth in a lingual direction *(Fig.* 3.31).

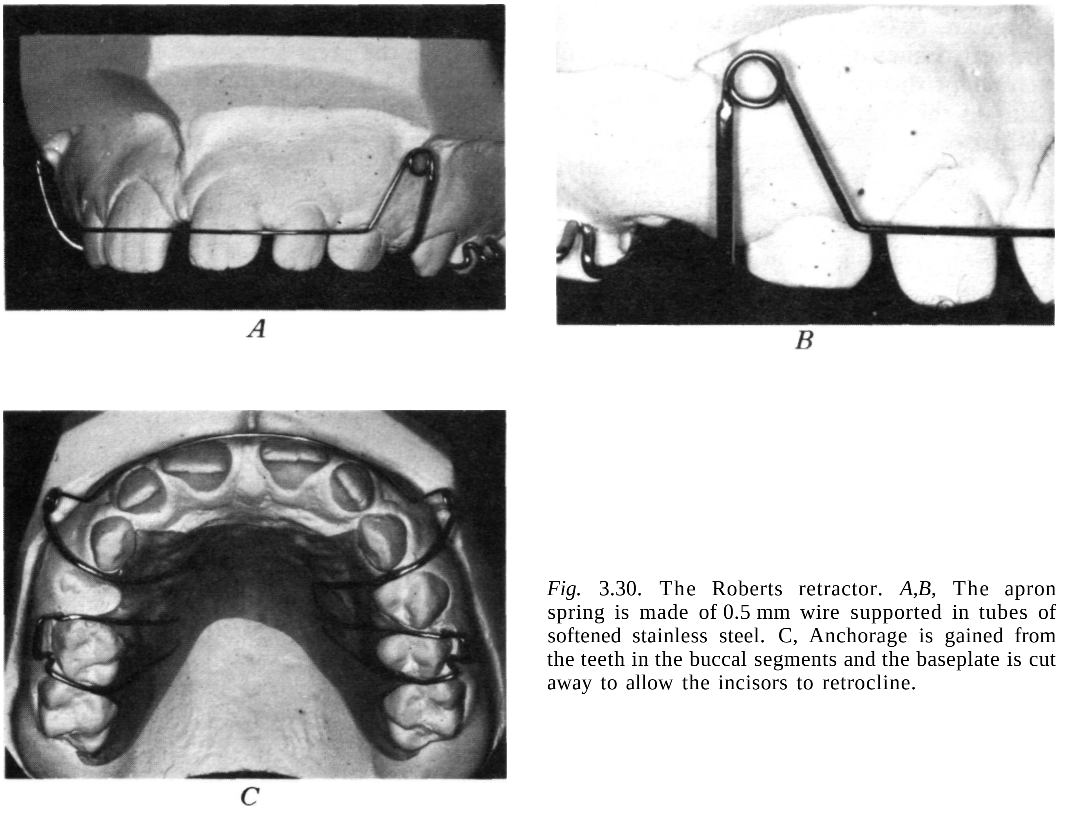


Fig. 3.30. The Roberts retractor. *A,B,* The apron spring is made of 0.5 mm wire supported in tubes of softened stainless steel. C, Anchorage is gained from the teeth in the buccal segments and the baseplate is cut away to allow the incisors to retrocline.

Neither the high labial bow and apron spring nor the Roberts retractor is entirely convenient for the retroclination of a single incisor or to apply pressure to a single incisor as, for instance, when producing rotation. A much simpler arrangement is to

In most cases, but not all, it is necessary first to retract canine teeth after creation of space by extraction farther back in the arch. (*See* Mesiodistal movement of teeth, p. 63.)

Figs. 3.32-3.36 illustrate various aspects of lingual movement of upper incisors.

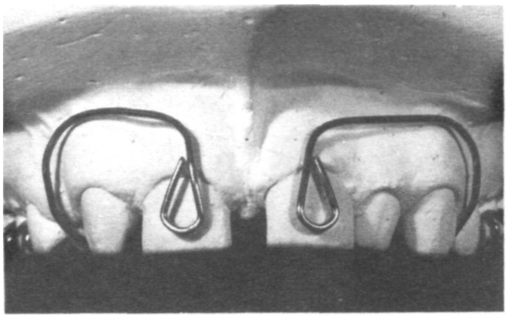
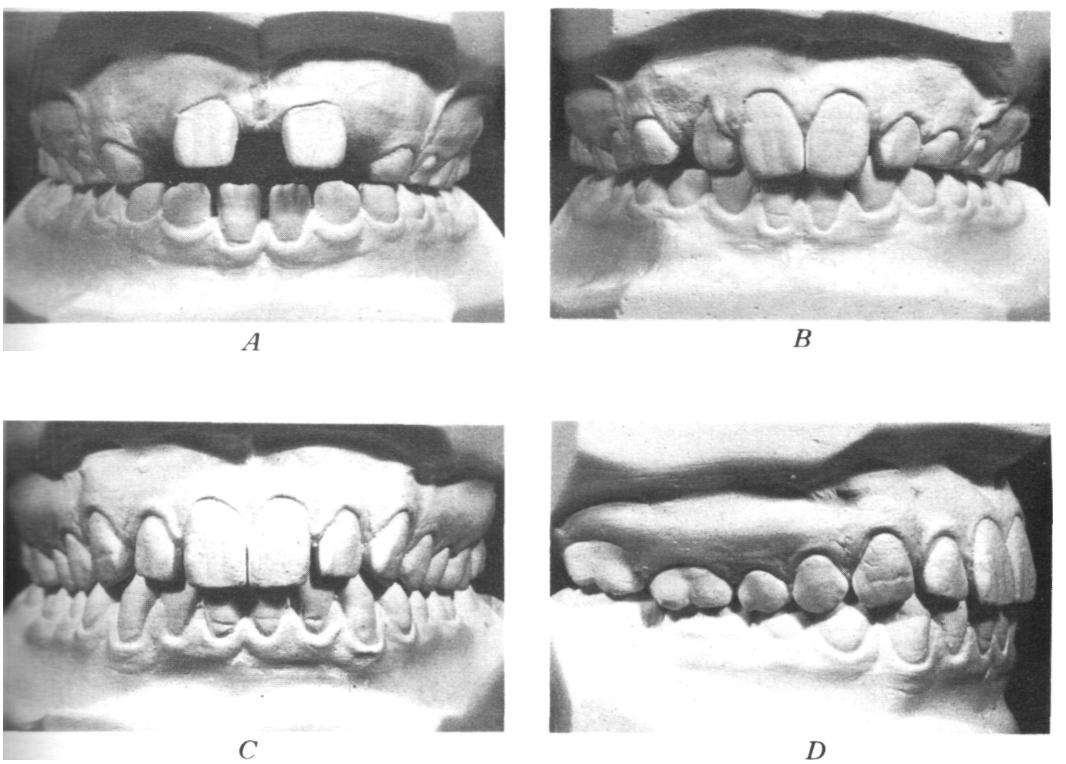


Fig. 3.31. Single self-supporting springs for lingual movement of upper incisors. These are made of 0.7 mm wire and the ends are formed into loops which are smooth to the inner lip surface.



A *B* *C* *D*

Fig. 3.32. A patient aged 8 years who sucked her thumb and had a grade 2 fraenum labii. *A,* Before treatment. *B,* A fraenectomy was done and an appliance with self-supporting springs was used to retrocline ill. The appliance also acted as a substitute for the thumb. Thumb sucking was thereafter discontinued. *C, D,* The occlusion developed normally and the patient had excellent arch form and normal occlusion.

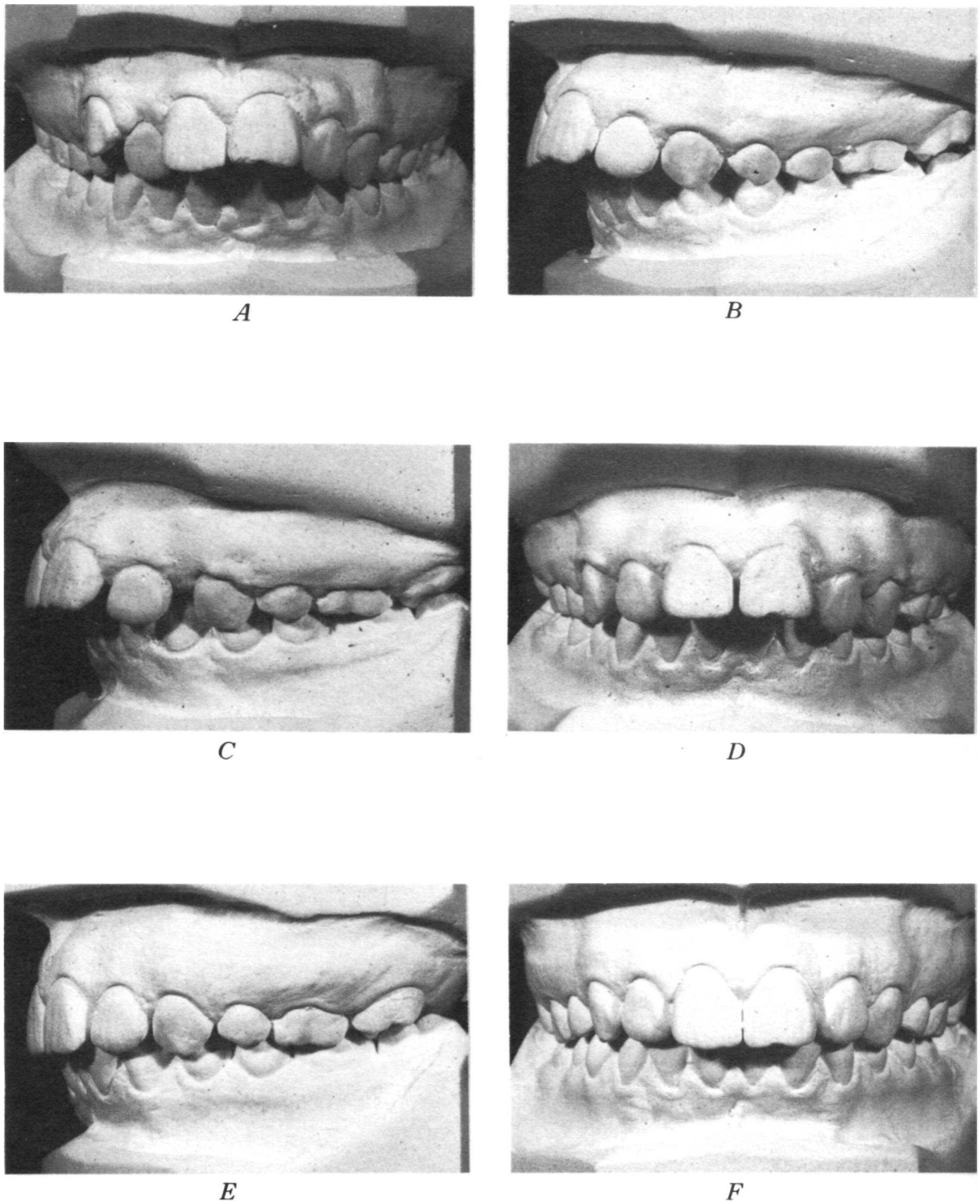
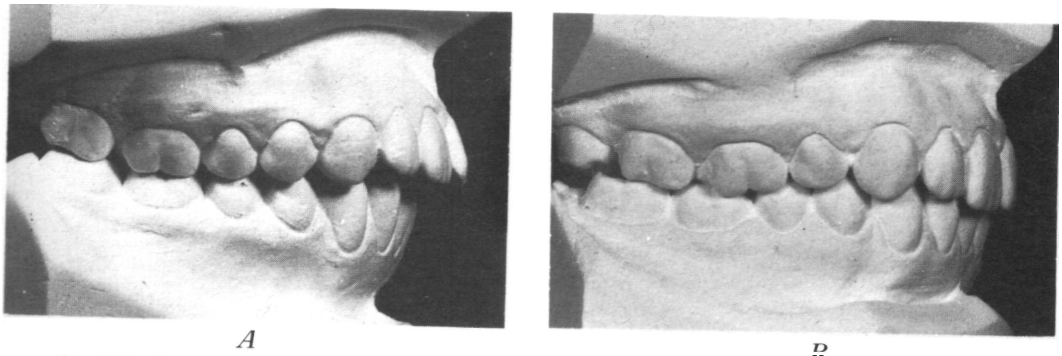
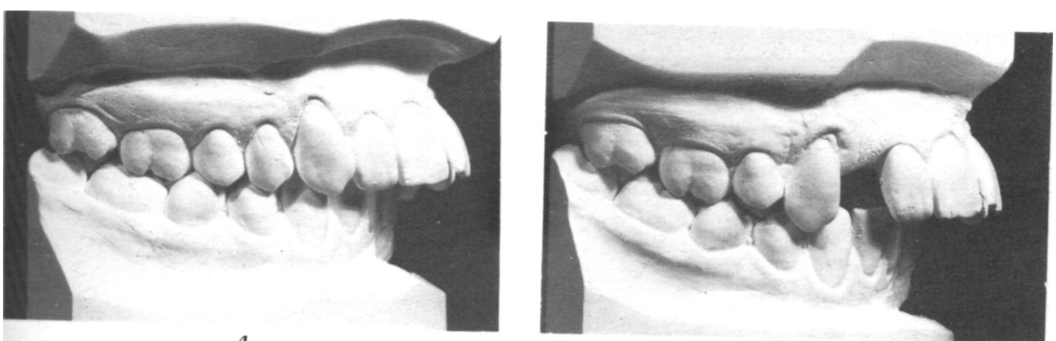


Fig. 3.33. A patient aged 12 years who had a Class II division 1 malocclusion. This was treated by extraction of the upper first premolars, retraction of the canines and lingual inclination of the incisor teeth (C). *A, B,* Before treatment; *C, D,* first premolars extracted, canines moved distally; *E, F,* Treatment complete

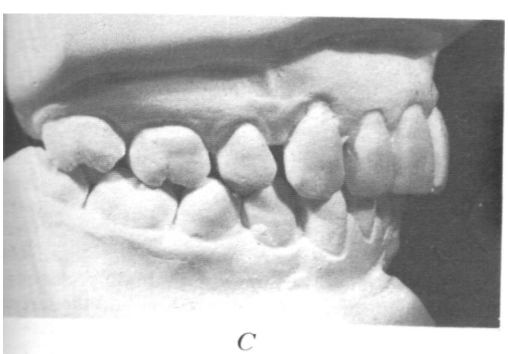


A B

Fig. 3.34. A patient aged 20 years who had a Class II division 1 malocclusion. This was treated by extraction of first premolars and retraction of the canines and incisor teeth. *A,* Before treatment; *B,* After.



A B



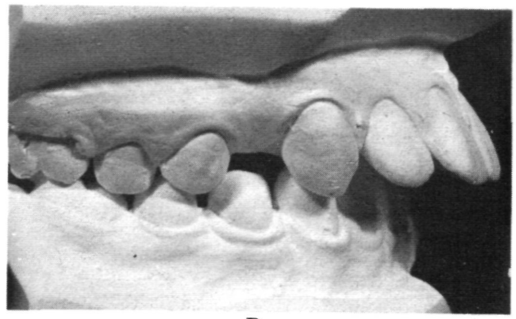
C

Fig. 3.35. *A,* Young adult female with severe Class II division 1 malocclusion. The overbite was complete and was reduced by means of a Sved plate after which the first premolars were extracted. *B,* The canines have been retracted. *C,* The labial segment has now been retroclined. The condition remained stable and, as a final stage of treatment, the canine teeth were rotated mesiolingually as they were showing the mesial surface and had a pointed appearance. The patient maintained a very high standard of oral hygiene and was producing erosion of the gum margins at the canine teeth but was warned about the appropriate oral care.

A

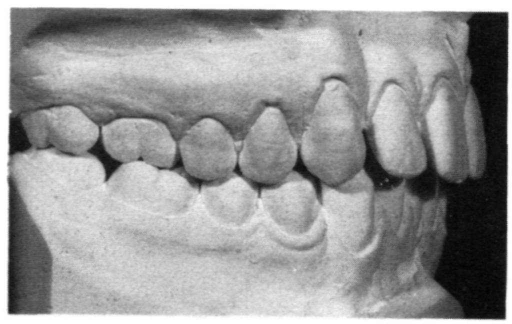
B

C

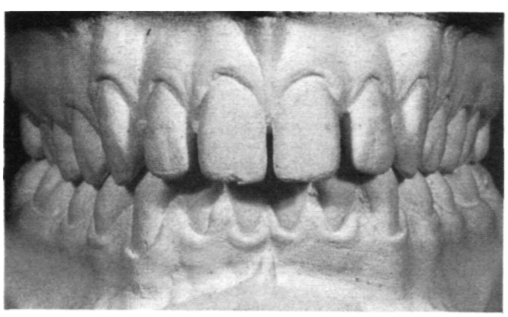


D

E

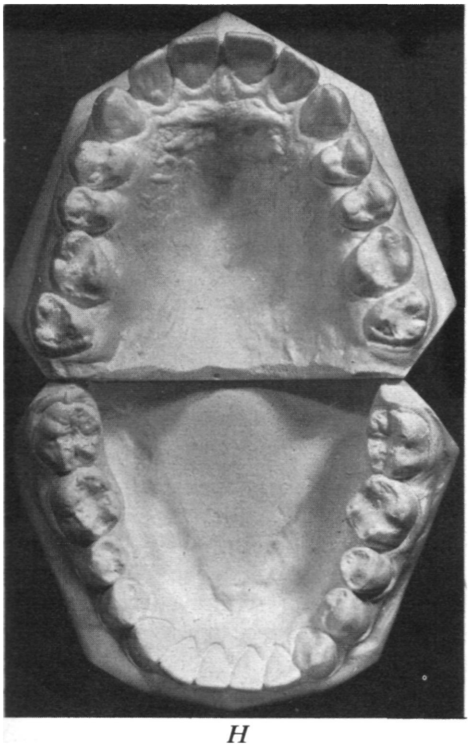


F

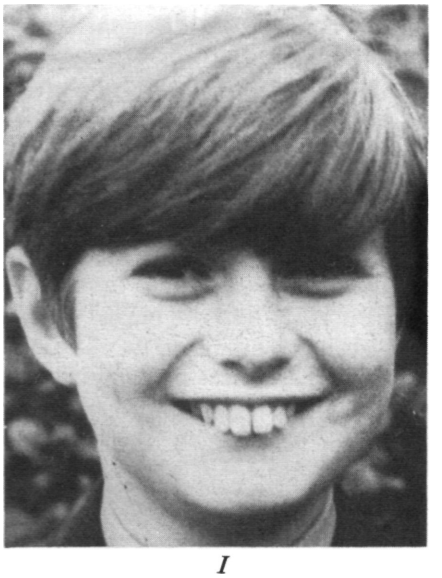


G

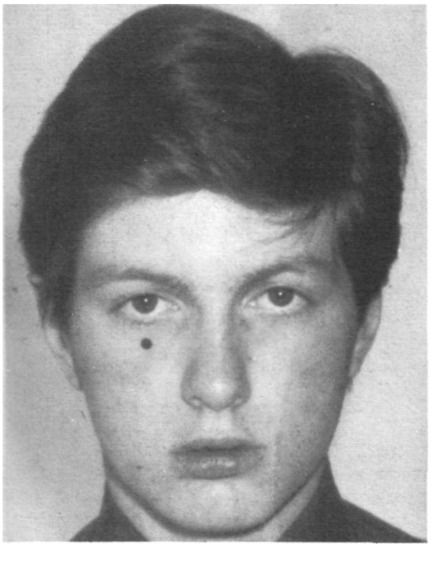
Fig. 3.36. *A, B,* A young boy with a very pronounced Class II division 1 malocclusion. The first molars had very heavy fillings. The lower first molars were extracted at the age of 10 years and the spaces closed up very rapidly, C. At age 12 years the overbite was reduced by means of a Sved plate and the upper first permanent molars were removed and the premolars retracted into normal relation with the lower premolars, *D.* The canines were then retracted, *E,* and the upper anterior teeth retroclined, *F, G, H, I, J, K,* portraits at age 8 and at age 18.



H



I



K

Fig. 3.36 (*cont.*)

Lingual Movement of Canines

Upper and lower canines, which are prominent and which He opposite an existing space in the arch or a space which has been created by extraction, can be moved lingually into such a space by means of a spring made like a self-supporting canine retractor with the acting end lying on the labial surface of the tooth. The spring is activated in a lingual direction. A self-supporting canine retractor can be adjusted to act in this way by turning the end through 90°.

Lingual Movement of Molars and Premolars

There is little space in the buccal segments for the placement of arches for the support of springs so that in this area lingual movement must be carried out by means of self-supporting springs.

Such springs need to be attached to the baseplate and brought across the occlusal surfaces of the embrasures so that great care must be taken that the tag of the spring does not impede the lingual movement of the tooth and, naturally enough, the baseplate must be cut away sufficiently to allow the tooth to move. There is not too great a problem in the upper arch where the baseplate runs down to the middle line, but in the lower arch the baseplate must be left adequately thick for easing away from the tooth and the easing must be carried right down well beyond the gum margin. The active end of the spring begins with a coil for additional flexibility and the arm of the spring is laid against the buccal side of the tooth and activated in a lingual direction. It is possible in this way to move one molar or two premolars with a single spring.

Springs for lingual movement of premolars may also be constructed like the self-supporting canine retractor and can also be made to move two premolars. (*See Fig.* 3.26.)

Chapter 4

Mesiodistal Movement of Teeth

Labio- and buccolingual tiltings of teeth do not usually produce untoward effects, the inclinations which result are, as a rule, corrections of misalignments. The mesiodistal alignment of the teeth is important to the interproximal contact relationships of the teeth and mesiodistal tiltings, whether occurring naturally or as a result of orthodontic tooth movement, can lead to poor approximal contacts, unfavourable functional alignment of tooth axes and, in the anterior region, an undesirable appearance of the teeth.

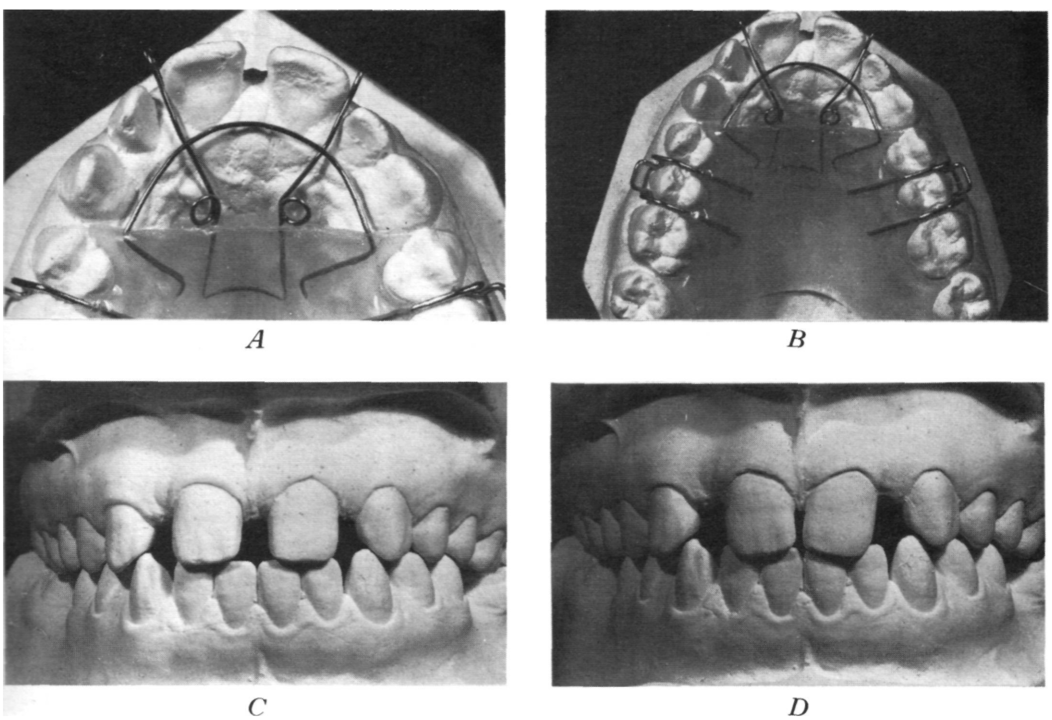


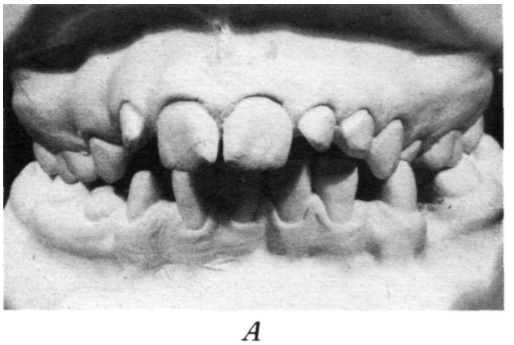
Fig. 4.1. A, B, Palatal finger springs to approximate $\underline{1|1}$. Note the point of attachment of the springs and the manner in which they are brought round to the distal surfaces of the teeth. Pressures used are equal and opposite so giving reciprocal anchorage. *C,D,* The teeth are moved together but incline slightly. The apices of the teeth are moved together as shown in Chapter 5.

Mesiodistal inclination of the teeth can, therefore, be seen from the point of view of wrong inclinations that can be simply corrected by tilting teeth into correct alignment by a removable appliance or as a mesiodistal movement which may produce an undesirable inclination of the tooth being moved.

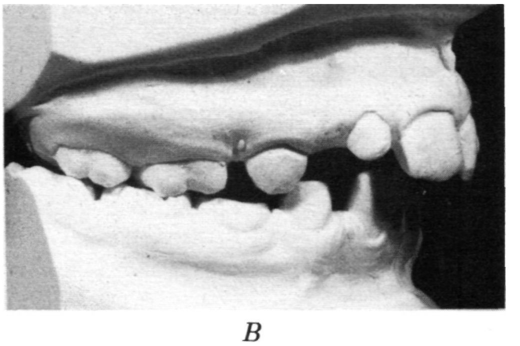
The need for making mesiodistal movements arises in the alignment of the dental arch, there being space either occurring naturally or created by extraction of a tooth or of teeth. Such movement may be required at any point in the dental arch from the incisor region to the neighbourhood of the second and third molar teeth.

The most effective way of moving teeth mesiodistally is by the use of a palatal finger spring suitably guarded and guided and placed so that the line of action of the spring is along the line of the dental arch. This entails some care in placing the point of attachment of the spring and this detail is too often neglected in the construction of appliances.

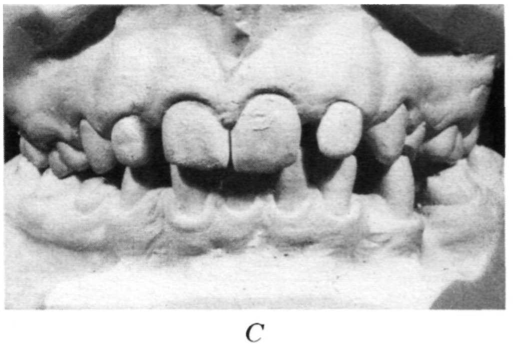
In the incisor region, the need for mesiodistal movement often occurs when there is spacing due to the absence of teeth, such as the lateral incisors, or due to damage to a tooth, usually a central incisor, leading to its loss. The adjustment of the space available to make possible the placing of an artificial tooth is the usual requirement and when front teeth are moved mesiodistally by means of a removable appliance this always produces tilting of the tooth *(Figs.* 4.1, 4.2). If the tilting corrects an otherwise unde-



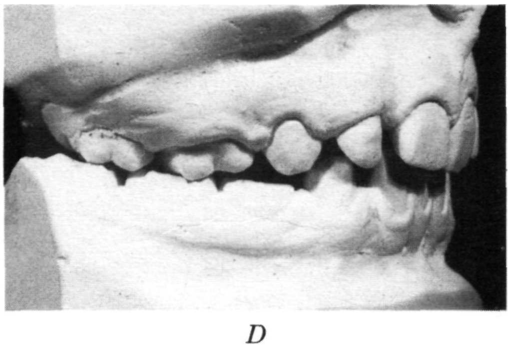
A



B



C



D

Fig. 4.2. *A, B,* This patient had absence of a number of premolars and sucked a thumb, so creating an overjet. C, D, The incisors were retroclined and the lateral incisors were positioned in the centre of the space available preparatory to crowning.

sirable inclination, this is all to the good (*Fig.* 4.3), but often the movement of the crown into a position to make possible the placing of an artificial tooth tilts the tooth that is moved, producing an unpleasant appearance due to the inclination of the incisal edge and possibly an abnormal contact with the adjoining tooth (*Fig.* 4.4).

The ideal answer to this problem is to use a multiband appliance to rearrange the teeth as this gives control also of the axial inclinations. It is, however, possible to correct axial inclinations of anterior teeth with removable appliances if they are not rotated. (*See* Rotation and root movement of teeth, p. 82.)

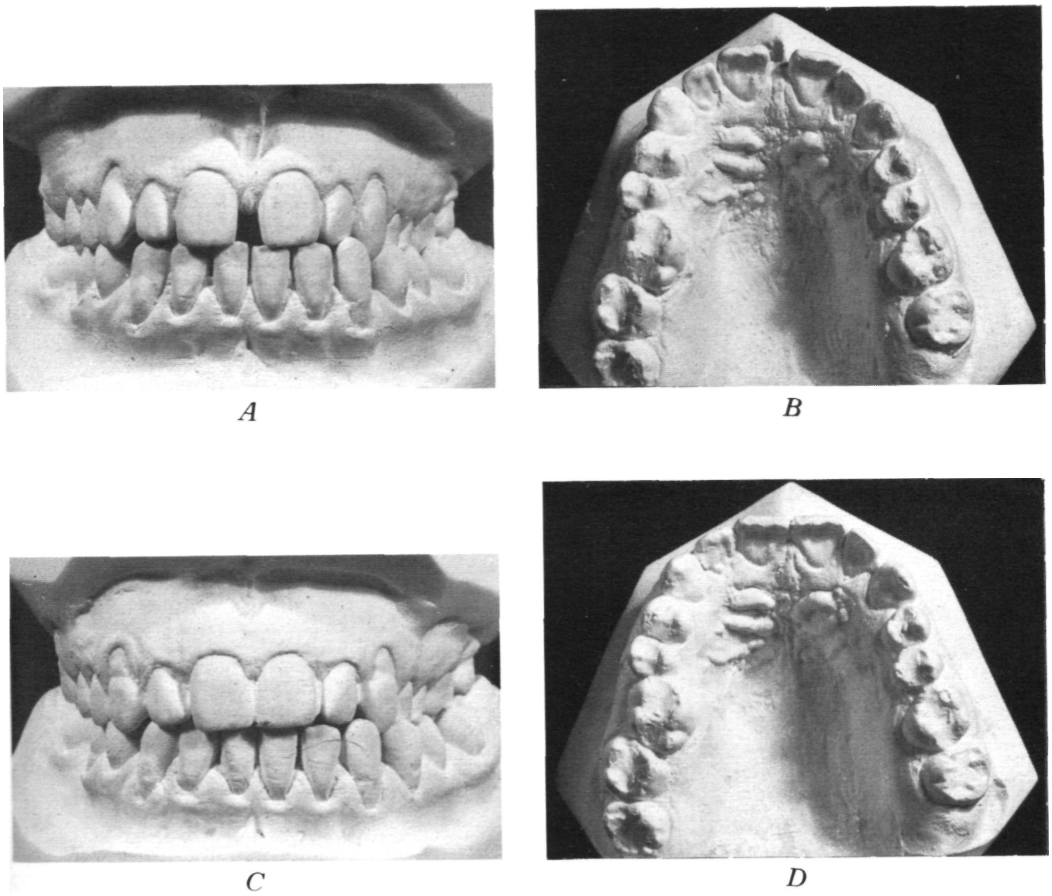
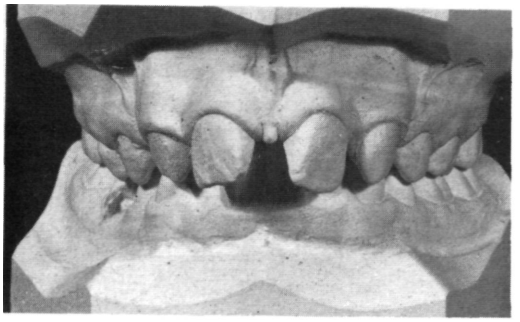
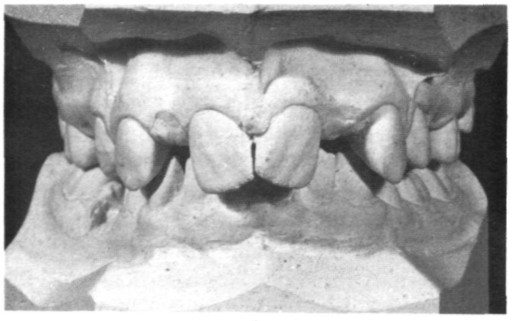


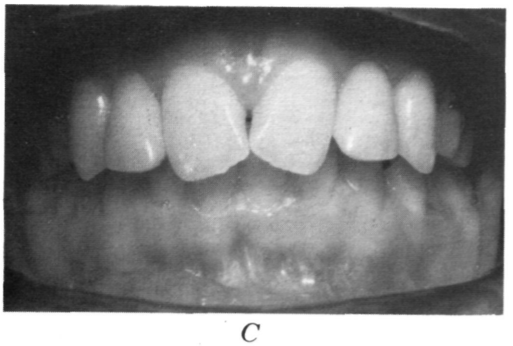
Fig. 4.3. *A,B,* These are records of a female patient aged 30 years who was self-conscious about the spacing between $\underline{1|1}$. There was also a tendency to prenormal occlusion and a reduced overbite. The fraenum labii was a well-defined Type *2.C,D,* Fraenectomy was performed and $\underline{1|1}$ were approximated; $\underline{2|2}$ were moved mesially into contact with $\underline{1|1}$ and spacing among the anterior teeth disappeared completely.



A

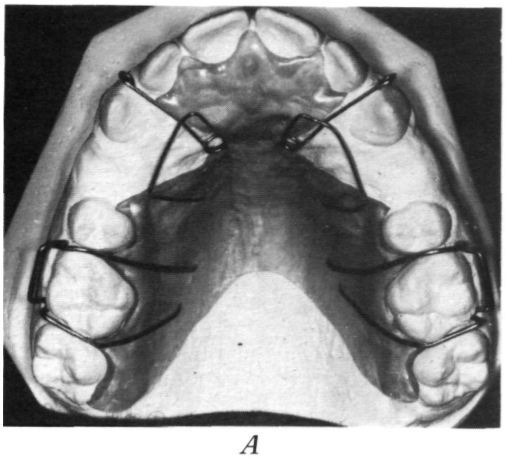


B

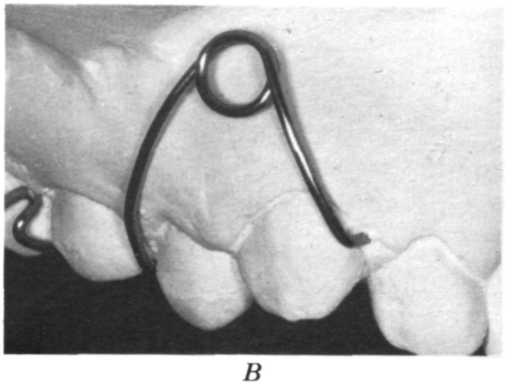


C

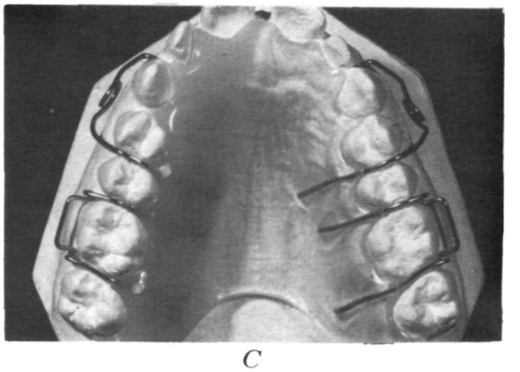
Fig. 4.4. *A,* The patient had absence of lateral incisors and a large median diastema. The central incisors were also rotated. *B,* The incisors were approximated as shown. C, A chrome cobalt denture was placed.



A



B



C

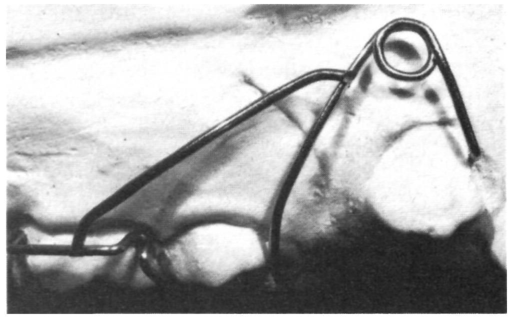
Fig. 4.5. *A,* Palatal canine retractor springs. It is important with these springs to have the point of attachment sufficiently far forwards to ensure that the spring acts along the line of the dental arch. *B,* The standard buccal canine retractor. C, Palatal view. The first premolars have not yet been removed. Note the distribution of the baseplate to gain maximum anchorage.

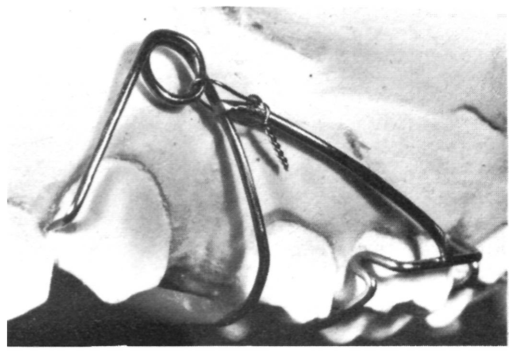
The distal movement of upper canine teeth can usually be done by palatal finger springs (*Fig. 4.5A),* but sometimes needs to be done by a buccally placed, self-supporting spring of 0.7 mm wire. This spring is useful at any time but is particularly so when the canine overlaps the lateral incisor and is not easily accessible from the lingual side of the arch *(Fig. 4.5B,C).*

The plain or standard buccal canine retractor is perfectly satisfactory if adjusted with care, but can be further improved by the addition of a stabilizer welded to the bridge of a clasp on a tooth farther back in the arch *(Fig.* 4.6). The welding must be done accurately and it is sensible to place a safety ligature as shown just in case the wire fractures if the appliance is roughly handled and the part above the weld becomes detached. The effect of the stabilizer is to restrict vertical movement without noticeably affecting the antero-posterior flexibility of the spring. The spring can then be applied to the tooth with great accuracy.

Premolars and molars can be moved mesiodistally without difficulty using springs of 0.5 mm thickness. It is necessary to make the springs with a suitable combination of coil size and arm length. If the coil is too large and the arm too long, the spring may not generate enough pressure and prove difficult to keep in contact with the proper spot on the tooth. Again, the point at which the spring is fixed in relation to the tooth is important if the correct line of action is to be achieved *(Fig.* 4.7).

When moving premolars distally into the space created by the removal of the first molar, it is perfectly feasible to move the two premolars with one spring. The practice of using separate springs for the premolars is to be deprecated as the appliance is unduly complicated for the patient, the spring for the second premolar is liable to become jammed between the teeth and it is inefficient to use two springs where one will suffice. Another practice which must be condemned is that of boxing-in springs if this is not necessary and can be avoided. Such boxing makes adjustments of the





B

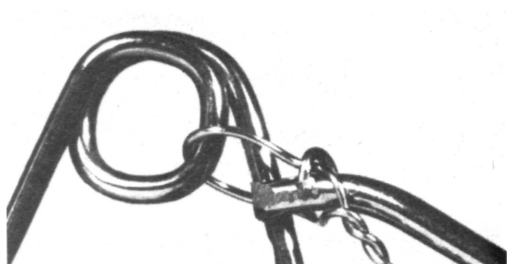
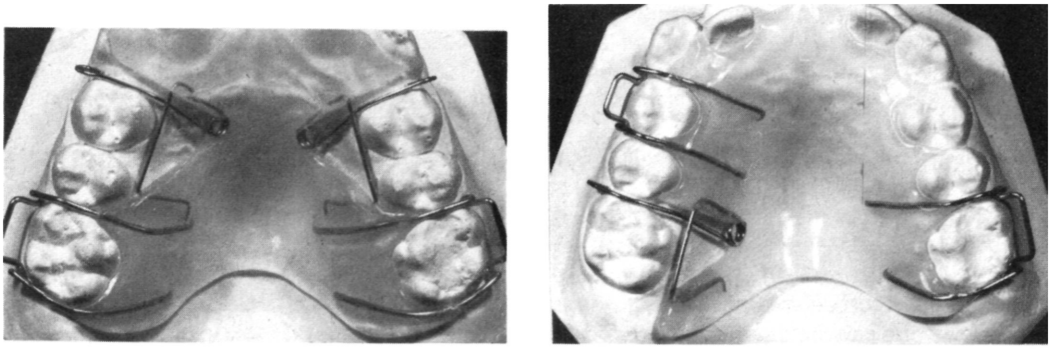
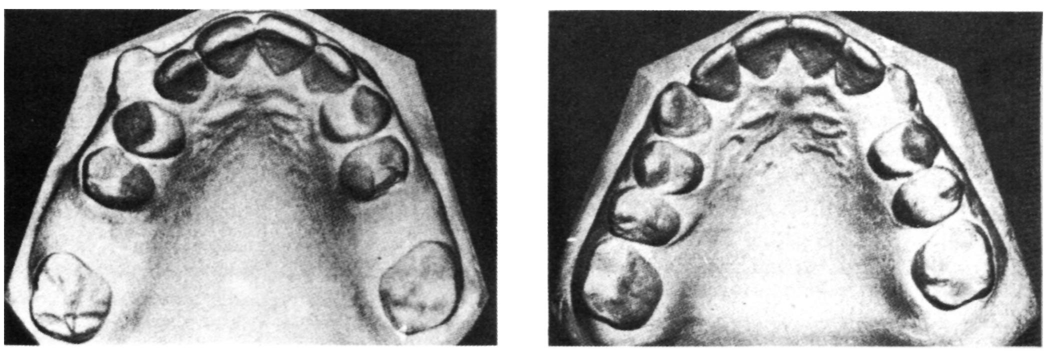


Fig. 4.6. The stabilized canine retractor. *A,* The stabilizer is welded as shown to the spring and to the bridge of a molar clasp. *B,C,* The stabilized buccal canine retractor with safety ligature. The ligature runs through a little stirrup of soft 03 mm wire welded to the stabilizer and through the loop of the spring. If the canine retractor fractures due to rough handling of the appliance, the fracture usually occurs above the stabilizer and the ligature retains the loose piece.



A *B*

Fig. 4.7. Palatal retractors for premolars and molars. *A,* The second premolar has not yet been removed. *B,* The molar is to be moved distally to provide room farther forwards.



B

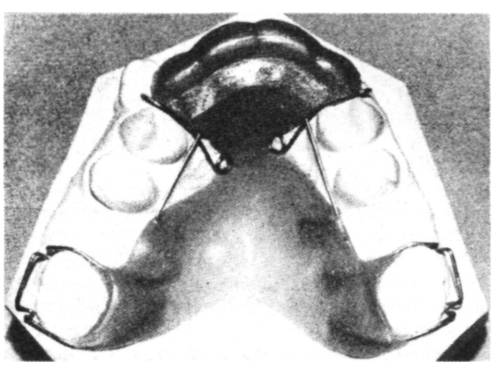


Fig. 4.8. Distal movement of premolars; $\underline{6|6}$ were very carious and had to be removed. *A,* $\underline{3|3}$ were completely blocked out. *B,* $\underline{54|45}$ were moved distally using a single finger spring each side with Sved anchorage and clasps on $\underline{7|7}$ (C).

spring and guide unnecessarily difficult and is unhygienic. In some situations, making the baseplate continuous over springs is necessary to make the baseplate strong enough and the consequent disadvantages have to be accepted.

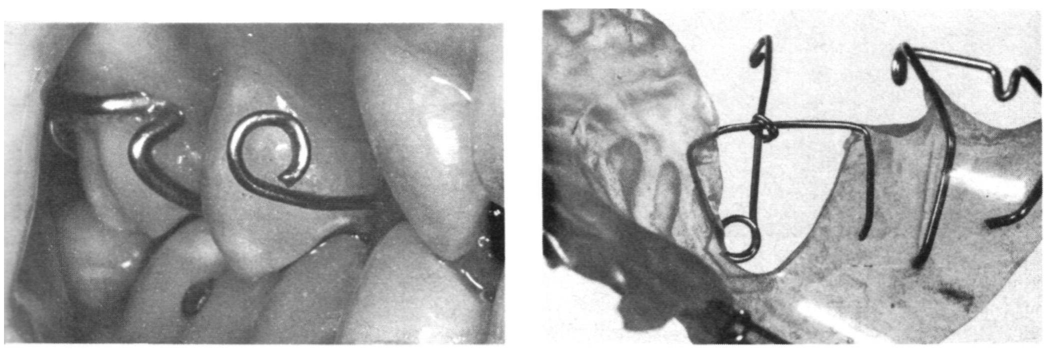
In the case shown in *Fig.* 4.8, all the space for 3|3 was obtained by moving 54|45 distally into the spaces left by extraction of 6|6 due to severe caries. Anchorage was by clasping 7|7 and using a Sved bite-plane.

The free ends of palatal finger springs should be turned into a large loop (*Fig.* 4.9, *A*). This end then may be allowed to project a little which makes it easier for the patient to place the spring in position and the smooth end will not injure the lip or cheek. A cut end, on the other hand, is uncomfortable and inconvenient and difficult for the patient to handle without risk of hurting the finger.

An important aid in the design of finger springs which run along wire guides is to link the spring to the guide wire with a loop of hard fine wire (*Fig.* 4.9, *B*). A hard wire of 0.3 mm thickness is wound twice tightly round the crossing and cut off closely. A probe is then pushed through the loop to open it sufficiently to let the spring move freely. The loop should be wound in the direction that allows the spring to run freely as it acts and not in the direction that causes the spring to jam as it acts.

The effect of such a link is to prevent the patient from accidentally lifting the spring away from the baseplate and so causing it to press into the gum and periodontal membrane. The spring also remains more accurately at its point of application and does not wander up and down the surface of the tooth that is being pressed on.

In the lower arch, a slight problem arises in that the plane of the spring and its coil are vertical but the arm must turn horizontally to lie against the approximal surface of the tooth to be moved. The answer is to make the spring neatly and the baseplate to fit accurately so that the patient will have as little inconvenience as possible. It is here that boxing in of the spring has to be



A *B*

Fig. 4.9. *A*, The free end of a palatal finger spring should be turned into a large loop as this will not injure the inside of the cheek. As shown, the loop can be quite large. *B*, The link which stabilizes the spring against the guide wire.

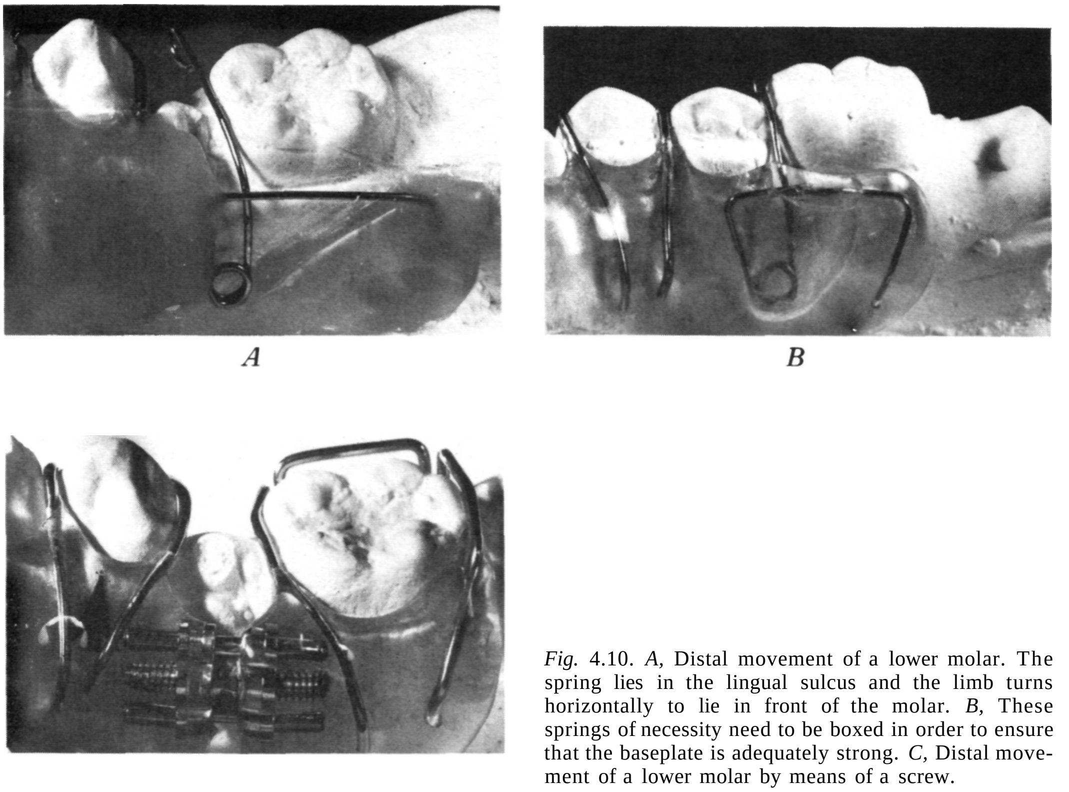


Fig. 4.10. *A,* Distal movement of a lower molar. The spring lies in the lingual sulcus and the limb turns horizontally to lie in front of the molar. *B,* These springs of necessity need to be boxed in order to ensure that the baseplate is adequately strong. *C,* Distal movement of a lower molar by means of a screw.

accepted in order to make the baseplate strong enough *(Fig.* 4.10,A,B). Some mesiodistal movements may conveniently be done with screws. The distal movement of upper and lower molars is shown in *Figs.* 4.10, C, 4.11 and 4.12.

Lower canines can be moved mesiodistally by a buccal self-supporting spring in the

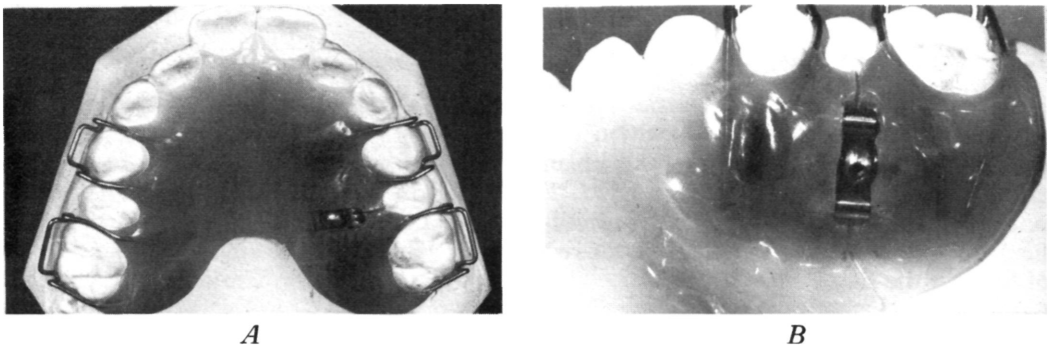
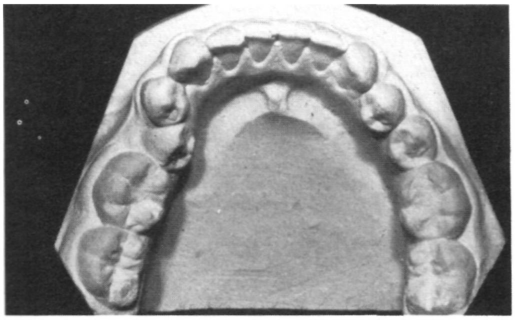
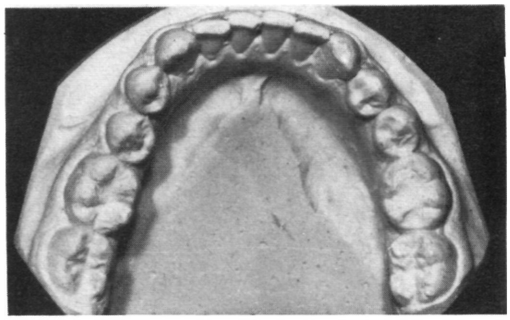


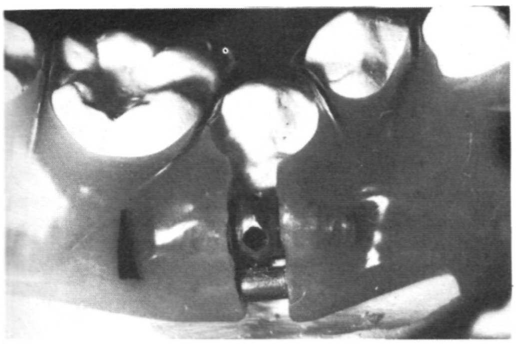
Fig. 4.11. Distal movement of an upper molar by means of a screw. *A,* The general layout of the baseplate to gain maximum anchorage. *B,* The fitting of the screw.



A



B



C

Fig. 4.12. Mesiodistal movement of teeth in buccal segments by means of a screw. This treatment was designed to open a space for |5 by reciprocal movement of the teeth in front of and behind the site of the space opening. *A,* Before treatment. *B,* After treatment. *C,* Fitting of the screw to the appliance.

same way as upper canines. It is not usually necessary to stabilize these springs in the lower arch as in the upper, although there is no reason why this should not be done if desired.

The lower incisors can be moved mesiodistally with removable appliances, but this movement is usually more expeditiously and efficiently carried out by means of multiband appliances which ensure complete control of the tooth arrangement, including rotations.

A special case of mesiodistal movement is the disimpaction of molar teeth which become impacted below the tooth immediately in front. This can happen to a first molar caught below the distal surface of the second deciduous molar or a second molar impacted below the first molar. This can occur both in the upper and in the lower arch (*Fig.* 4.13,^,fi,C). Such impacted teeth can be freed by the use of a short spring of 0.9 mm wire as shown in *Fig.* 4.13, *D,E, F, I.* A spring of this kind is self-supporting, needing no guide or guard, and its range of action is very small. The end of the spring is flattened so that it can be placed exactly at the mesial surface of the semi-erupted tooth. When correctly constructed, the spring finds its way to the point of application and slips down the slope of the mesiolingual cusp of the tooth. Disimpaction only requires a small movement which takes place in a few weeks and the appliance can be inspected at fortnightly intervals, if desired, in order to keep up adjustments

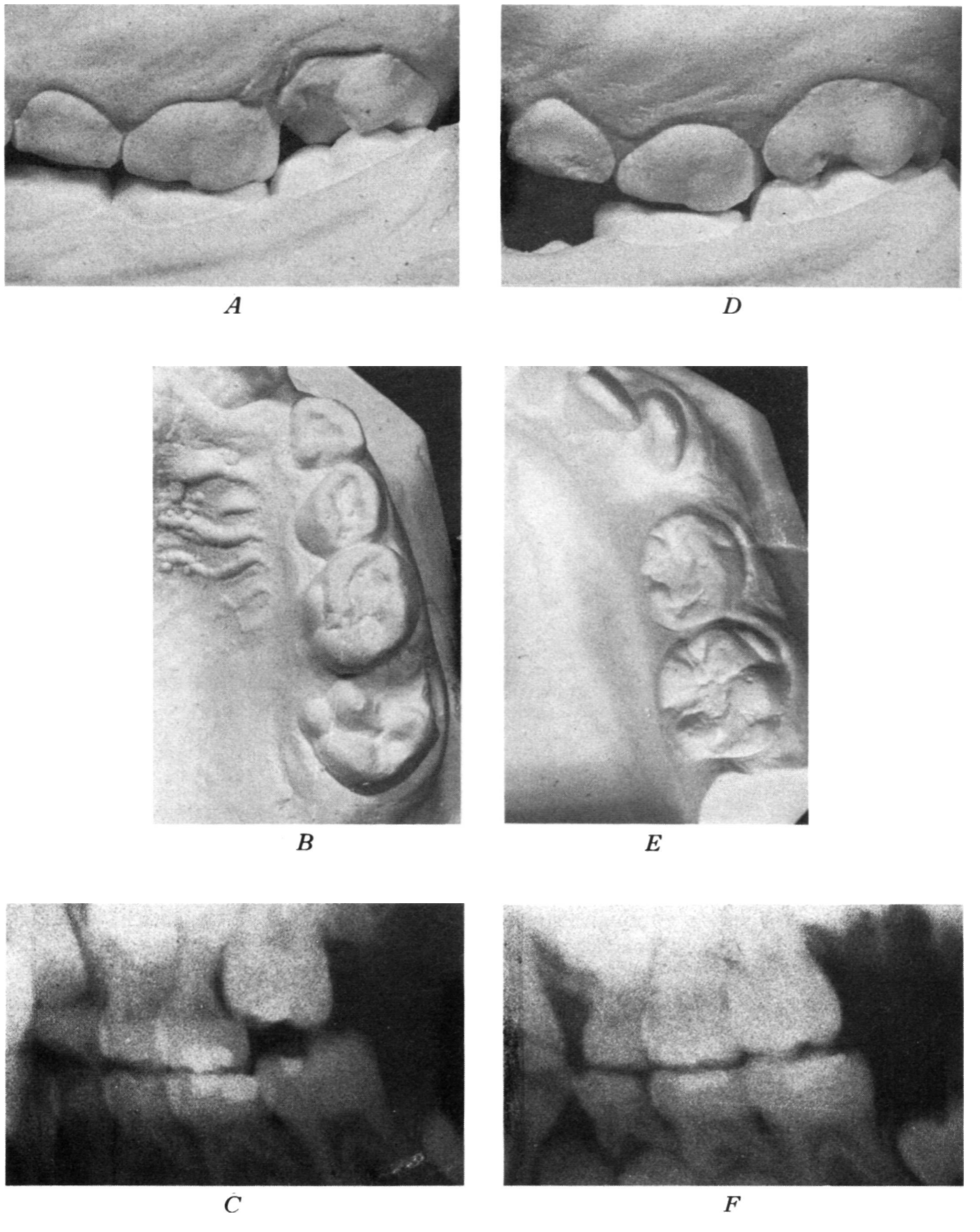
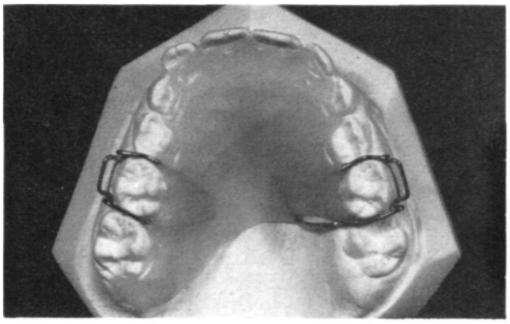
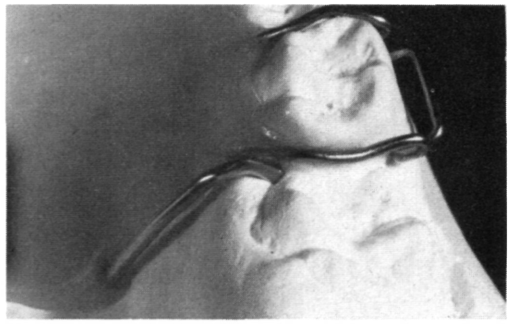


Fig. 4.13. Disimpaction of |6 which is caught below |E . *A,B,C,* Appearance before treatment. *D,E,F,* After treatment: treatment time 3 months. *G, H,* The design of the appliance. Note the short, stiff spring which slips down mesially to |6. The activation of this spring is very slight, 0.5-1.0 mm, and the spring seats itself automatically when the appliance is inserted. Note also the clasp on |E_ which ensures accurate retention of the appliance.



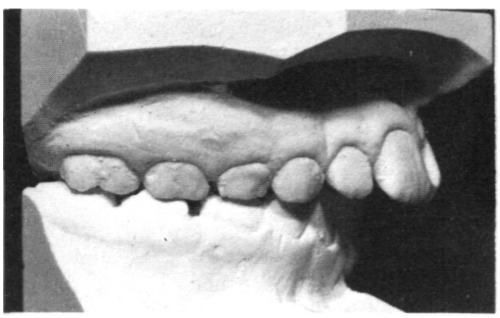
G



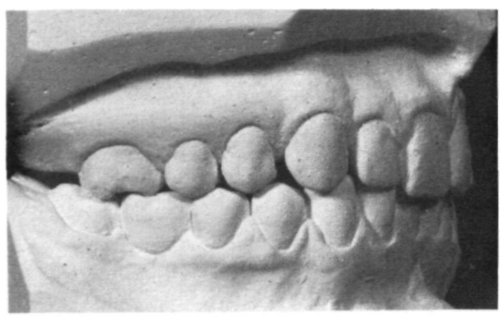
H

which need to be of a very small amount (*Fig.* 4.13, G,H). An appliance of this kind can be used in the lower as well as in the upper arch.

Fig. 4.14 shows the result of moving upper premolars distally after extracting upper first molars because of their carious condition. Space was thereby created for correction of a considerable overjet.

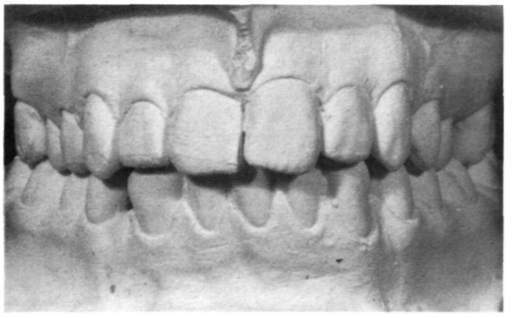


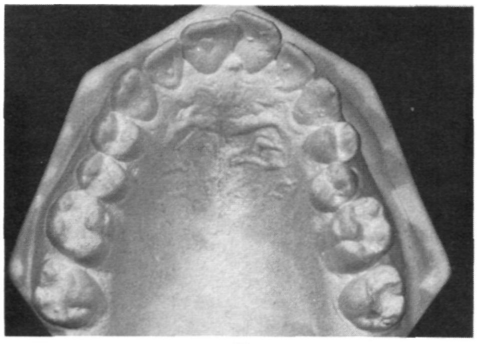
A



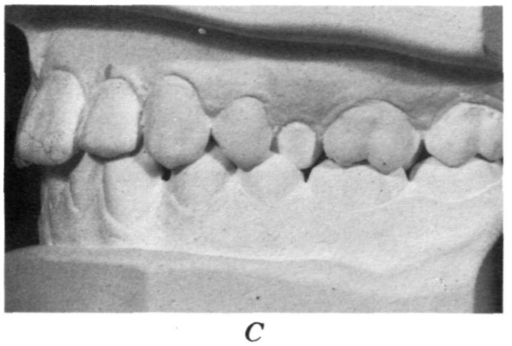
B

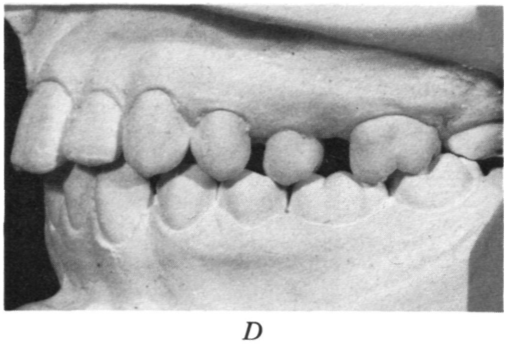
Fig. 4.14. A Class II division 1 malocclusion, in which 6|6 were very heavily filled and were removed. *A*, At 7 years of age. *B*, 54|45 were removed distally and the anterior teeth retroclined; 7|7 erupted and came into occlusion. C, 8|8 erupted and completed the upper dental arch (age 16).



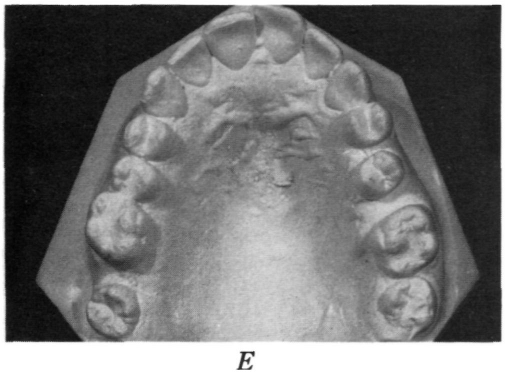


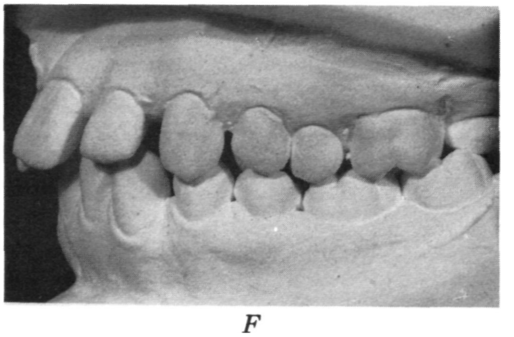
A *B*





C *D*





E *F*

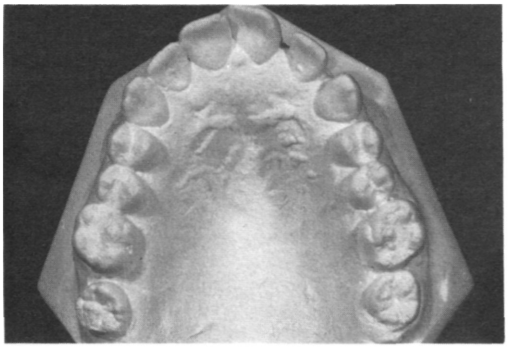
Fig. 4.15. A,B,C, A patient aged 19 complained of irregularity of 1. The upper third molars were as yet unerupted. There was also crowding and impaction of |5.

D, E, F, G, H, 7|7 were extracted and first |6 (D, *E),* then 45 and |3 moved distally *(F, G, H).* This created space for 12. 8|8 erupted and made contact with 6|6.

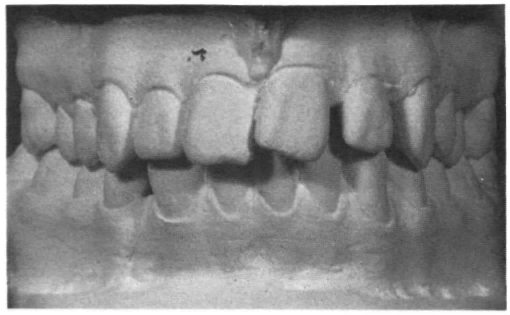
1 was then rotated distolabially *(I, J)* and a pericision done to stabilize the result.

K, L, M show the appliances to move |6, then |45 and finally |3 in a distal direction.

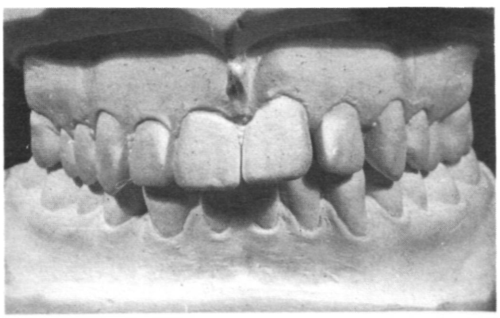
The subject shown in *Fig.* 4.15, aged 19 years, complained of irregularity of 1 which was worsening. Upper third molars were approaching eruption. The upper second molars were removed and the space of |7 was transferred to the region of |12 by distal movement of 13456. The third molars erupted and made good contact with the first molars.



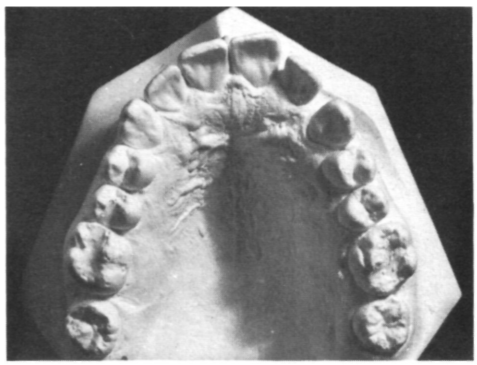
G



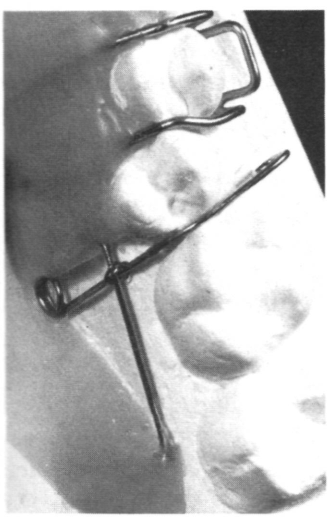
H



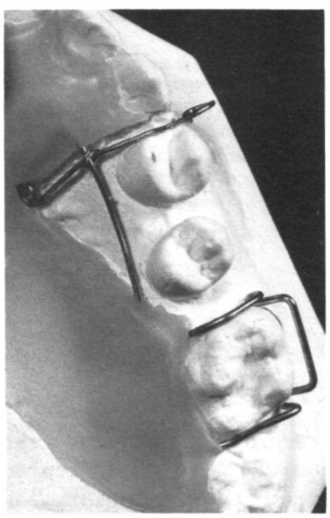
I



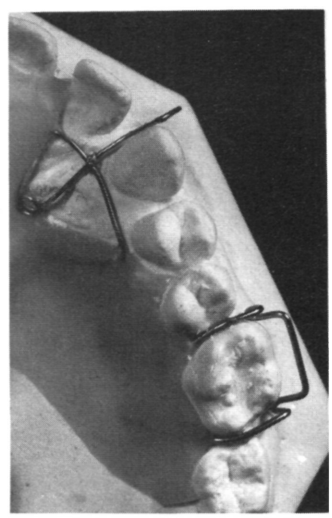
J



K

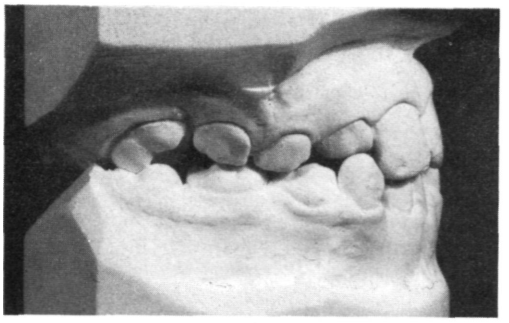


L

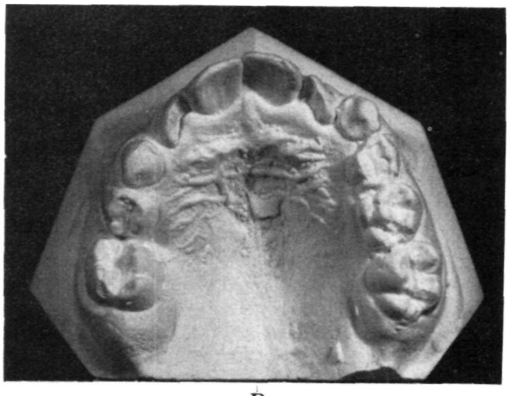


M

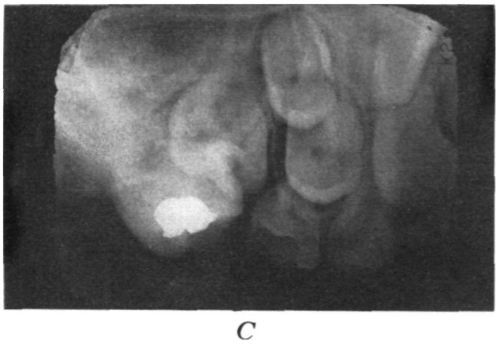
Fig. 4.15 *(cont.)*



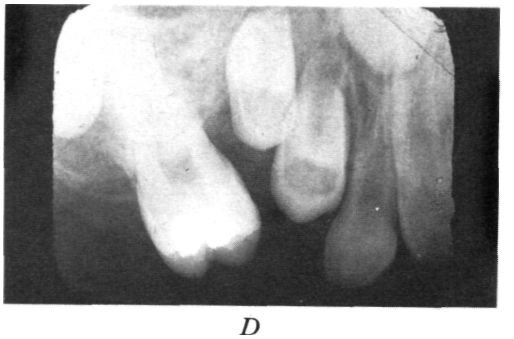
A



B



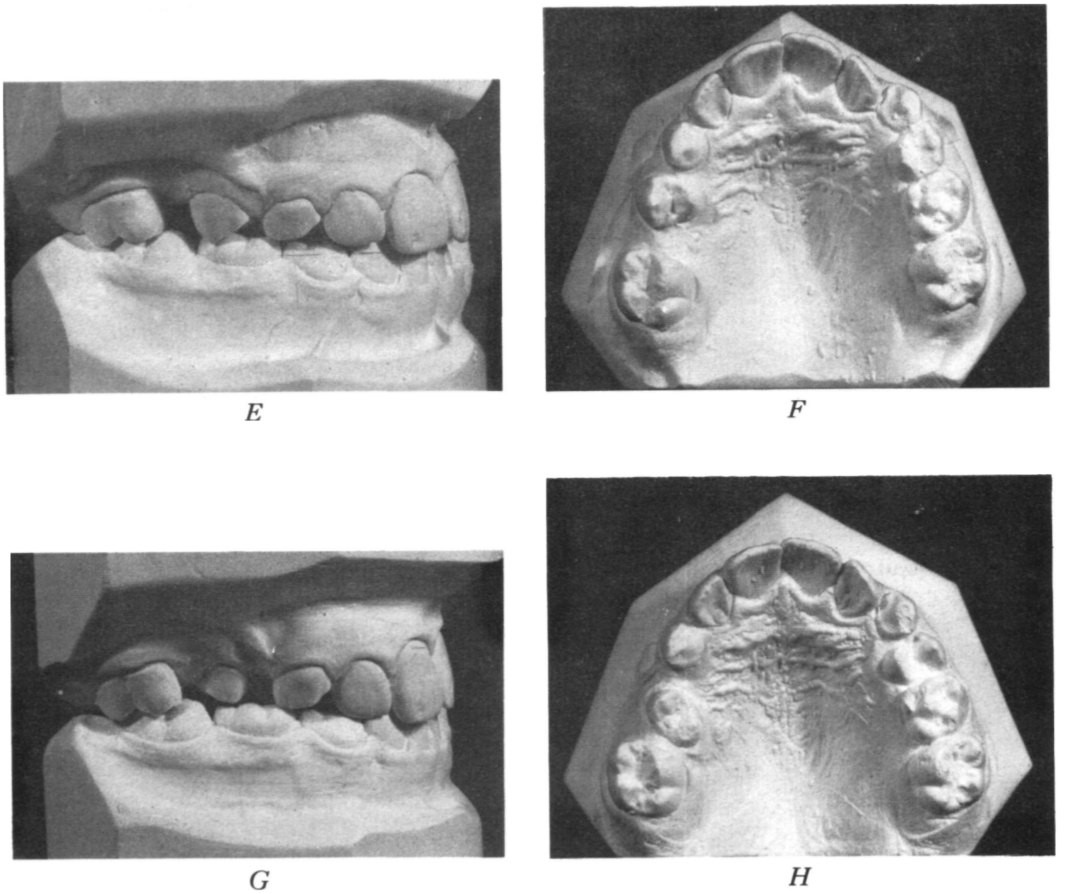
C



D

Fig. 4.16. A boy of 9 presented with E submerged and out of sight and 54) unerupted. 6 had inclined steeply forwards and there was about 10 mm space between 6D|.
A, B, C, Clinical and X-ray appearance on first examination. *D,* ED have been removed.
E, F, 6j has been moved distally and 4 has erupted.
G, H, 4|has been removed, and 5 has erupted. 6 has been retained in its position after distal movement.

The boy of 9 years whose records are shown in *Fig.* 4.16 presented with E submerged and out of sight and |6 severely tilted and almost in contact with D. There was an underlying crowding of the dentition (Angle Class I). The deciduous teeth ED were removed and 6 was moved distally; 4 thereafter erupted and was removed; 5 then erupted. The patient now aged 13 was very slow in getting teeth. It was anticipated that a further three permanent units would be removed for orthodontic treatment.



E *F* *G* *H*

Fig. 4.16 *(cont.)*

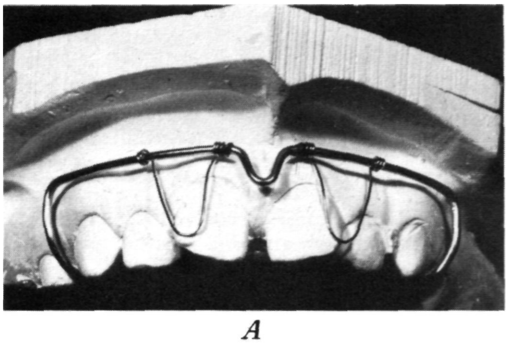
Chapter 5

Rotation and Root Movement of Teeth

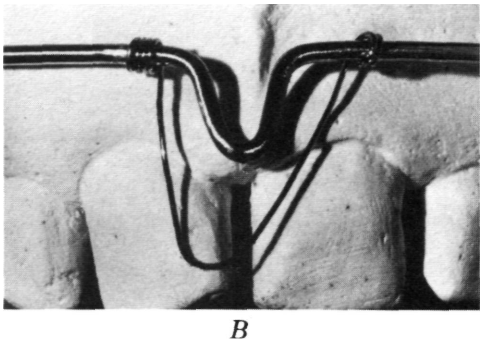
There are certain rotation and root movements that removable appliances can perform very well and it is helpful to bear these possibilities in mind when considering treatment problems.

The production of a rotary movement requires the application of two equal and opposite pressures acting at a distance apart to produce a *mechanical couple* See Fig.* 1.7.A. This will produce rotation about a point somewhere between the lines of action of the two forces. It is therefore necessary to find, on a tooth to be rotated, two points at a suitable distance apart on which pressures in opposite directions may be applied, and this requirement automatically eliminates the possibility of rotating certain teeth. For instance, canines, upper and lower, are of a

* 'A couple consists of two equal parallel forces which act in opposite directions. When acting on a rigid body, it cannot produce motion in any particular direction since the algebraic sum of its resolved parts in that direction is zero; it follows that its effect is to produce rotation' (Borchardt W. G. *A School Certificate Mechanics and Hydrostatics).*



A



B

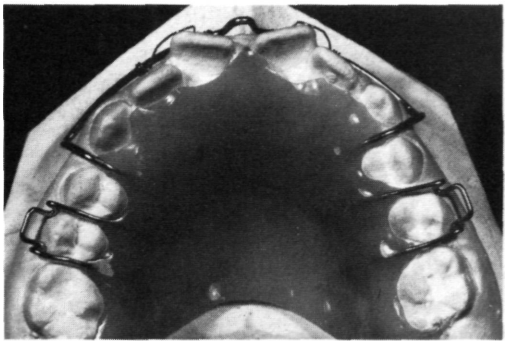


Fig. 5.1. Apron springs on high labial arch which apply precise pressure on the corners and edges of the incisor teeth. *A,* Pressure on distal corners of 1 1. *B,* Pressure on a single tooth, 1 . C, Lingual view of *A.*

rounded shape which does not offer two points near the outside of the contour of the tooth to which suitable pressures may be applied. Lower incisors, again, are so small in width that the forces even when applied at the extreme ends of the incisal edge are so close together that an effective mechanical couple cannot be produced.

It is important when constructing appliances for rotation and root movement to ensure that the springs act exactly at the points intended and do not slide away to some other nearby but unsuitable point. For this reason it is sometimes necessary to make springs rather stiff in order to ensure accuracy of application to the teeth and to accept the short range of action inherent in such springs. Cantilever springs are perfectly suitable for developing the necessary pressures. On the labial side, accurately made apron springs supported on a high labial arch are effective *(Fig.* 5.1), or self-supporting springs of 0.7 mm wire may be used *(Fig.* 5.2). On the lingual side, cantilever springs may be used *(Fig.* 5.3), or the torque spring is flexible but at the same time robust *(Fig.* 5.4).

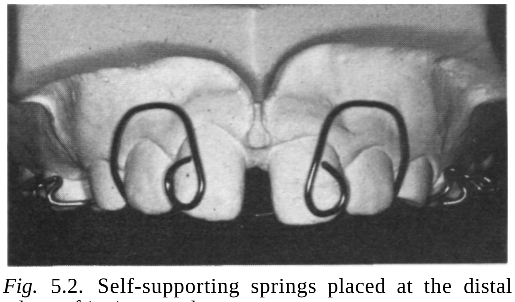


Fig. 5.2. Self-supporting springs placed at the distal edges of incisor teeth.

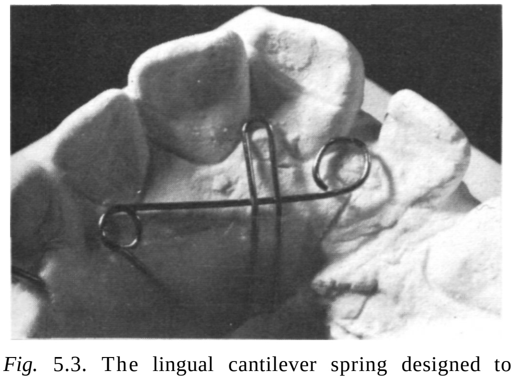


Fig. 5.3. The lingual cantilever spring designed to apply pressure precisely to the edge of an incisor tooth to produce one component of a mechanical couple.

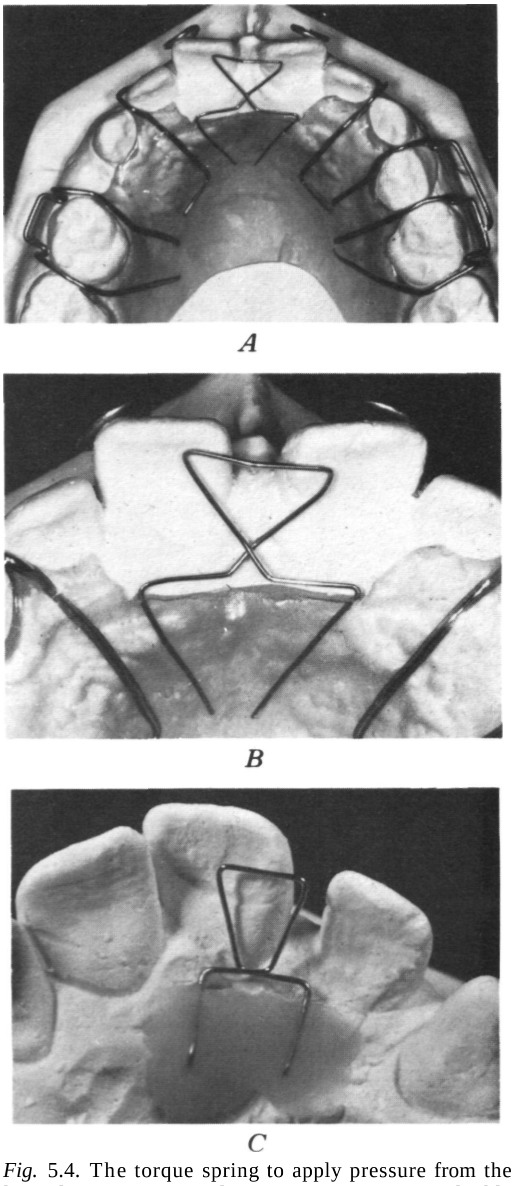


Fig. 5.4. The torque spring to apply pressure from the lingual aspect to produce rotation. *A,B,* A double spring acting on two teeth. *C,* A single torque spring.

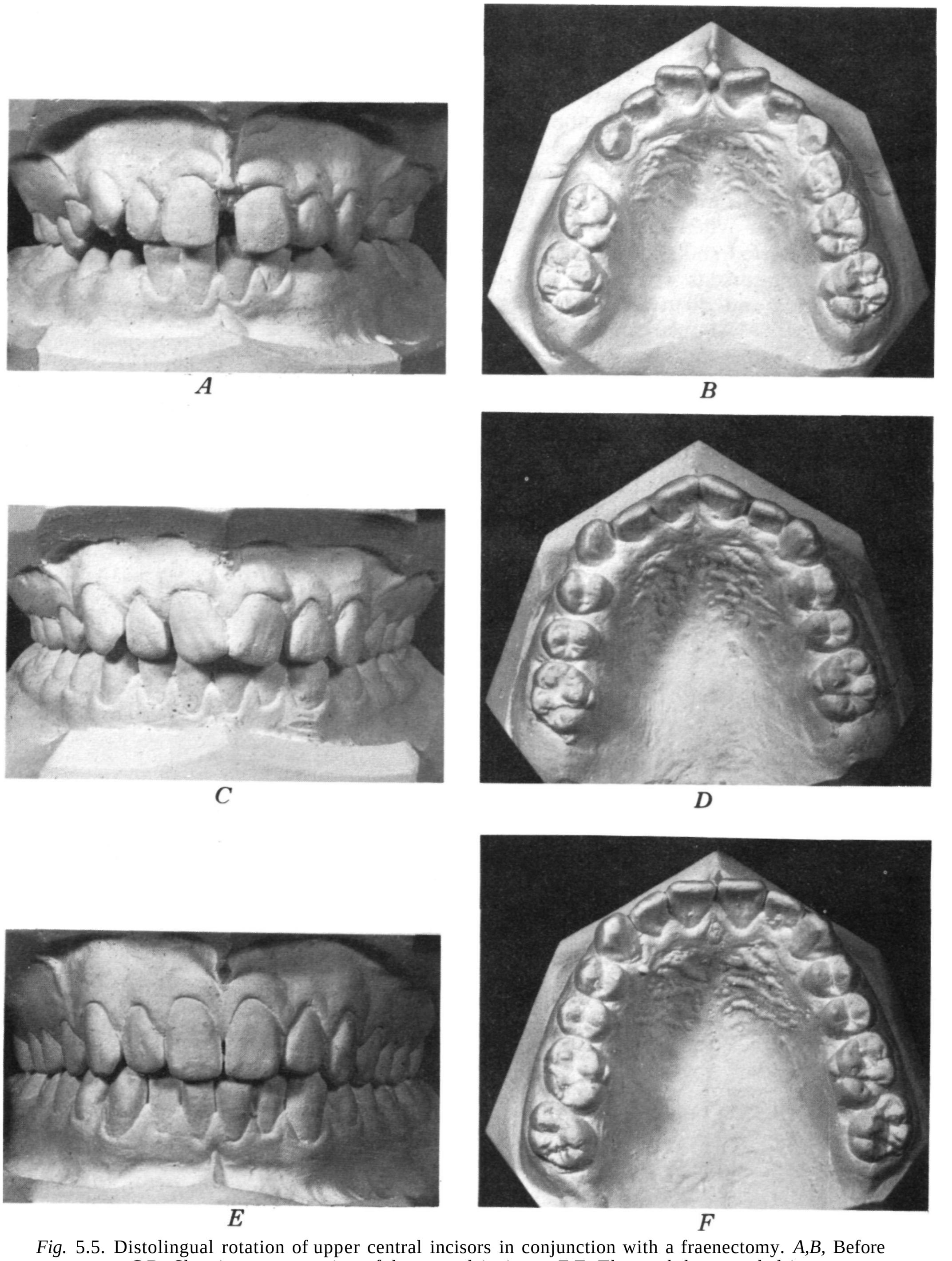


Fig. 5.5. Distolingual rotation of upper central incisors in conjunction with a fraenectomy. *A,B,* Before treatment. *C,D,* Showing over-rotation of the central incisors. *E,F,* The teeth have settled into correct alignment.

The torque spring and self-supporting labial spring are a useful combination and can be used effectively for single teeth.

ROTATION OF UPPER INCISORS

Possibilities for the use of these appliances are shown in *Figs.* 5.5, 5.6, 5.7 and 5.8. If the lateral incisors are wide enough, they can be rotated with such removable appliances.

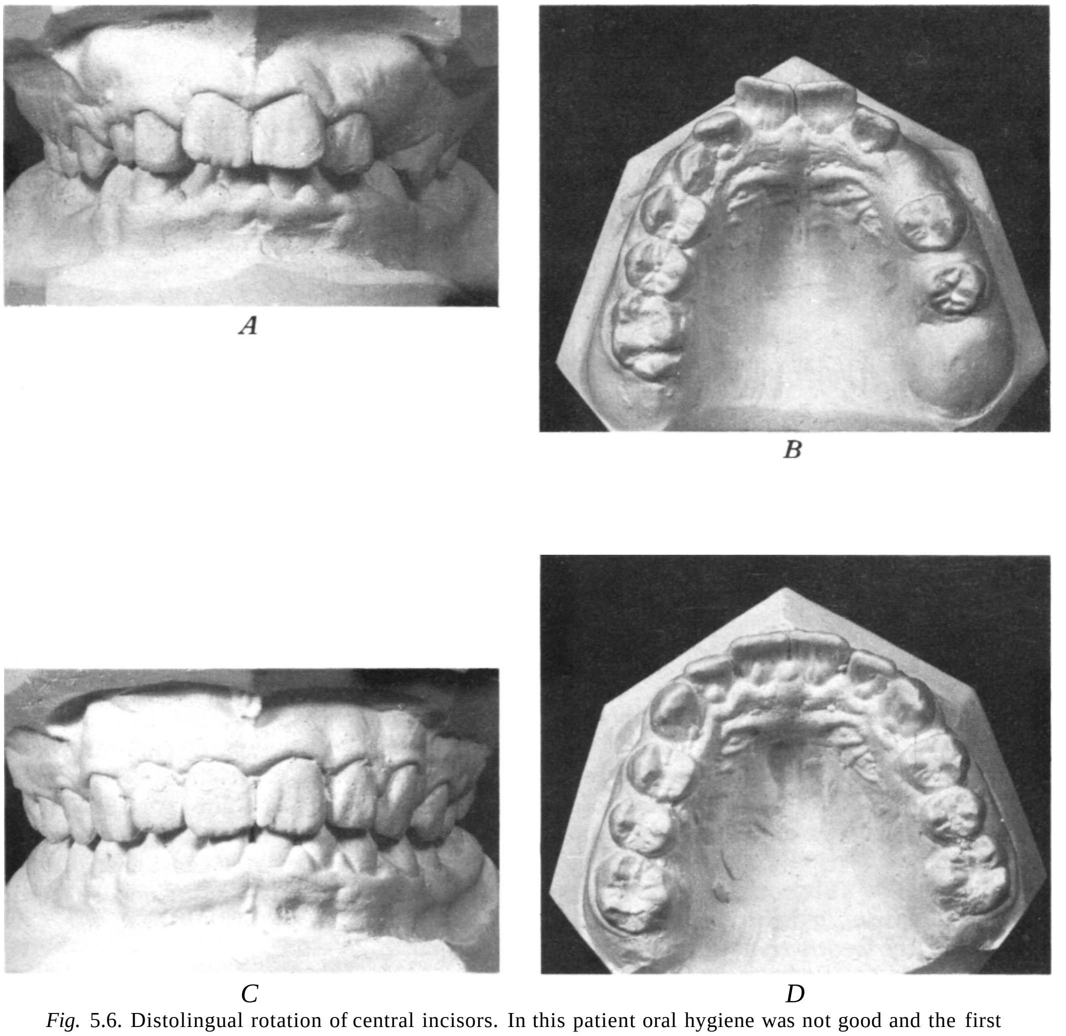


Fig. 5.6. Distolingual rotation of central incisors. In this patient oral hygiene was not good and the first molars were removed as part of orthodontic treatment. *A, B,* Before treatment. *C, D,* At end of treatment.

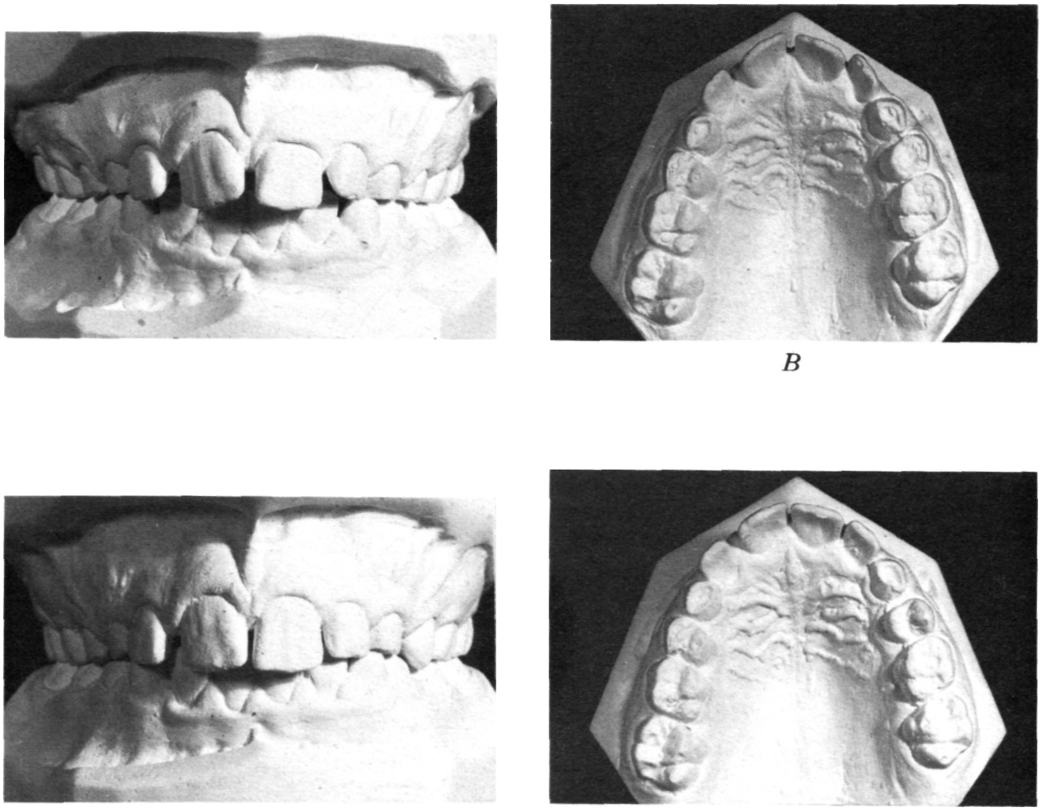


Fig. 5.7. *A,B,* A patient aged 8 years with rotation of the upper central and lateral incisors. *C,D.* The teeth were aligned with self-supporting springs on the labial side and torque springs on the lingual side.

ROTATION OF PREMOLARS AND MOLARS

A common misplacement of the upper first premolar is to find the lingual cusp rotated mesially and biting buccally to the lower first premolar *(Fig.* 5.9, *A, B).* Rotation of the upper premolar by swinging the lingual cusp distally will produce correct occlusion *(Fig. 5.9, C,D).* This rotation may be performed by pressing firmly on the mesial surface of the tooth opposite the lingual cusp. The buccal cusp rests against the mesial surface of the tooth behind and the tooth rotates about its point of contact with the second premolar *(Fig.* 5.10, *A, B).* It will be noticed that here only one force is used and that the place of the second is taken by a fixed point, the point of contact, between the first and second premolars. There is, therefore, in this case not strictly a couple but a force rotating about a point. The value of the force for rotation purposes is given by the *moment* of the force about this point.* As the distance between the line of action of the

* 'The tendency of a force ... to turn a body round a given point .... is measured by the product of the magnitude of the force and the length of the perpendicular drawn from the point on its line of action, this product. . . being called the moment of the force about the given point' (Borchardt W. G. *A School Certificate Mechanics and Hydrostatics).*

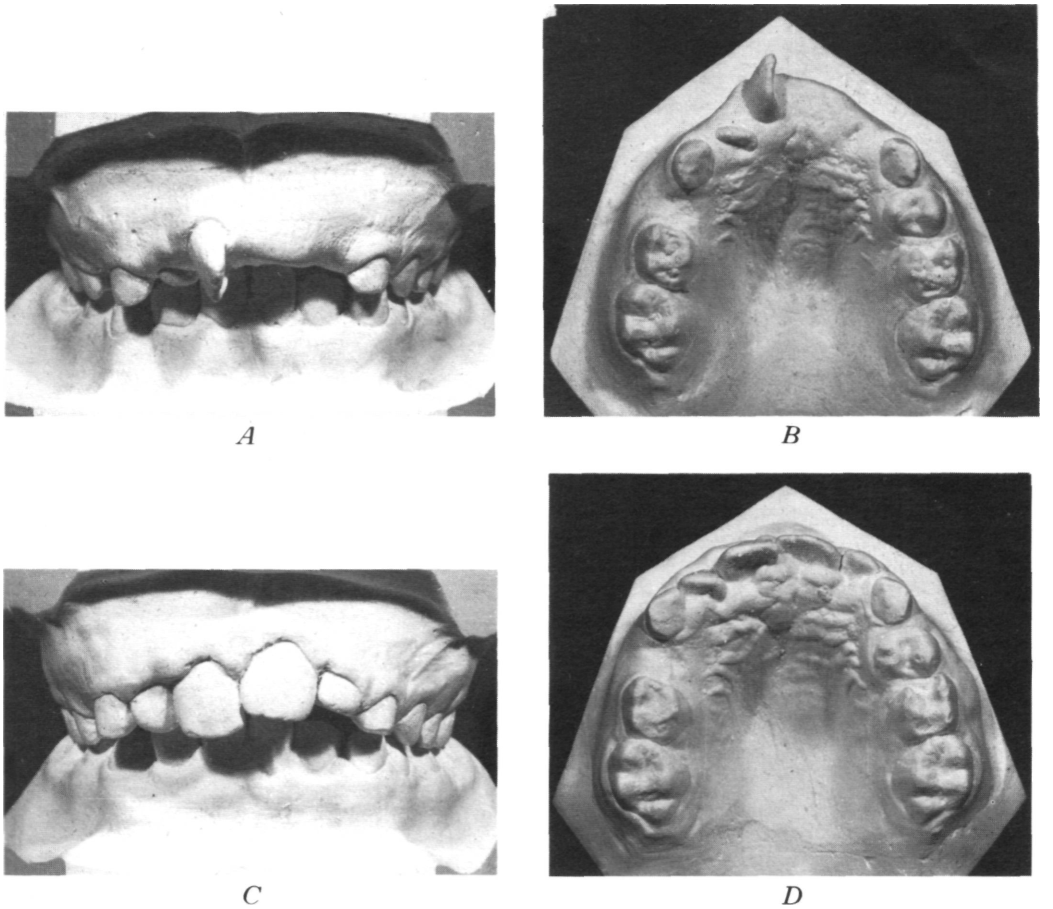


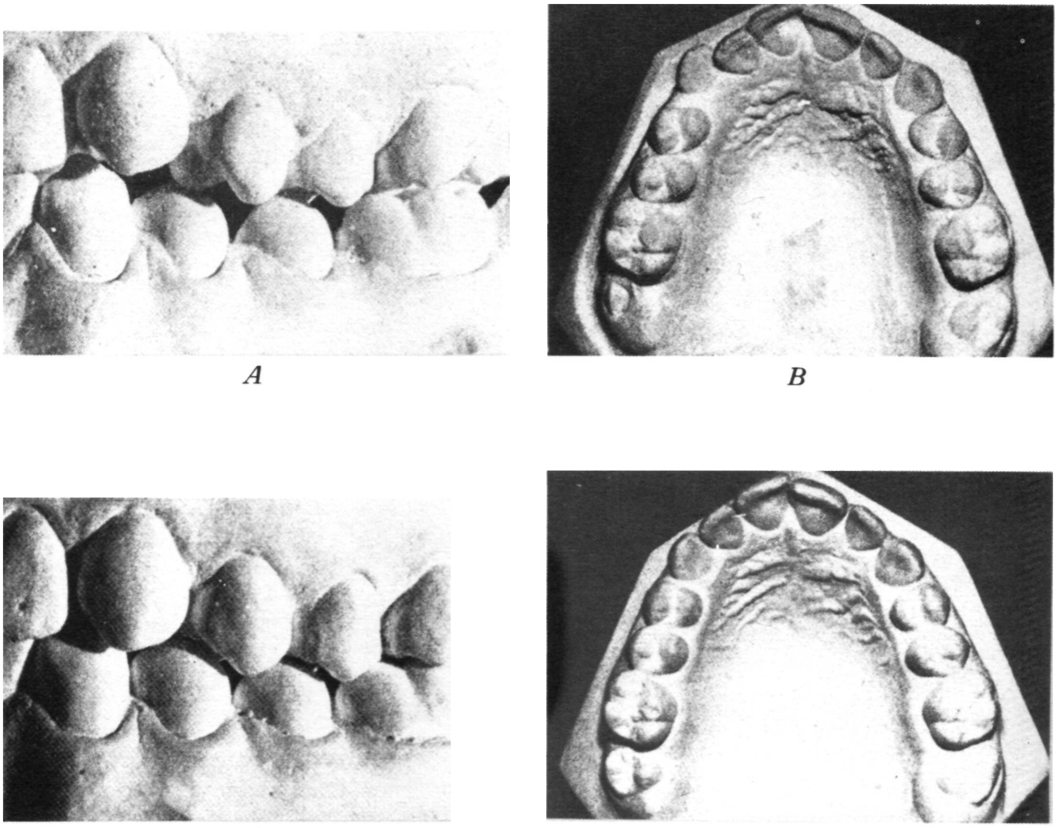
Fig. 5.8. A patient aged 8-5 years who presented with i| rotated 90 ° and [l unerupted; \l was exposed and erupted without any difficulty; il was rotated with a removable appliance and the two incisors remained satisfactorily in line. The patient had an underlying postnormal occlusion which was eventually treated by conventional means. *A, B,* Before treatment of j. *C, D,* At end of treatment.

force and the point is comparatively small, the value of this moment is low, hence the rotating effort is small. It is found clinically that rotations such as this take a considerable time.

Another common tooth misplacement is the mesiolingual rotation of the upper first permanent molar, which considerably reduces the space required for the second premolar *(Fig.* 5.11, *A).* This tooth may be rotated distally by pressure on the mesial surface opposite to the mesiobuccal cusp *(Fig.* 5.11, *B).* Rotation takes place about the palatal root *(Fig.* 5.11,C).

ROOT MOVEMENT

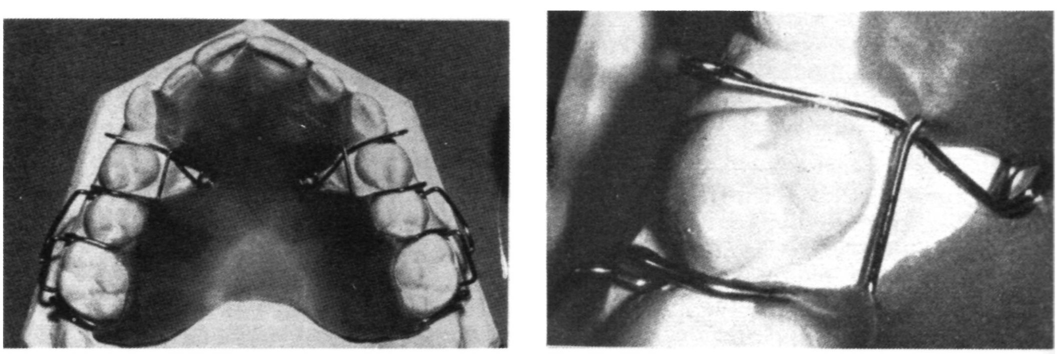
This term refers to the tipping of apices in one direction or the other, a movement that is usually performed with most of the fixed appliances. If it is desired to tilt the roots of an upper incisor mesially or distally, this may be done by applying equal and opposite pressures to the mesial and distal surfaces of the crown of the tooth near the incisal edge and at the cervical margin *(see Fig.* 1.7).



A B

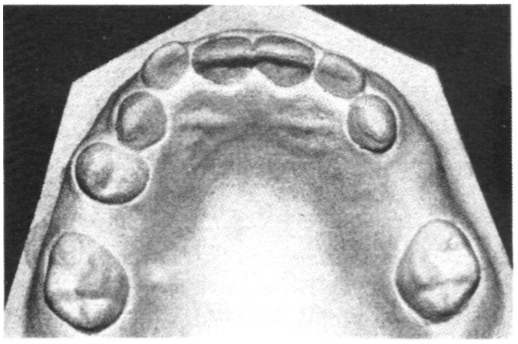
C D

Fig. 5.9. *A,B,* Distal rotation of upper premolars to produce correct occlusion with lower premolars. *C, D,* After rotation there is improvement in first premolar occlusion.

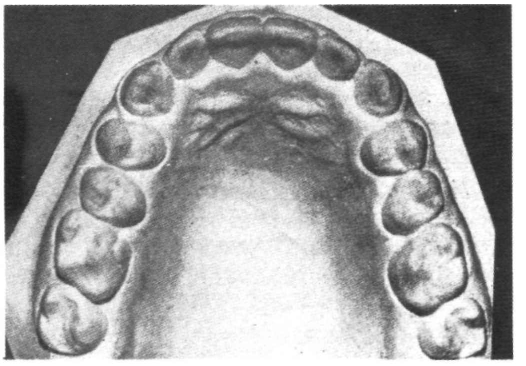


A B

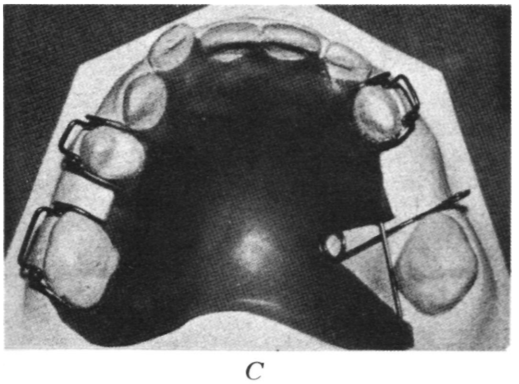
Fig. 5.10. *A,* The appliance to produce distal rotation of upper first premolars about the contact point with the second premolars. *B,* The point of application of pressure on the first premolar.



A



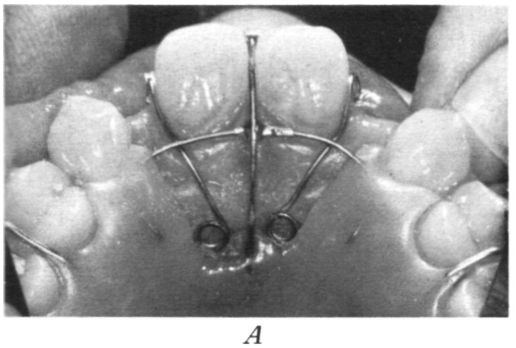
B



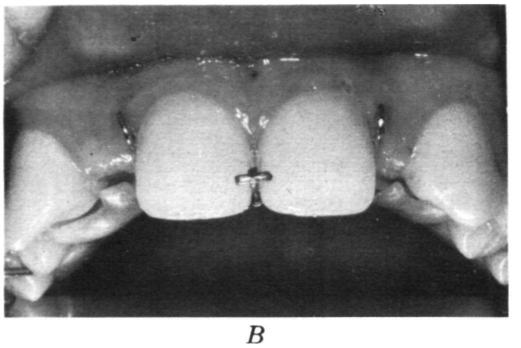
C

Fig. 5.11. *A,* Distal rotation of an upper first molar about the palatal root to make room for the second premolar *(B). C,* The spring to produce distal rotation of the upper first molar.

Fig. 5.12 *(A)* shows the palatal view of the two finger springs which press with equal and opposite pressures at the cervical margins of the central incisors in a mesial direction. The incisors have been tipped together but are prevented from moving further mesially at the incisal edges by the stop wire of 0.7 mm stainless steel with a little T piece on the labial aspect of the teeth. This arrangement also prevents the teeth from overlapping under the pressure at the distal surfaces *(Fig.* 5.12, *B).* If this appliance is adjusted and worn carefully, the apices of



A



B

Fig. 5.12. The mesial tipping of the apices of upper central incisors. *A,* A stop and restraining piece have been put near the incisal edges between the central incisors. *B,* The finger springs act at the gum margins.

the incisors will become tipped together *(Fig.* 5.13). The patient shown in *Fig.* 5.13 was aged 17 years and had excellent occlusion apart from absence of 2|2. The central incisors had spaced out as shown but the rest of the dental arch showed interproximal contact between the teeth.

The lingual tipping of upper anterior tooth roots is a movement which is usually thought of in connection with fixed multiband appliances. Bass (1975) has shown that it is possible to perform this movement by pressure in a lingual direction at the gingival margin on the incisors while preventing lingual movement at the incisal edges by using a Sved bite-plane *(see Fig. \.1,E).*

An appliance for this purpose is illustrated in *Fig.* 5.14. Clasps should be placed well forwards to ensure accurate fitting of the Sved bite-plane and it is as well to clasp the first molar teeth also. The spring shown acts on both incisors but separate springs may be placed on each tooth. The spring is really a double-ended cantilever of 0.6 mm wire and its short length and small coils render it fairly strong in action. In practice only a short activation is given and as a bodily movement is being effected, fairly firm pressure can be used. Tubes may be soldered to the first premolar clasps and extra-oral traction may be used to reinforce anchorage at night time.

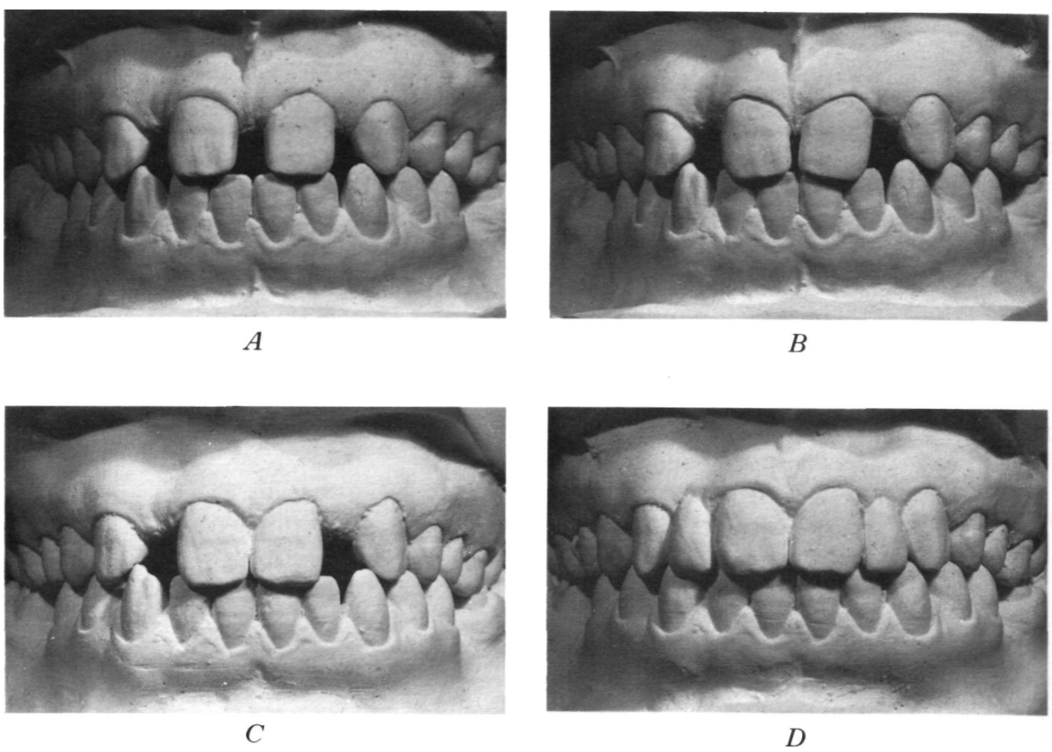


Fig. 5.13. Upper central incisor space closure and root alignment in a patient aged 17. *A,* Before treatment. *B,* The incisors have been inclined together. *C,* The apices have been tipped mesially. *D,* A prosthesis has been fitted.

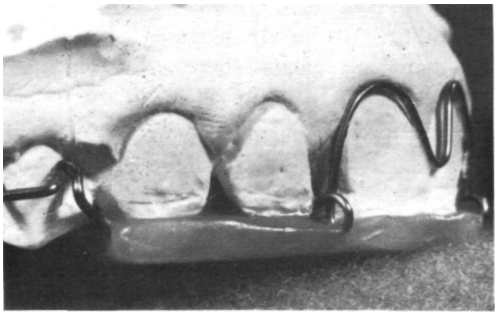


Fig. 5.14. Lingual root torque on upper incisors. A Sved plate is used and pressure in a lingual direction is applied by a double cantilever spring as shown or single springs may be used on each tooth. (With acknowledgements to Bass, 1975.)

The baseplate must be left thick enough behind the incisors so that it can be cut away to allow the teeth to tilt lingually at the apices.

Teeth which do not present points at which pressures may be applied to produce rotatory movements may be rotated and tipped by means of a whip spring locked into an attachment banded or bonded to the tooth.

A box-type of attachment was used by Watkin (1933) for his modification of the pin-and-tube appliance and a box attachment in stainless steel was described by Friel and McKeag (1938) *(Fig.* 5.15). This box was well known as the 'McKeag box.'

The McKeag box has been used for not only the Watkin pin-and-tube appliance, but also for the whip spring to develop tipping and rotatory moments on single teeth.

The McKeag box was, for many years, available commercially and presses and pliers could also be procured or were made up by practitioners for the fabrication of the device as required. There has, however, been a move towards currently available precision attachments which are sometimes pressed into service for use with the whip spring. Being designed for attachment to an

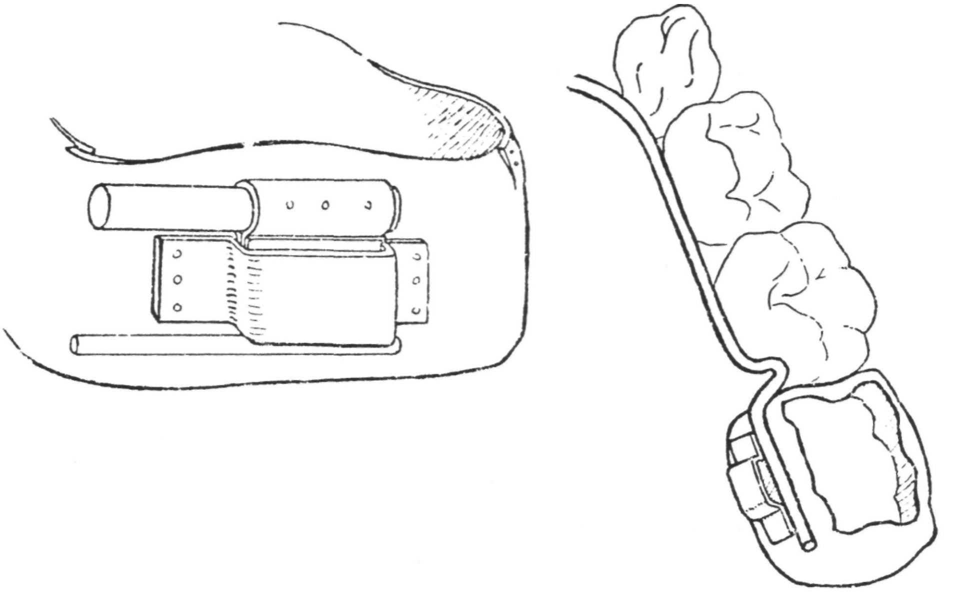


Fig. 5.15. The McKeag box. This box accepts a post 3 x 0.6 mm. It is pressed from strip and welded by a flange at each end. Introduced originally for lingual arches of 10 mm wire. (Reproduced by kind permission of the European Orthodontic Society.)

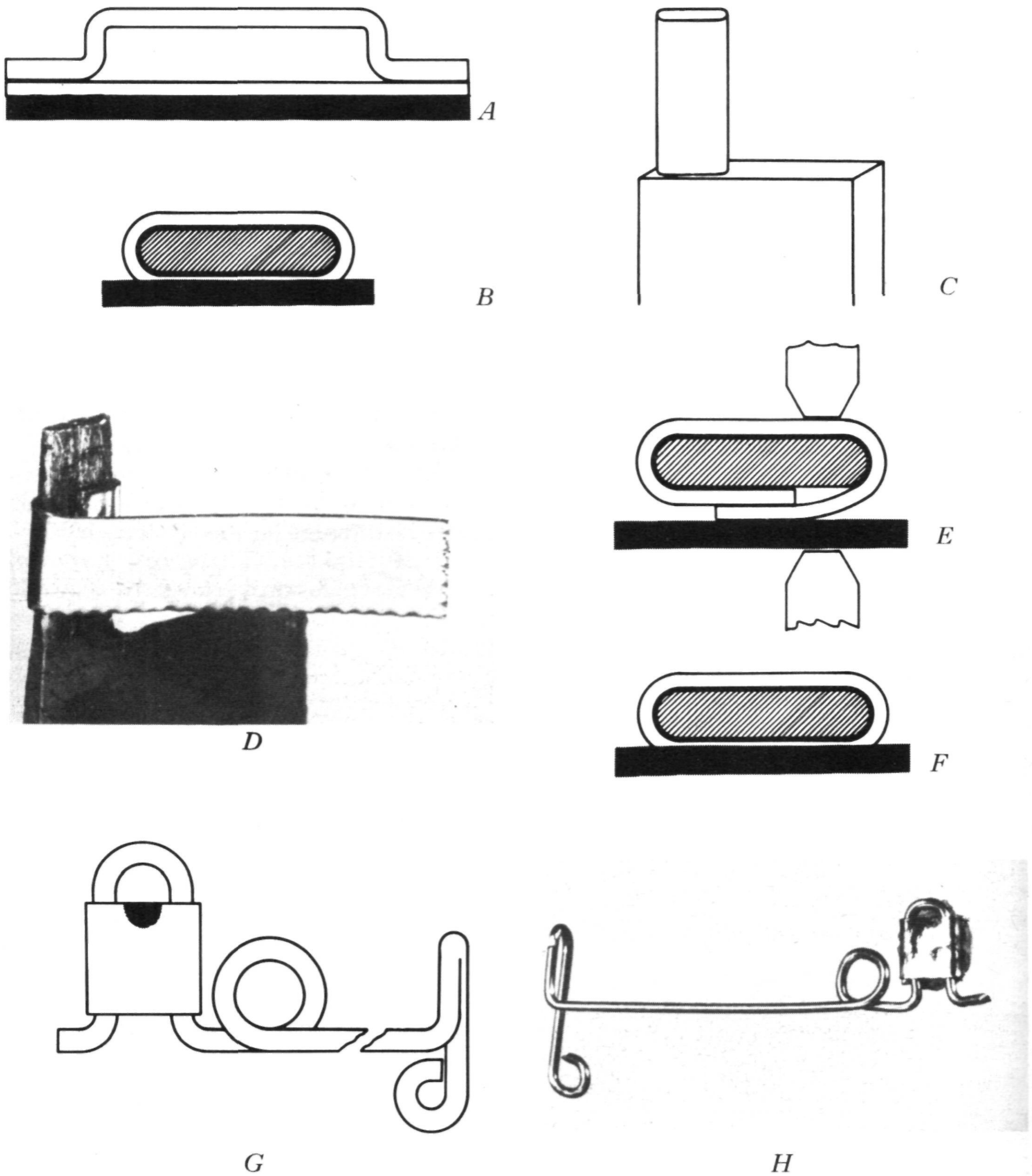


Fig. 5.16. The construction of the Minibox. *A,B,* The dimensions of the Minibox. The Minibox *(B)* is narrower and flatter than the McKeag box and is made for posts 2.5 x 0.5 mm in size. The Minibox is wrapped round the post and welded directly to the band or backing material. *C, D,* The Minibox is made by wrapping band material 015 mm thick and 0.3 mm wide round a former of copper. The former is filed from copper strip and is made 0.5mm thick, 2.5mm wide and about 40mm long. The edges are rounded. Band material is wrapped round (D) and cut off and flattened down. *E, F,* Welding the Minibox. The box is welded right through to the band or backing. The copper former conducts the current but does not weld to the steel. The box is then pressed and rocked off the former. *G, H,* The whip spring is made of 0.5 or 0.4 mm wire and held in the box by a slight dent at the top edge. The spring is removed by pinching the curve of the post against the bottom edge of the box with spring-forming pliers.

archwire that passes through, however, it is not always a simple matter to fix a whip spring firmly enough to eliminate lost motion in the attachment. The Minibox, however, is a simple and effective successor to the McKeag box and brings the advantages of compactness and greater strength and the fact that no equipment is needed for its production.

Fig. 5.16 *(A)* shows that the McKeag box is pressed from strip stainless steel with a flange at either end for welding to a band and, today, to a backing for bonding purposes. The standard box is made for a post 30 mm wide and 06 mm thick. The flanges and thickness of the material of the box make a total width for the attachment of about 5.0-6.0 mm. When welded to a band or bonded to a tooth, especially a small tooth, such an attachment is unduly bulky and difficult to fit to the contour of an anterior tooth in particular. Also the attachment is made for too thick a post as the preferred wire for a whip arch is 0.5 or 0.4 mm.

The Minibox, however, does not have flanges but is wrapped around the post, in this case a U loop, and is welded directly to the band or to the backing, without flanges (Fig.5.16,B).

The construction of the box is of the utmost simplicity. *Fig.* 5.16(C) shows a strip of copper with a post filed at one end. The post measures 05mm thick and about 2.5 mm wide and is filed using a fine jeweller's file. The post should be about 4.0 mm long.

To make a Minibox, band material of 015 mm thickness is wrapped round the copper post using Howe pliers, and the excess cut off *(Fig.* 5.16,D). The Minibox is then welded to a band or to a gauze backing

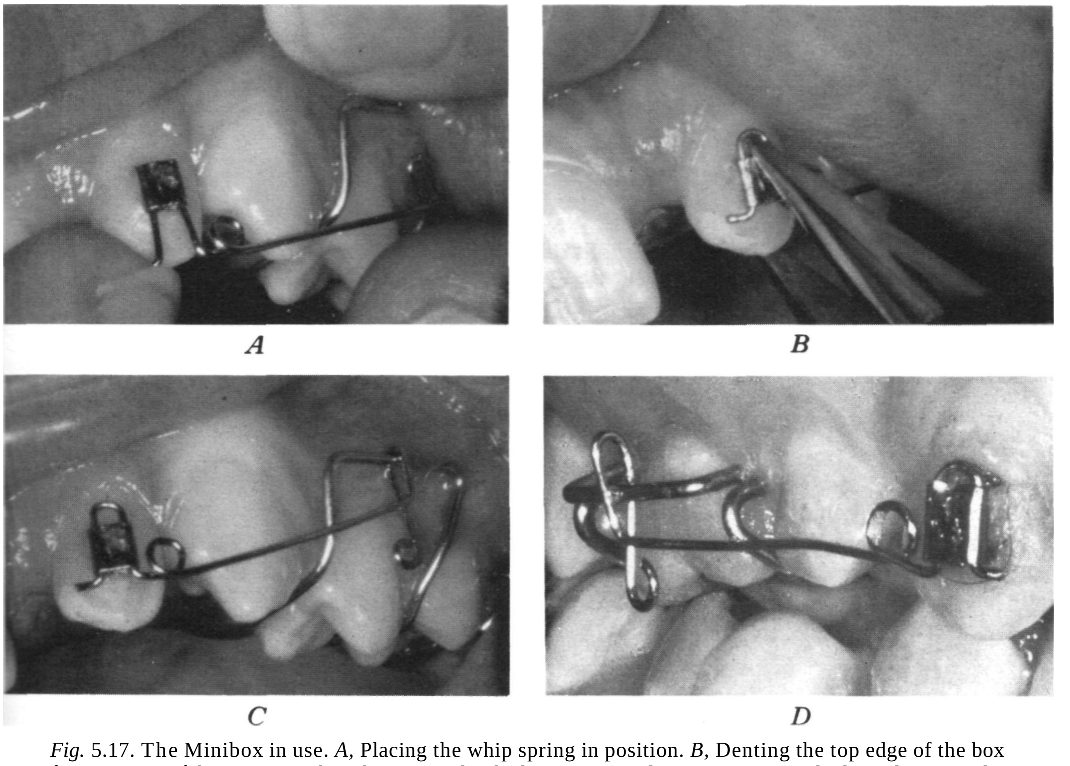


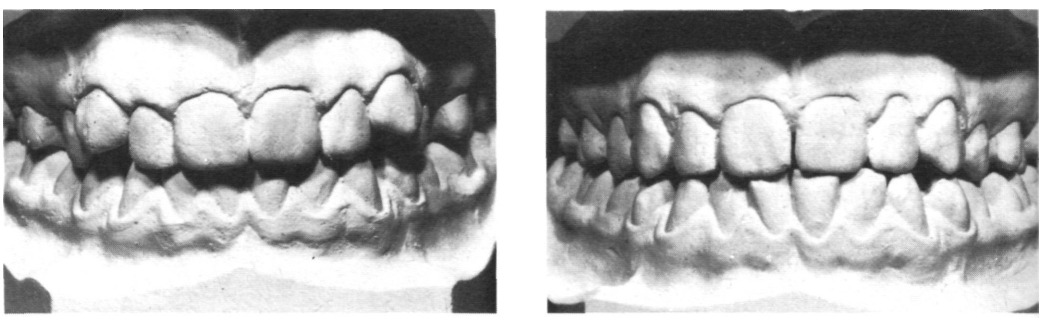
Fig. 5.17. The Minibox in use. *A*, Placing the whip spring in position. *B*, Denting the top edge of the box for retention of the post. *C*, The whip spring hooked onto a special wire support on the baseplate. *D*, The whip spring used for rotation of a canine tooth.

(Fig. 5.16, E). The copper post conducts the welding current but does not weld to the steel band material. The box is then carefully pressed and rocked off the post and the backing trimmed to the size of the box *(Fig. 5A6,F).*

The post of the spring is a U loop which should be made to fit the box with a little tension to ensure absence of 'slop' or lost motion.

The whip arch fits as shown in *Fig.* 5.16 *(G, H)* and the spring is locked into the box by slightly denting the top edge. A bottom edge of the box with spring-forming pliers when the post will snap past the dent in the top edge. The post is then gently rocked out of the box. The free end of the whip spring is looped onto the bridge of a clasp or a loop of wire can be placed in the buccal sulcus especially for the purpose.

The appliance is shown in use in *Fig.* 5.17. With this attachment, teeth may be rotated and tipped as required using a molar clasp or a loop of wire placed a short distance away in the buccal sulcus. It is also possible to hook a whip spring onto a labial bow where the



A *B*

Fig. 5.18. Rotation and distal root tipping of 3|3. *A,* Before treatment. *B,* After treatment.

slight dent only is needed. The box should not be flattened in or else the post will be very difficult to remove. To remove the post, the curve of the U is pinched against the direction of rotation requires an attachment towards the front.

Fig. 5.18 shows the correction of rotated upper canine teeth.

Chapter 6

Expansion/Contraction

Orthodontic expansion of the dental arches has long been a subject of controversy. There is still debate as to whether arch width and size are determined by facial build or by the moulding activity of the soft tissues of the face and mouth. A factor broadly known as the *compensatory capacity* of the alveolar structures to carry the teeth into satisfactory arch form has been suggested and breakdown of this factor is brought forward as the cause of unsatisfactory tooth arrangement which must include, in some cases, lack of width of the arch form.

There is no problem regarding arch width if the occlusal relationship is correct bucco-lingually and the form of both the individual arches is a smooth harmonious curve.

Today it is generally agreed that expansion of both upper and lower dental arches simultaneously is not a satisfactory procedure in view of the inevitable relapse that occurs to an unpredictable degree. It is sometimes maintained that rapid and extensive lateral expansion, particularly of the upper arch and involving separation of the mid-palatal suture, can be used to produce a permanent widening of the dental arches because of what is termed 'controlled relapse' to a predicted dimension.

The whole procedure must be looked at from the point of view of what is being attempted. It is sometimes maintained that crowding of anterior teeth is attributable to lack of arch width and that lateral expansion will produce space for the correction of such crowding. Lateral expansion of the arches does not produce significant space for the correction of anterior crowding, and in crowding conditions alignment of the labial segments without extracting teeth at some point to create space produces a rounding out of the anterior teeth into a wider circle by means of proclination of these teeth. Dental arch expansion, whether lateral or antero-posterior, tends to place segments of the dental arches in positions which are not stable and from which relapse of more or less degree will take place in the absence of some new stabilizing factor.

The main role of expansion is the possibility of correcting discrepancies of bucco-lingual occlusion by buccal or lingual movement of these segments as a whole by using expansion or contraction appliances.

It is here that the removable appliance is well fitted to operate and clasped expansion appliances can efficiently produce expansion or contraction of the buccal segments. It is important, however, to regard this movement as intended for the correction bucco-lingually of occlusal relationships rather than to gain space for anterior teeth by a general widening of the dental arch.

Anchorage problems do not as a rule arise, as expansion implies that simultaneous equal and opposite movements are being carried out. The force employed and its reaction are, therefore, both being made to do useful work.

LATERAL EXPANSION OF THE UPPER ARCH

Expansion of the upper arch can be carried out by means of a simple baseplate with a screw placed so as to act in a transverse

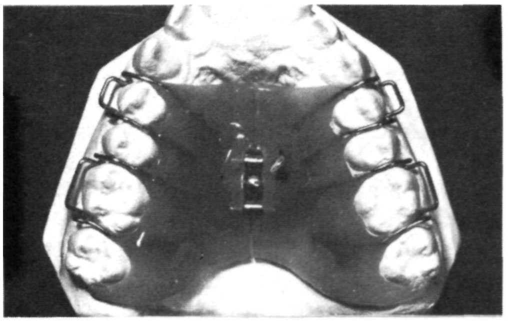


Fig. 6.1. The upper screw expansion appliance, generally known as the Badcok plate. An equal amount of expansion is produced anteriorly and posteriorly.

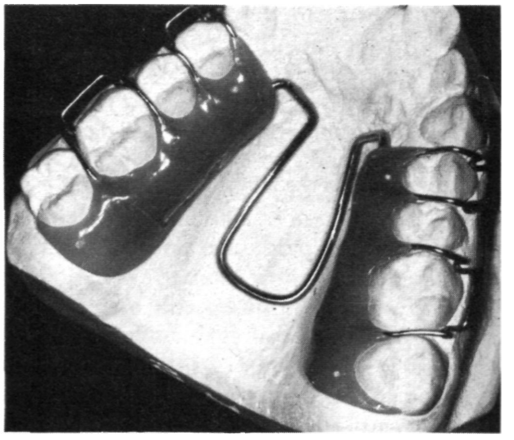


Fig. 6.2. The upper expansion arch or Coffin spring. The small registration pits can be seen anteriorly and posteriorly. The archwire is 125 mm thick.

direction *(Fig.* 6.1). The screw should be placed midway between the most anterior point and the most posterior point on either side at which pressure is to be exerted. This is necessary so that, as far as possible, leverage on the screw is avoided. Leverage leads to the imposition of bending forces on the screw and in consequence the risk of a fracture.

If different degrees of expansion are required at the front and at the back of the buccal segments an expansion-arch type of appliance should be used.

An appliance of this kind was described by Walter H. Coffin in 1881, and the arch or spring which produces the force or pressure is today commonly known as the Coffin spring.

Originally the baseplate was made in one piece and cut down the midline with a fine saw after vulcanizing. Present-day practice is to make the baseplate in two small segments, large enough to make contact with all the teeth to be moved and to contain the tags of the clasps and the ends of the archwire *(Fig.* 6.2).

The archwire is of 1.25 mm thickness and is formed with a generous loop in the centre; it stands 1.0 mm away from the soft tissue of the palate. The archwire is usually made first and the tags of the clasps looped over it before constructing the baseplate. Four small pits should be drilled with a very fine rosehead bur at each extremity of the baseplate, and these are used as registration points for recording, by means of dividers, the amount of expansion or activity given to the appliance before it is inserted.

The amount of activation given to such an appliance before insertion will depend on the length and thickness of the archwire and on the number of teeth being moved. Experience shows, however, that a range of activity of 2.0-4.0mm (1.0-2.0mm each side) is usually sufficient at a time, and further degrees of expansion are achieved by subsequent adjustments.

Before any adjustment is made to an appliance of this kind the width between the registration point anteriorly and posteriorly should be measured with dividers and recorded. The amount of expansion given to the appliance will then be known *(Fig.* 6.3).

Adjustment of the appliance is effected by grasping the centre of the arch with Adams universal pliers and squeezing firmly, when the anterior end of the appliance will expand *(Fig.* 6.4, *A).* Expansion of the posterior

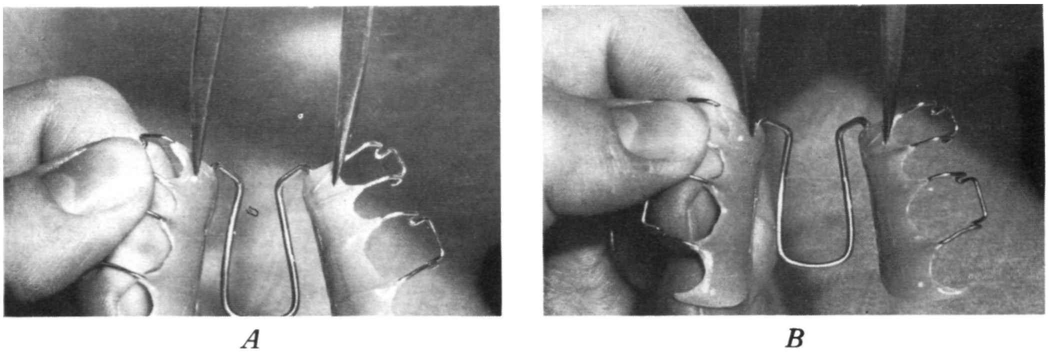


Fig. 6.3. Registration of the expansion imparted to the upper expansion arch. *A,* Before activation. *B,* After activation.

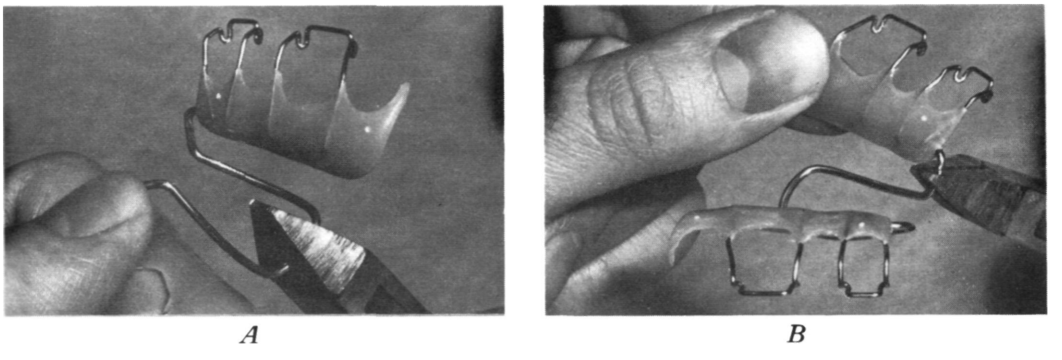


Fig. 6.4. Adjustment of the upper expansion arch. *A*, Slight straightening of the archwire at the spot grasped in the pliers produces an expansion at the anterior end of the appliance. *B*, Adjustment for expansion at the posterior end is effected for each side separately. The archwire is held firmly at the spot shown and the posterior end of the appliance moved laterally in a horizontal plane. The other side is adjusted similarly.

ends is done by opening the appliance at the back by the anterior ends of the arch. It is necessary to make this adjustment by grasping a straight section of the arch in the pliers and bending the distal end of the appliance laterally *(Fig.* 6.4, *B).* Making the adjustment by grasping a bend in the arch at the front with the pliers and squeezing it will not do, as the arch does not run horizontally in this section and making the adjustment in this way will tip the distal end of the appliance away from the palate as well as laterally. If both ends of the appliance are adjusted in this way and hence tipped, the effect will be to tip the loop of the arch into the palate. Making an adjustment at the anterior ends of the appliance by squeezing the archwire only is very likely to introduce warpage and distortion.

LATERAL EXPANSION OF THE LOWER ARCH

Lateral expansion of the lower arch can be effected with a screw type of appliance with the screw placed in the middle line behind the incisors *(Fig.* 6.5). With this arrangement, however, leverage on the screw is very great and any bending of the screw will result in lack of expansion at the distal parts of the arch.

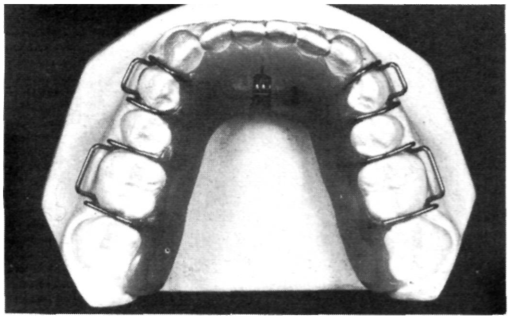
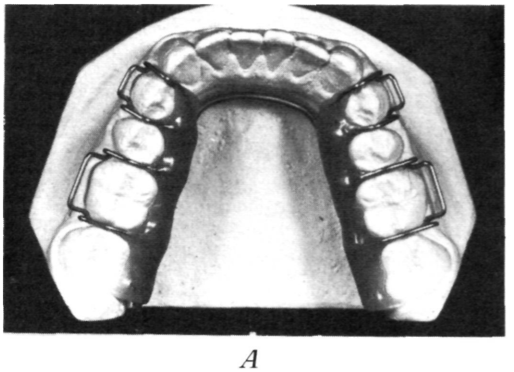


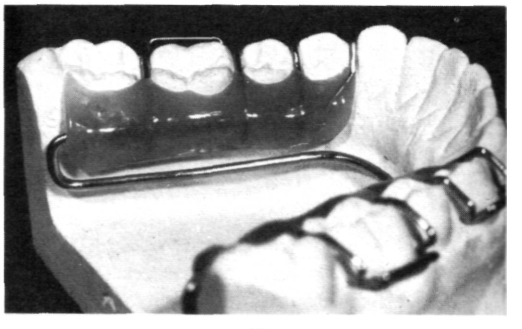
Fig. 6.5. The lower screw expansion appliance or lower Badcock plate.

A better arrangement is to use the expansion-arch type of appliance. Not only is this appliance efficient but an easily controlled difference in expansion can be produced anteriorly or posteriorly *(Fig.* 6.6).

As with the upper arch expansion appliance, the baseplate is only large enough to contain the ends of the arch and the tags of the clasps. The arch is 1.25 mm thick and registration pits are made at the ends of the baseplate. Adjustment of the appliance is done in much the same way as the upper type of appliance. The posterior ends of the appliance are expanded by grasping the curved horizontal middle section of the arch with Adams universal pliers *(Fig. 6.7,A).* Adjustment of the anterior ends is made for

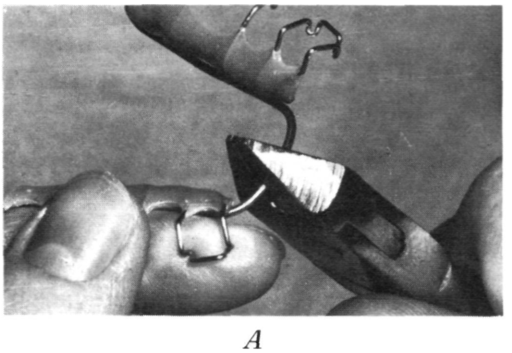


A

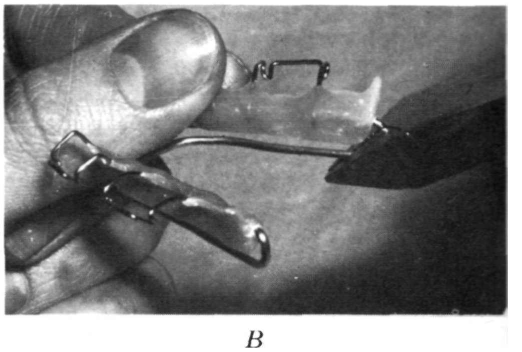


B

Fig. 6.6. *A,* The lower expansion arch or Coffin spring. *B,* The disposition of the arch in the premolar and molar region.



A

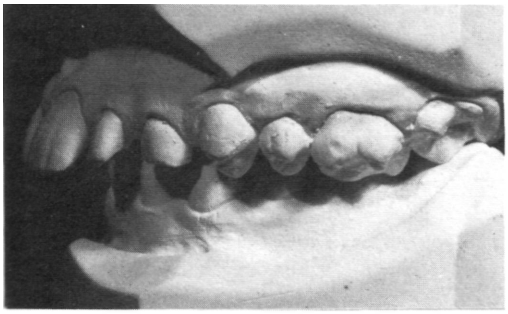


B

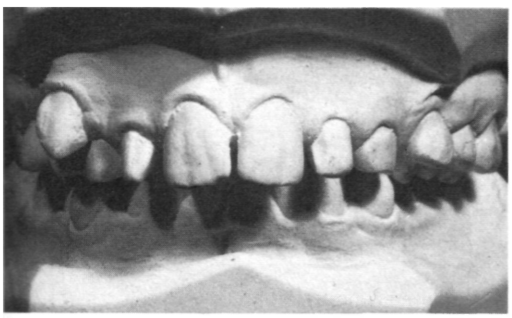
Fig. 6.7. Adjustment of the lower expansion arch. *A,* For adjustment posteriorly the middle section of the arch is straightened slightly by grasping firmly with Adams universal pliers. *B,* The anterior ends are adjusted by grasping each posterior end firmly as shown and adjusting the anterior end in a horizontal direction. Registration of expansion is carried out as shown in *Fig.* 6.3.

each side separately while gripping the distal ends of the arch firmly by a section that cannot be distorted by pressure of the pliers *(Fig.* 6.7, *B).* The range of activity should be about 2.0-4.0mm at a time, further expansion being done by subsequent adjustment.

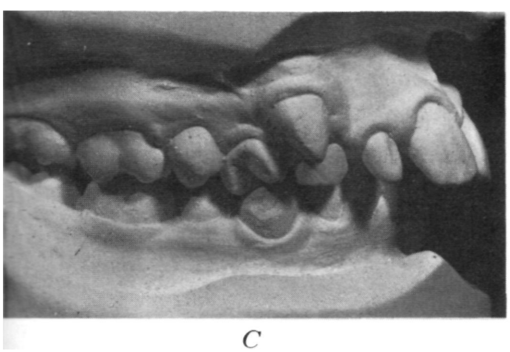
The cases shown in *Figs* 6.8 and 6.9 illustrate the adjustment of the width of one arch to match the other. In *Fig.* 6.8 the lower arch was expanded to match the upper and in *Fig* 6.9 this upper arch was contracted to match the lower.



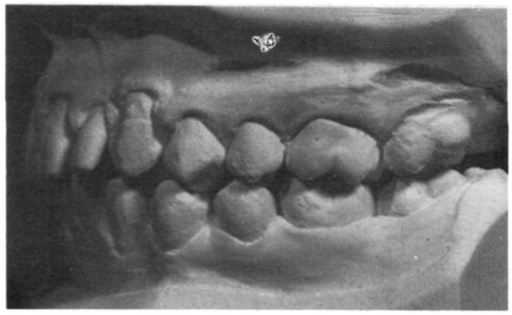
A



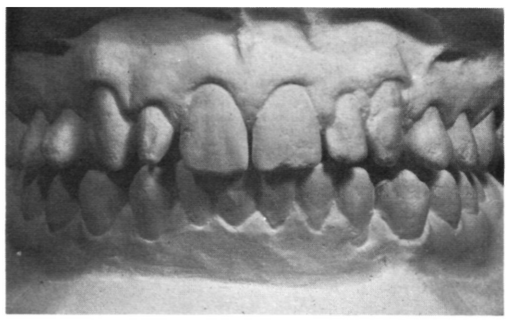
B



C



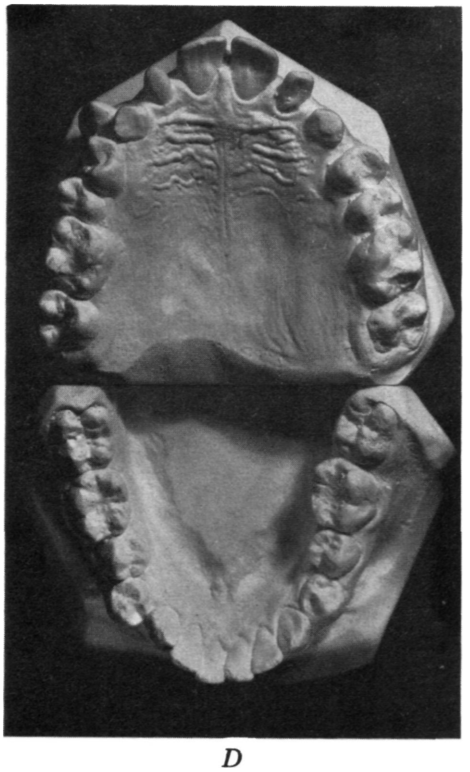
E



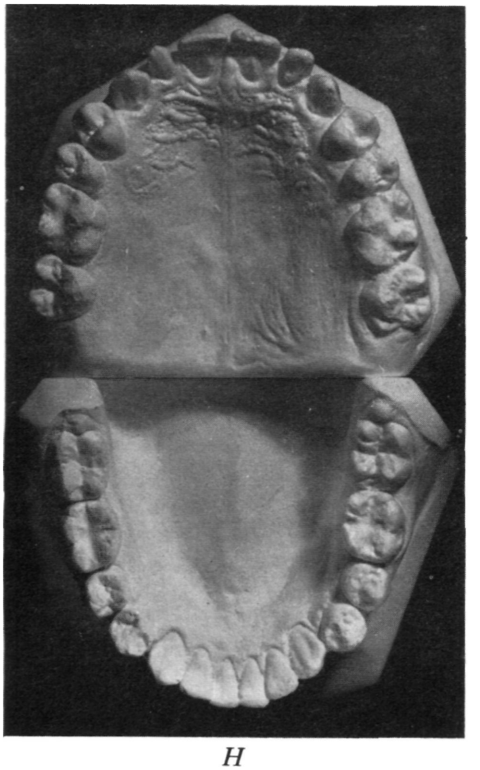
F

G

Fig. 6.8. The patient is a boy aged 13 years. *A, B, C,D,* before treatment. The problem included a very large upper arch with a severe irregularity in the right upper canine region and non-eruption of |3. Treatment included exposure of |3 and treatment to align the upper arch. The arch relationship buccolingually was corrected by means of a lower expansion plate of the Coffin type. *E,F,G,H,* Dental casts at age 18.

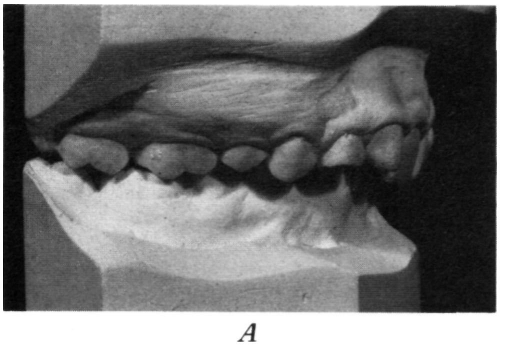


D

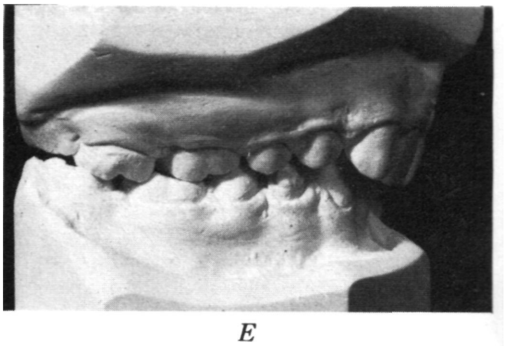


H

Fig. 6.8 (*cont.)*

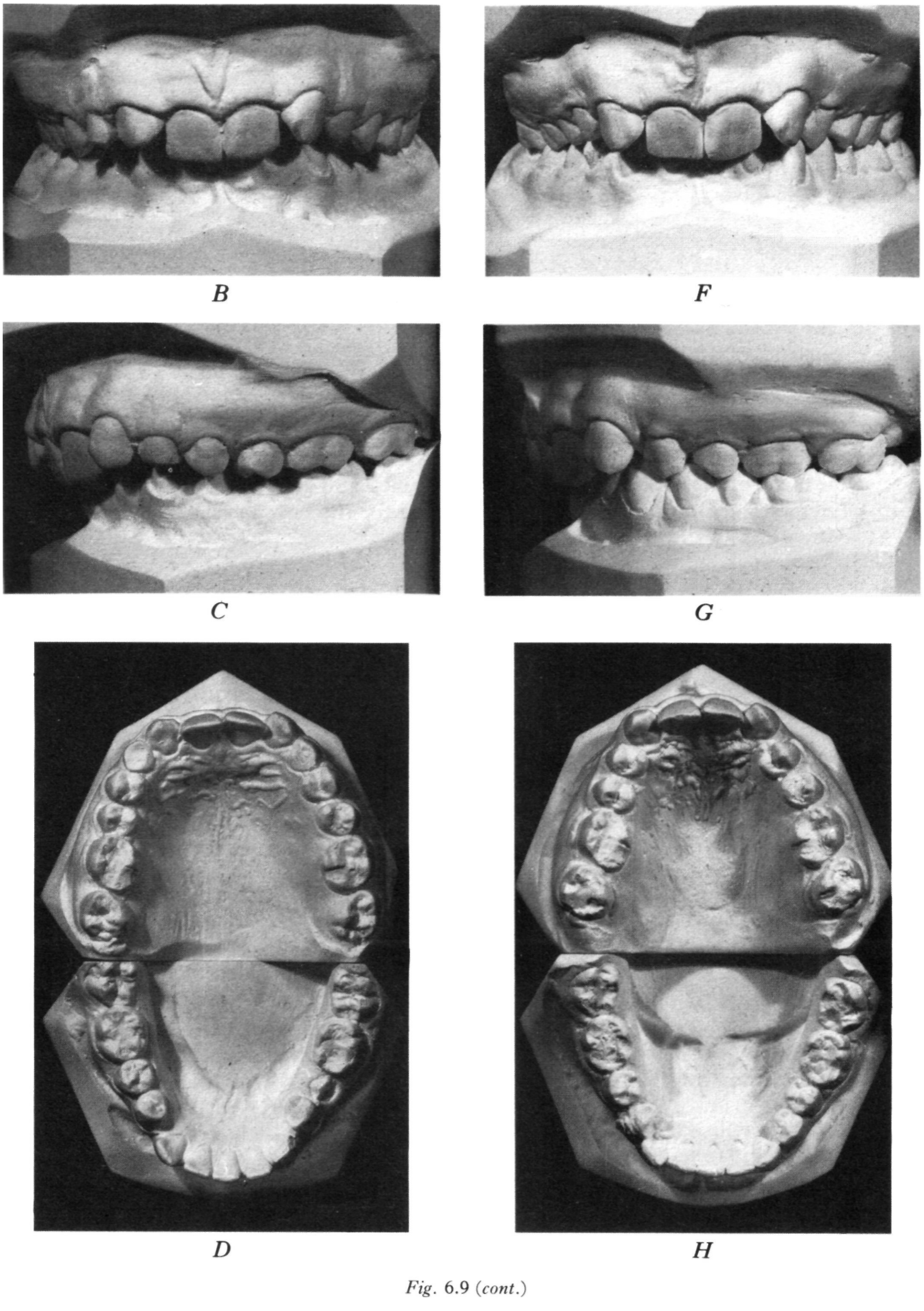


A



E

Fig. 6.9. Patient aged 12 with a well-arranged lower arch with spacing. The premolars are in scissors bite and the upper arches rather wide. Treatment entailed contraction of the upper arch using an appliance with clasps on first premolars and first molars and a bridge between the clasps to bring the second premolars lingually. Correct buccolingual occlusion was achieved and the lower arch was treated with a lower multiband to align |5. 2 2 are missing and 3 3 are to be aligned and suitably adjusted in shape. *A-D,* Before treatment. *E-H,* After treatment.



B F C G D H

Fig. 6.9 (*cont.*)

Chapter 7

Intermaxillary and Extra-oral Traction

The design of traction plates does not differ greatly from that of ordinary upper or lower removable appliances. Firm retention for the appliances is necessary so that four clasps on each plate are normally required. Where four claspable teeth are not present use may be made of the accessory arrowhead clasp to increase retention of the appliance. It is not so much that the appliance requires to be fiercely clasped to the teeth but that it needs to be positively supported at each corner, so that levering and tipping effects are resisted.

THE LOWER TRACTION APPLIANCE

The standard lower traction appliance is clasped on the first premolars and first permanent molars {*Fig.* 7.1). In some instances this retention is not available because the first premolar has not erupted. It is then necessary to put an auxiliary arrowhead clasp on a second deciduous molar. The lower traction hook on the first permanent molar may be of the standard type.

An indispensable feature of the lower traction plate is the labial bow (*Fig.* 7.2). This bow serves the purpose of preventing proclination of the lower incisors. The bow must lie accurately against the labial surfaces of the incisors and canines nearly at their incisal edge. These teeth are thus prevented from inclining forwards under the pressure exerted on them from behind and so become more resistant to movement than if they are simply permitted to tilt forwards. An element of 'stationary anchorage' is therefore obtained.

As the embrasures between the canines and the first premolars are already occupied by the wire of the premolar clasp, the tags of the bow are brought lingually between the canines and the lateral incisors. The wire used for the bow should be 0.6 mm.

UPPER TRACTION APPLIANCES

Upper traction appliances consist of a baseplate clasped to the first premolars and first molars and provided with a means of expanding the baseplate in a lateral direction (*Fig.* 7.3). This expansion mechanism is not necessarily provided for actively expanding the arch but is to permit expansion of the plate following the distal movement of the upper buccal segments. Distal movement is accompanied by expansion, because the teeth in moving distally move to a wider part of the arch. The expansion mechanism may be either the conventional screw or the Coffin expansion arch (*Fig.* 7.4).

The standard traction plate, clasped to the first premolars and first molars, is designed to produce distal movement of the buccal segments only. By dividing the operation of moving the upper arch distally into two stages, moving the buccal segments distally first, then retracting the upper incisors and canines separately, strain on the anchorage of the lower arch can be reduced.

When the upper buccal segments have been retracted and it is desired to retract the incisors and canines, a free-sliding labial

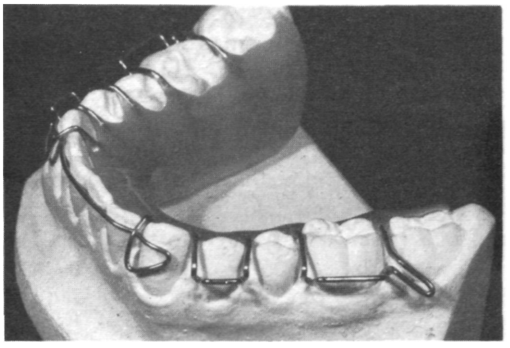


Fig. 7.1. The lower intermaxillary traction appliance with clasps on four teeth, hooks on the molar clasps and labial bow. The hooks may be welded onto the clasps as an afterthought but the hooks shown are stronger. It is also possible to place a loop in the bridge of the molar clasp to act as a hook.

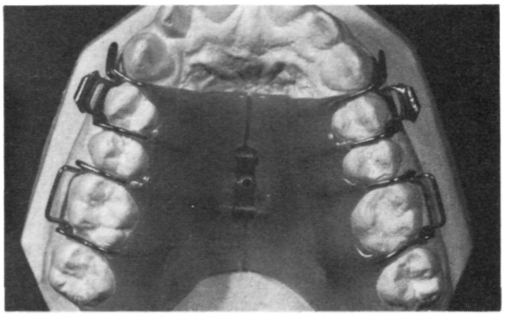


Fig. 7.3. Upper traction plate with screw, premolar hooks and tubes on premolar clasps.

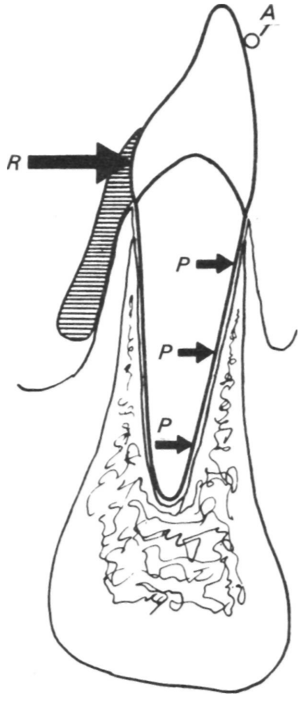


Fig. 7.2. The mechanical effect of the labial bow in the lower traction plate. The reaction *R* transmitted through the baseplate tends to procline the lower incisors. The labial arch *A* prevents proclination and converts the pressure on the lower incisors into pressure *P*, *P*, *P*, distributed evenly over the labial alveolar bone. An element of 'stationary anchorage' is thereby created.

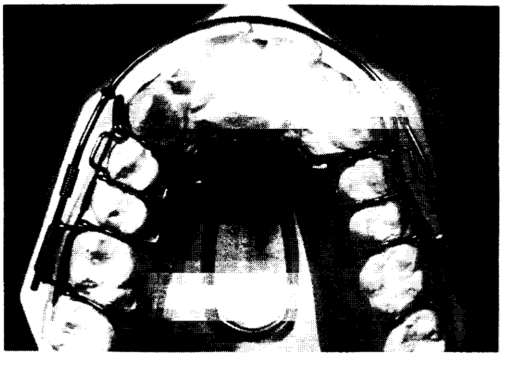
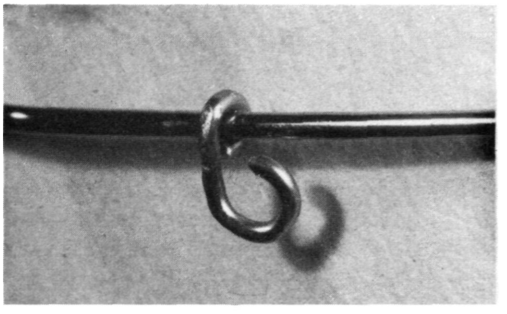


Fig. 7.4. Upper traction plate with hooks on premolar clasps, Coffin spring and free-sliding labial bow with stop hooks.

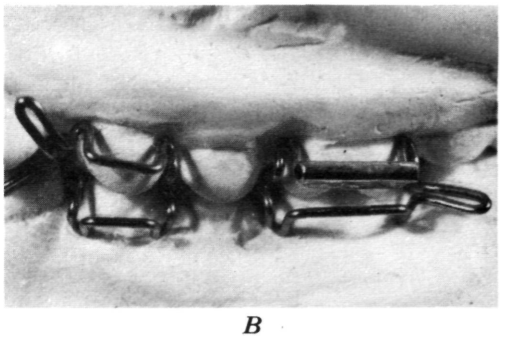
arch may be added to the upper appliance running in tubes soldered to the molar clasps. These tubes may be placed on the clasps from the outset in anticipation of the second phase of treatment or they may easily be added later when required.

It is necessary to make the free-sliding arch of wire 0.9mm thick to match the archwire with the tubing in order to ensure that the arch runs freely in the tubes.

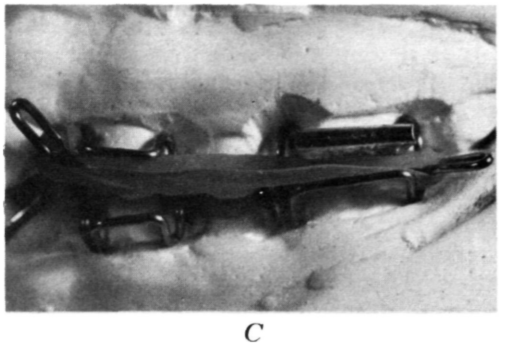
The traction hook on the buccal arch *(Fig.* 7.5, *A)* is also a stop for extra-oral traction. It is made from 0.7 mm soft stainless steel wire, welded or soldered, turned round the archwire. The free end is then turned backwards into a hook as shown.



A



B



C

Fig. 7.5. *A,* The stop hook. This is placed on a free-sliding labial bow. It is made of 0.7 mm soft wire welded or soldered to the bow and turned round it. The hook curls backwards and an extra-oral attachment can be hooked on in front *(see Fig.* 7.8, *D). B,* Intermaxillary traction hooks on upper premolar and lower molar. *C,* Intermaxillary elastic in place.

EXTRA-ORAL TRACTION

Extra-oral traction makes use of the anchorage of the back of the head and neck through the use of headgear. Headgear consists of a headcap or collar which distributes the reaction to the head or neck and contains the elastic element which stores the energy or force which is conveyed to the teeth.

Headcaps are open-work harnesses, formerly of leather or fabric, but today made of plastic products resembling one or other of these materials or with a smooth, hygienic surface. Cervical attachments are simple collars or straps to which are attached or in which are contained the elastic components.

Numerous variations of these devices are made commercially and recommended from time to time, each designed to make fitting and using easier and to overcome some particular difficulty.

Extra-oral headgear is connected to the intra-oral appliance in one of two ways. Either extensions of the intra-oral appliance are brought out at either side and elastics are looped onto them from the headgear, or else curved arms reach from the headgear into the mouth and hook onto the intra-oral appliance.

In the first arrangement, elastics are simply looped between the headgear and the extra-oral extensions or 'whiskers' as they are sometimes called, and in the second, arrangements must be made to ensure that the curved arm is guided and supported in the headgear. This means that some tubular section forms part of the headgear.

Today, ready-made headgear and extra-oral attachments are available, complete with instructions for their use. It is, however, possible to put together headcaps and cervical attachments using plastic belting material which can be cut to size and jointed using a hot knife. This can be done almost as quickly as assembling, adjusting and riveting the ready-made variety, and the finished result is more streamlined and certainly more economic especially if an assistant makes the headgear from measurements, which can be taken very quickly, for fitting on a subsequent visit.

Attachments can be made to such headgear by punching holes and by melting in hooks of stainless steel. Plastic tubing can be welded to the headgear for the guiding and controlling of curved arms. Cervical straps can be made of such belting and padded with foam strip joined with one of the impact adhesives or self-adhesive Sellotape.

THE CERVICAL ATTACHMENT

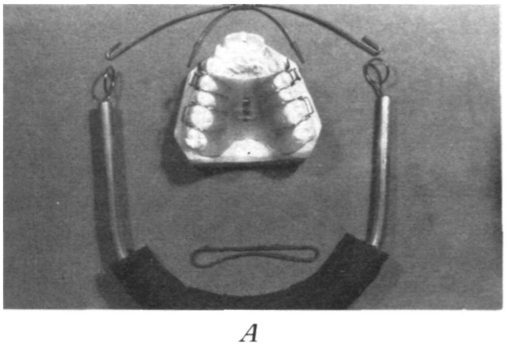
A convenient form of cervical attachment is the U-shaped aluminium tube with a foam rubber strip glued to it at the posterior part where pressure is produced on the back of the neck. This tube supports and guides the two extra-oral arms through which traction is brought to the intra-oral appliance, and contains the long elastic band from which the tension is derived (*Fig.* 7.6).

The details of the connection between the extra-oral attachment and the upper appliance will vary (*Fig.* 7.7).

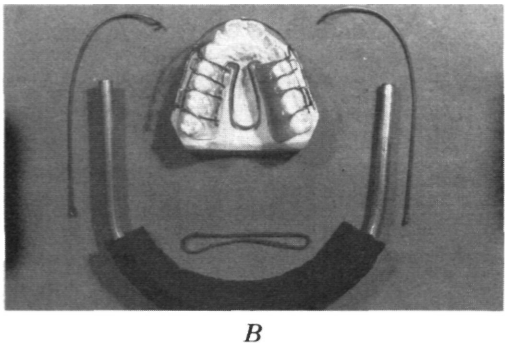
For the upper appliance that is being used only to retract the upper buccal segments it is most convenient to provide an attachment which plugs into tubes soldered to the first premolar clasps (*Fig.* 7.7, *A, B*). This attachment consists of a short labial arch made of 1.0 mm wire and provided with Trevor Johnson friction fit stops (Johnson, 1952) which hold it forwards and well clear of the labial surfaces of the incisors. The extra-oral bow is made from a single piece of heavy wire (1.25 mm), which is wrapped to the smaller arch with soft fine stainless steel wire (0.3 mm) and soldered. The ends of this bow are turned into convenient hooks. Traction is applied to the hooks by looping elastics over them or by forming loops on the ends of the arms that come from the cervical attachment.

Simpler cervical attachments are plastic strips with padding and elastics attached to holes or hooks (*Fig. 7.8,A,B,C*).

If the upper appliance is of the kind that is fitted with a free-sliding labial bow for retraction of the upper incisors, the arms which emerge from the cervical tube curve forwards and inwards and are formed into hooks which fit over the free-sliding labial arch and impinge on the front of the stop hooks (*Fig.* 7.8,D).



A



B

Fig. 7.6. Cervical traction appliances using a metal tube and cushion posteriorly. *A,* An extra-oral attachment is plugged into the premolar tubes. *B,* Extra-oral arms reach in to engage the free-sliding labial bow.

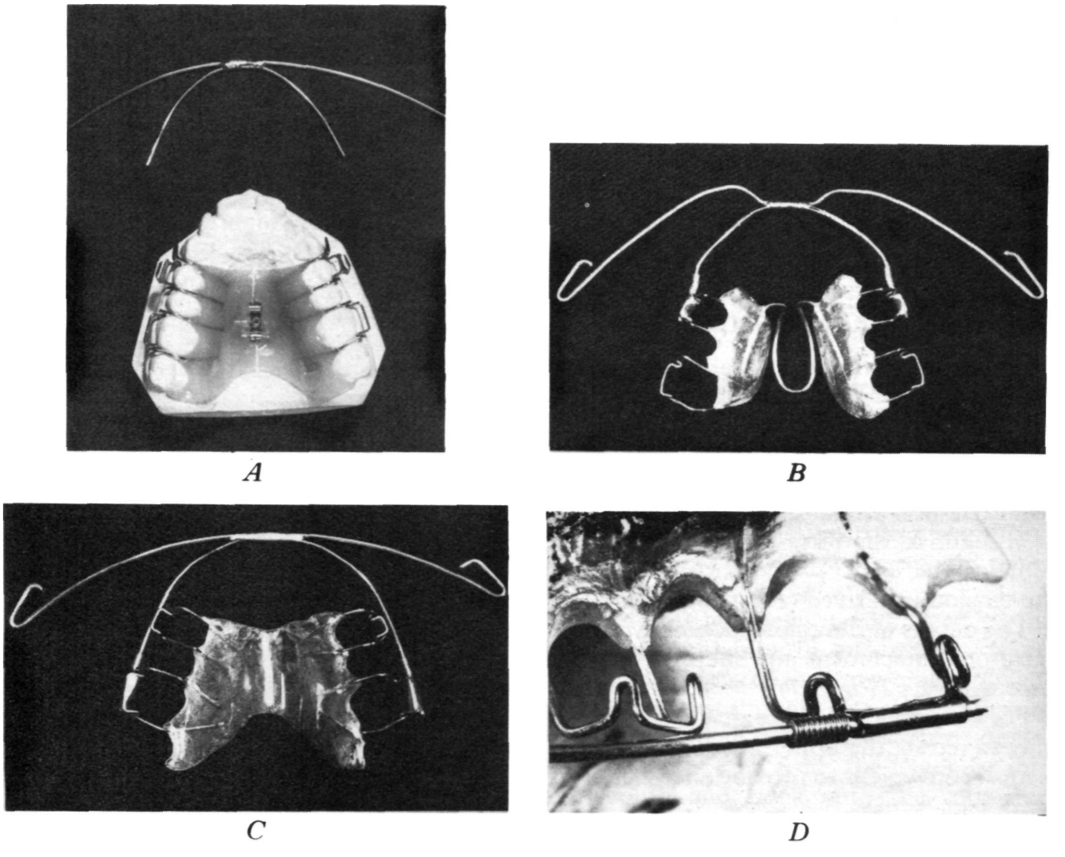


Fig. 7.7. *A,* The plug-in arch for tubes on the premolars. *B,* The Kloen extra-oral attachment. *C,* The standard extra-oral attachment plugged into tubes on the molars. *D,* Molar tube soldered to the clasp with a Johnson friction-fit stop on the labial arch.

THE HEADCAP

The headcap has the advantage that the direction of pull may be varied in a vertical direction and in some cases it may be thought better to have the pull coming from a higher point than would be possible with cervical traction.

Headcaps are best if of a simple design and consist of a coronal band, an occipital band and a sagittal connector. The lengths of these components are adjusted to determine the height from which the pull is exerted.

A headcap may simply offer a point at which an elastic is hooked or may embody a tube or sleeve which guides and supports an arm which reaches forwards and inwards to hook onto the intra-oral appliance.

The construction of the plastic headcap is shown in *Figs.* 7.9 and 7.10. Should there be any reason why plastic material cannot be used, the headcap can be made of webbing and sewn together as was formerly the normal practice.

There are three methods of attaching elastics to the plastic headcap: holes may be punched, through which different lengths of elastics may be looped at different points to adjust the strength of the pull; hooks may be

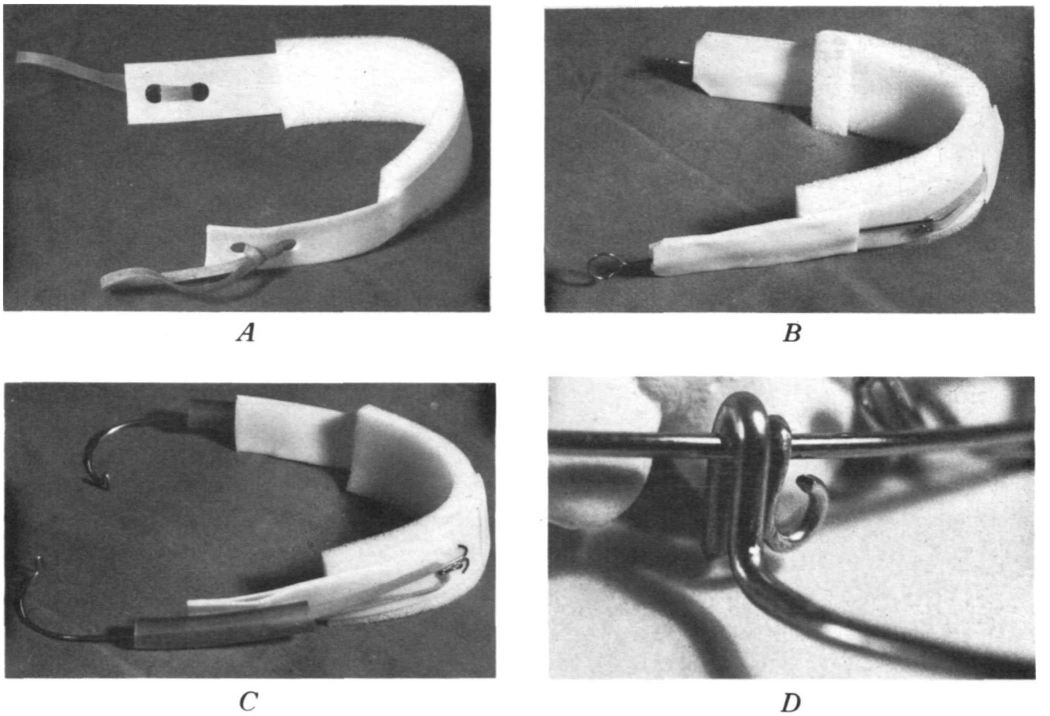


Fig. 7.8. Extra-oral headgear; the neckstrap. Neckstraps are made from plastic belting material and are jointed by welding with a hot knife or stuck together with double-sided Sellotape. *A,* The simplest neckstrap. The foam padding is fastened with Sellotape and the elastics looped into holes. *B,* Traction is conveyed to the 'whiskers' by wires with loops on the ends. The wires run within stainless steel tubing which lies in a sleeve of plastic belting. This gives a very smooth action. The elastic runs from side to side and is held in place by a cuff of belting in the centre at the back. *C,* Collar with arms running in plastic tubes. Individual elastics are used at either side looped on hooks melted into the plastic. *D,* The ends of the arms are formed into a U and hook onto the free-sliding archwire in front of the stop hook.

placed by heating the metal and welding them into the plastic; tubes may be welded on in which arms run and the elastic attached to holes, hooks or by slitting the end of the tube and jamming the elastic in the slit.

Extra-oral traction can be usefully employed in a number of other situations as, for instance, where reinforcement of intra-oral anchorage may be required. Such a need may arise, for example, where intra-oral appliances are being used for the retroclination of upper incisors and there is a risk of anchorage slippage. Another good example is where lingual root torque is being applied to the upper incisors as here there is a considerable forward reaction exerted on the teeth in the buccal segments. Extra-oral traction may also be applied to the lower arch in Class III malocclusion. The principles are the same; a baseplate is fitted and means found of extending the baseplate outside the mouth using a 'whisker' type of extra-oral attachment or by bringing the arms of the extra-oral traction apparatus inside the mouth and hooking it onto the appliance at some convenient spot.

Figs. 7.11-7.14 show a group of subjects in which intermaxillary and extra-oral traction were used in treatment.

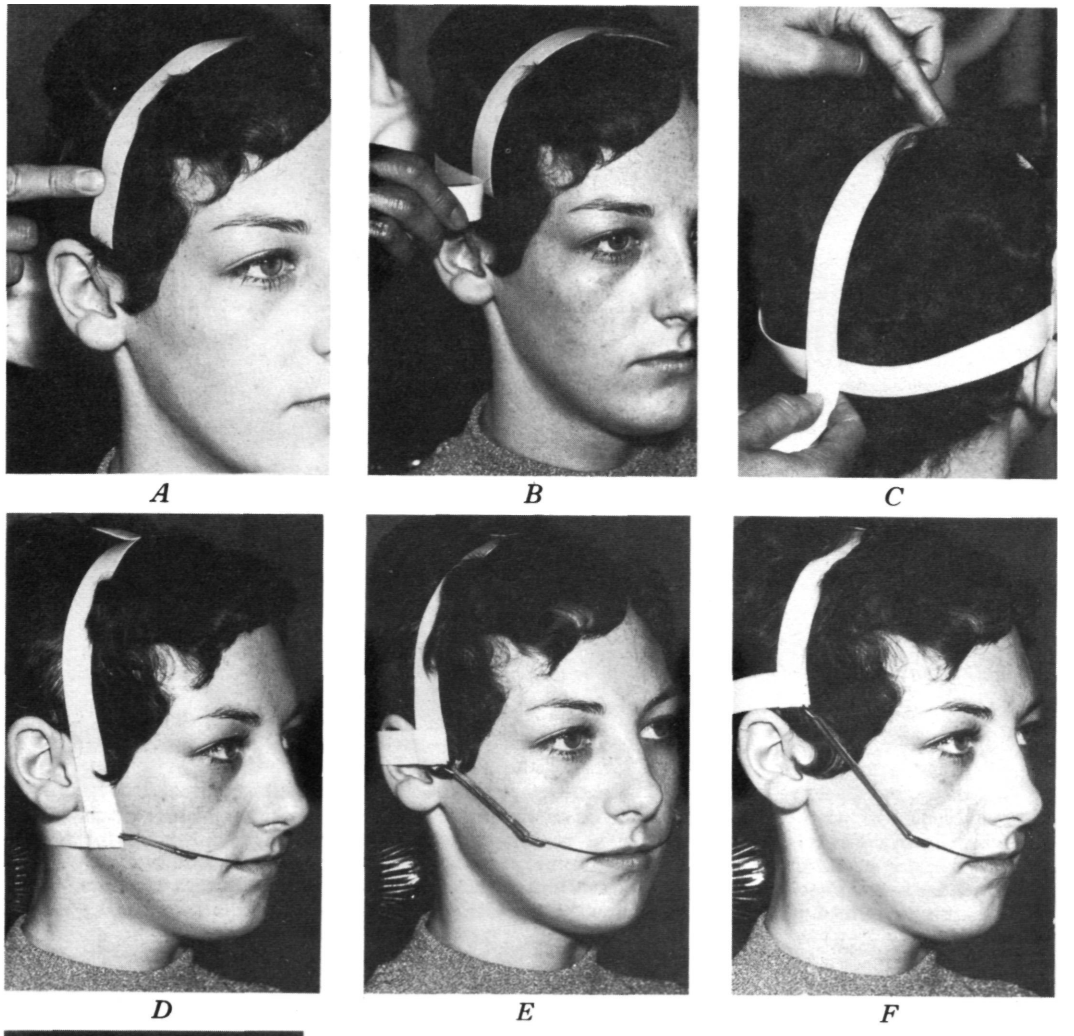


Fig. 7.9. Construction of the headcap. *A, B, C,* Measuring the tape. *D, E, F,* Low, medium and high-pull headcaps. *G,* Headcap with tube to guide the arm which reaches into the intra-oral appliance.

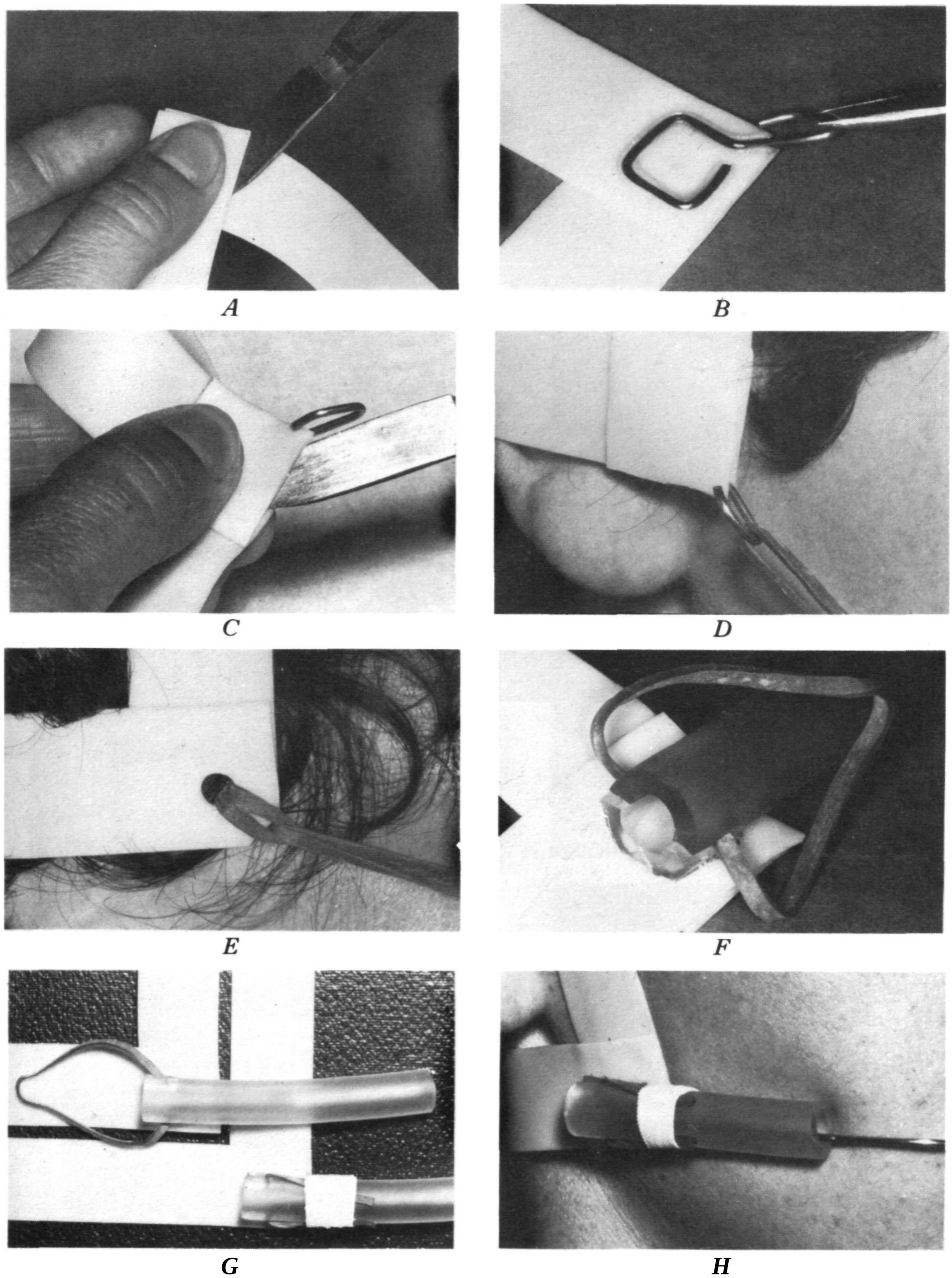


Fig. 7.10. Construction of the headcap. *A,* Joining the plastic tape with a hot knife. *B,* Melting in a hook *C,* Securing the hook with a patch of tape. *D,* The hook used for attachment of elastic. *E,* Attachment of elastic through a hole punched in the tape. *F, G,* Fixing elastic in a guide tube, the end of the elastic turned back, taped down with adhesive plaster. *H,* The guide tube with extra-oral arm in use.

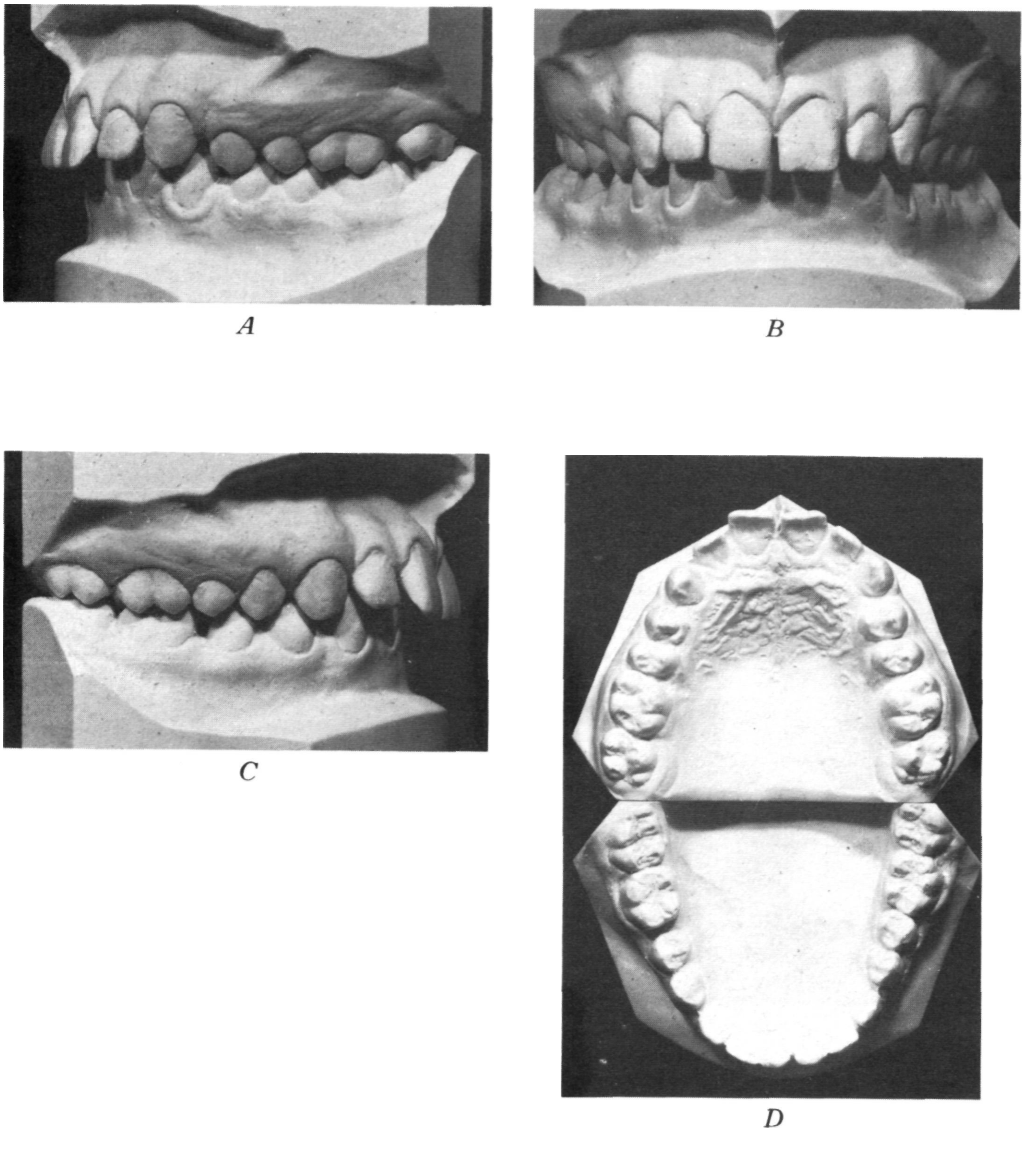
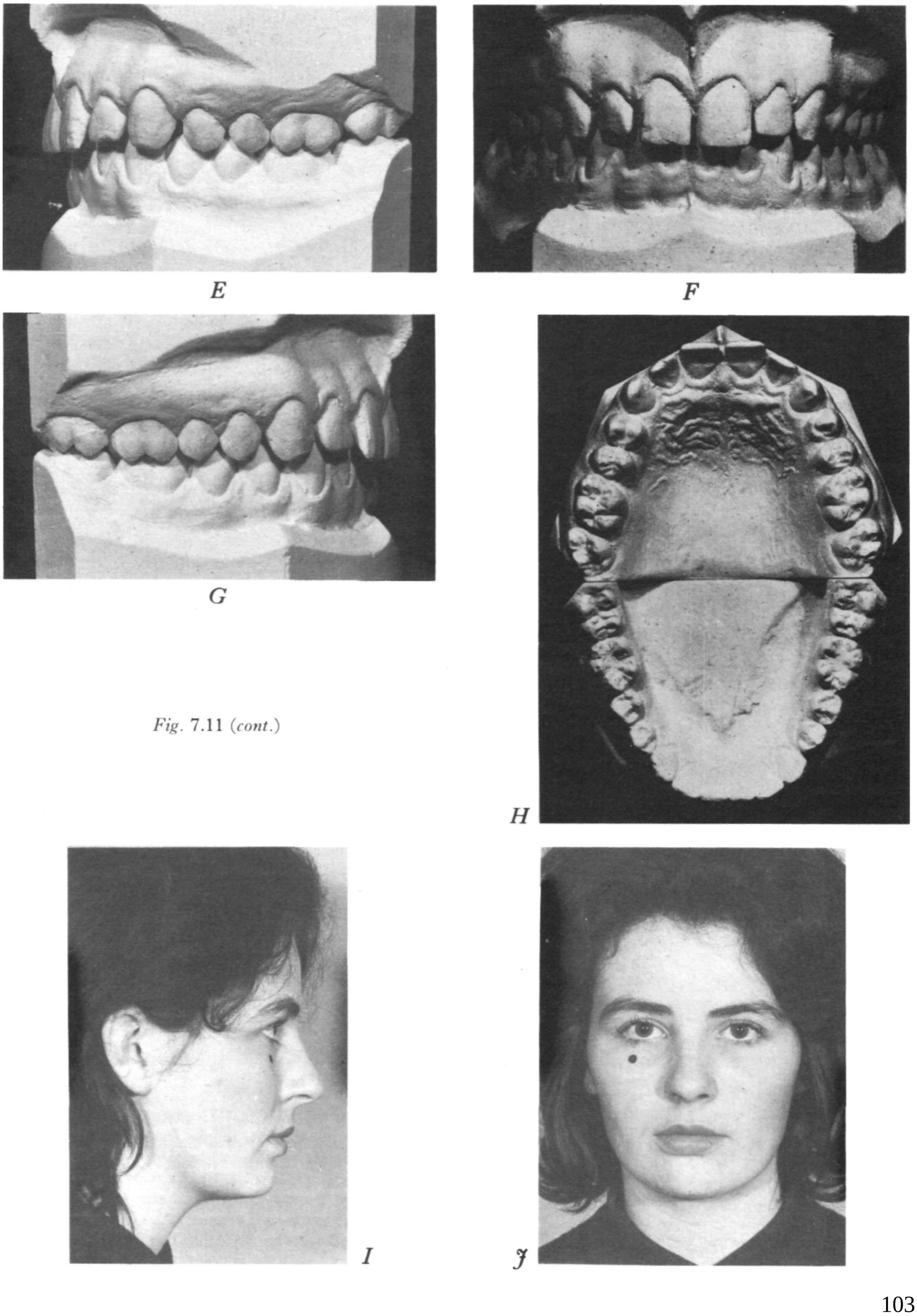
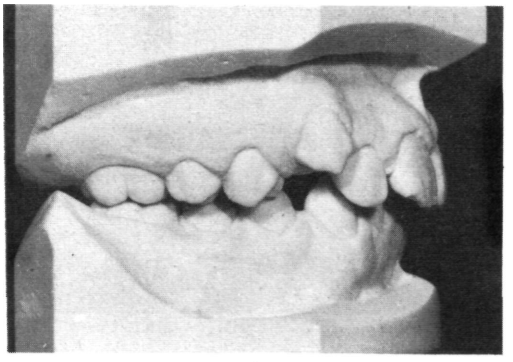


Fig. 7.11. Treatment of unilateral post-normal occlusion with unilateral intermaxillary traction. Patient has excellent arch form and dental base relation with spacing in upper and lower arch but was self-conscious about the upper incisor spacing and slight prominence. *A, B, C, D,* Before treatment. *E, F, G, H,* Appearance after correction of the unilateral malocclusion (5 years after treatment). *I, J,* Full face and profile (5 years after treatment).

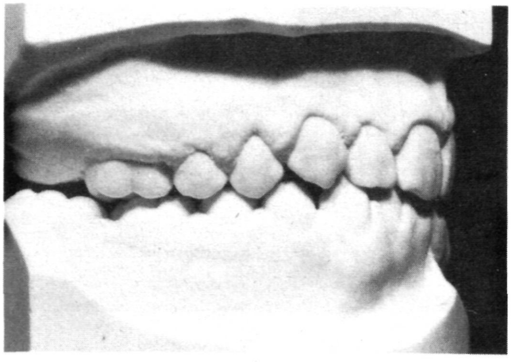


E F G H I J

Fig. 7.11 (*cont.*)

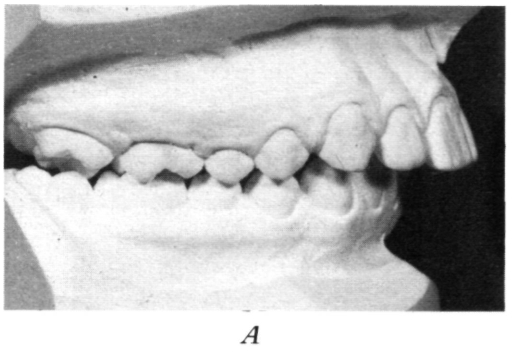


A

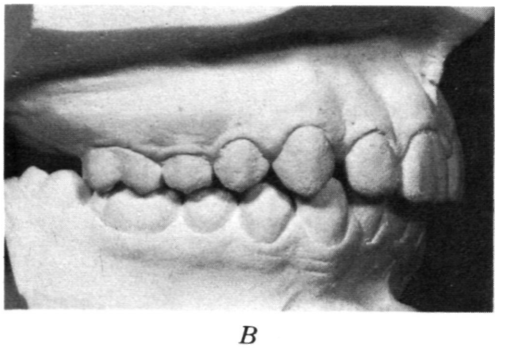


B

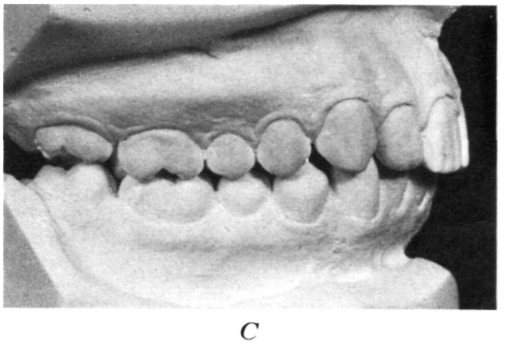
Fig. 7.12. Patient with prominence of upper anterior teeth and scissors bite on the right premolars. Treated with extra-oral traction and correction of scissors bite on the right side. *A,* Before treatment. *B,* After treatment.



A



B



C

Fig. 7.13. Classical Class II division 1 malocclusion. There was no spacing in the lower arch and it was decided to treat by extraction of upper second molars and extra-oral traction. *A,* Before treatment. *B,* Second molars have been removed and the arch discrepancy corrected by extra-oral traction. *C,* Upper third molars have erupted and the occlusion has stabilized although there was a very slight relapse.

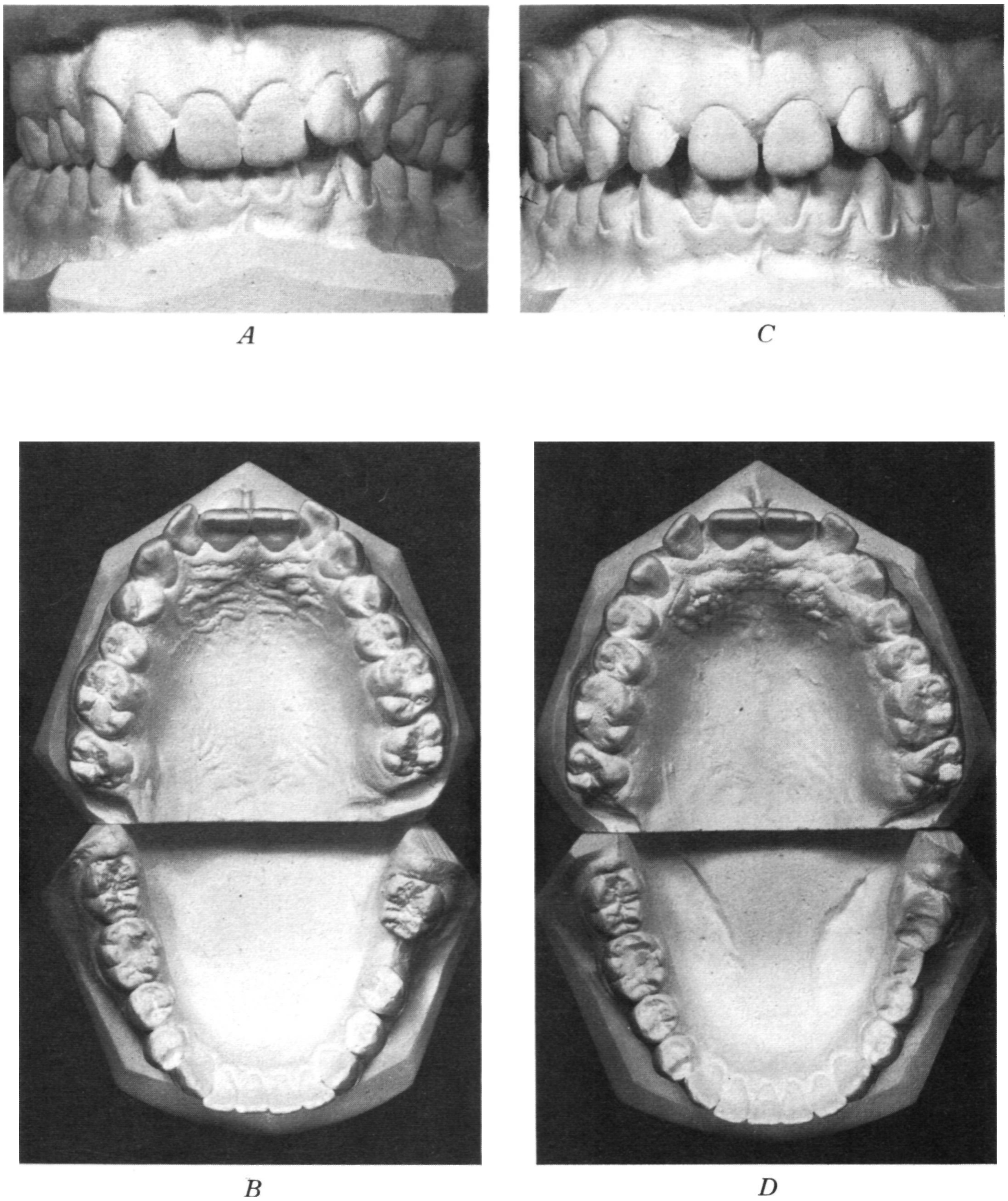
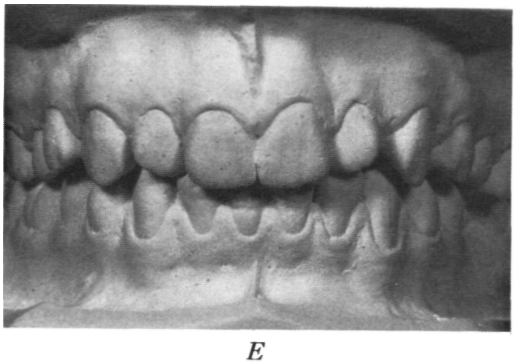
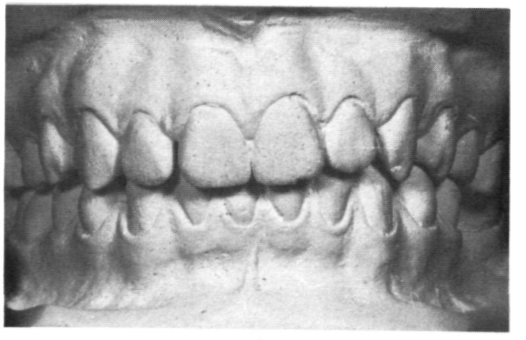


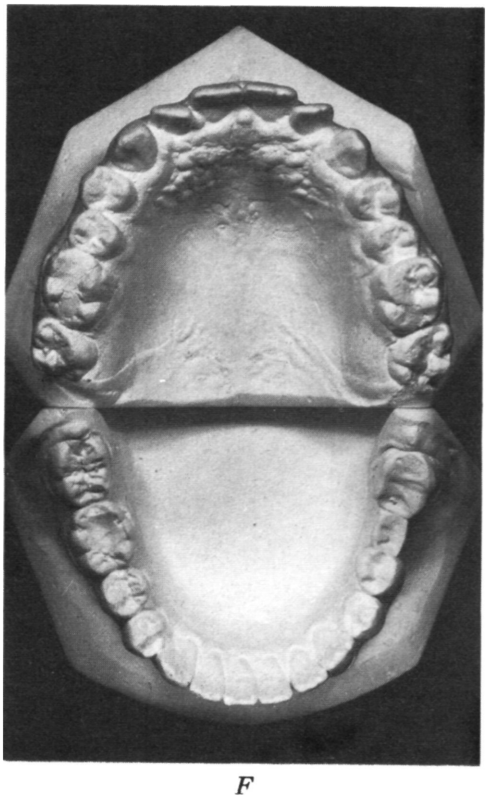
Fig. 7.14. Records of a patient aged 16 years with slight Class II division 2 malocclusion and absence of third molars. There were many restorations including the need for a bridge for [6. Lower arch form was excellent. A conservative approach was decided on by extra-oral traction with an upper removable appliance. *A, B,* Before treatment. *C, D,* Buccal segments have been moved distally and spacing has developed in the upper incisor region. *E, F,* The lateral incisors have been over-rotated mesiolingually. This position was maintained for 9 months with a removable appliance. *G, H,* Three years out of retention. Some lower arch restorations are being completed.



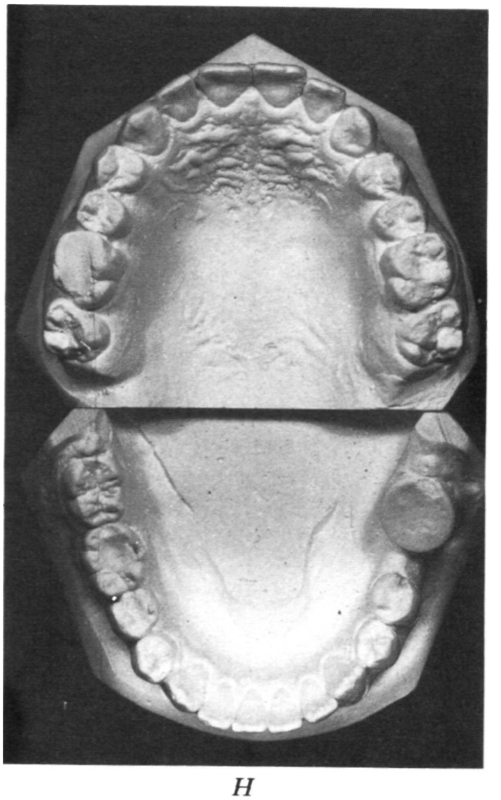
E



G



F



H

Fig. 7.14 (*cont*).

Chapter 8

Functional Appliances

Like the man who discovered that he had been speaking prose for years without realizing it, it is possible that orthodontists have for long been using functional appliances without thinking of the appliances in question as functional. Biting planes, whether flat or inclined, and the oral screen are functional appliances and the many, more complex, systems available today are extensions, elaborations and combinations of the two aspects of orofacial function employed in the 'plane' and the 'screen' type of appliance. Further activities introduced by the inclusion of elastic, pressure-storing elements into the appliances add a further dimension to the mechanical complexities.

Functional appliances act either through the media of the masticatory muscles, which have both their origins and insertions in bone, or through the craniofacial and lingual muscles, which have their origins or insertions or both in soft tissues.

Functional appliances can be either placed between and against the teeth, concentrating the pressures of the musculature on individual teeth or groups of teeth, or placed about the teeth, screening them from the pressures of the tongue, lips and cheeks.

Functional appliances may also combine these effects and by their presence in the mouth must inevitably do so in a more or less degree.

Another effect of functional appliances is to modify the pattern of movement of the mandible. This effect must occur coincidentally with many functional appliances and while the plan may be to devise means of influencing the positions of teeth, effects may also be produced on the mandible by accident. If the widest context is envisaged, then it is conceivable that effects may be produced on the face as a whole.

It is, indeed, such a concept that seems to inspire some of the more sanguine philosophies of functional appliance methodology in urging that appropriate functional therapy will engender facial development of a degree that can compensate for the all-too-obvious defects of nature in individual cases.

There is a parallel with the belief of Edward Angle that if the teeth were mechanically placed in correct relationships by fixed appliance therapy there would be a development of the facial structures to correspond with the new dental alignment (Angle, 1907 1910).

It would sometimes appear to be the belief of functional therapists that the same fortunate outcome is achievable by using the influence of function, which is one of the more important *raisons d'etre* of the organism, and that function is a more natural influence than mechanical treatment and thereby likely to be more effective.

The possible connections between functional appliance therapy and facial growth in general will be discussed in due course.

SIMPLE FUNCTIONAL APPLIANCES

The bite-plane and the oral screen illustrate in their simplest form the principles of functional appliances operating through, first, the muscles of mastication and, secondly, the musculature of the face and tongue.

Bite-planes

Bite-planes may be divided into planes which lie parallel to the occlusal plane and planes inclined at an angle to the occlusal plane.

Bite-planes lying parallel to the occlusal plane (sometimes called horizontal bite-planes) are designed to produce mainly axial stresses on the teeth. Such planes are intended either to prop the bite temporarily to facilitate certain tooth movements or to cause certain adjustments of the vertical relationships of the teeth.

Inclined bite-planes are designed to produce stresses lateral to the axes of the teeth and thereby lead to their movement in a lateral direction.

The anterior bite-plane

This consists of a platform behind the upper incisor teeth on which the lower incisors bite (*Fig.* 8.1). Formerly, the plane was simple in construction and was often used with a labial bow of heavy wire. The rationale of this arrangement has nowhere been expounded, but it seems implicit that as the pressure of the bite falls on the plane, the slopes of the cingula of the upper anterior teeth would cause the generation of an anterior component of force producing proclination of these teeth and a sinking of the baseplate into the gum tissues behind the upper incisors. The labial bow was intended to obviate these effects, but the arrangement is not efficacious and has been abandoned in modern practice.

The purpose of the anterior bite-plane usually is to reduce the overbite of the anterior teeth. It was formerly thought that the effect was brought about by depressing the lower anterior teeth into the alveolar bone but this is now known not to occur.

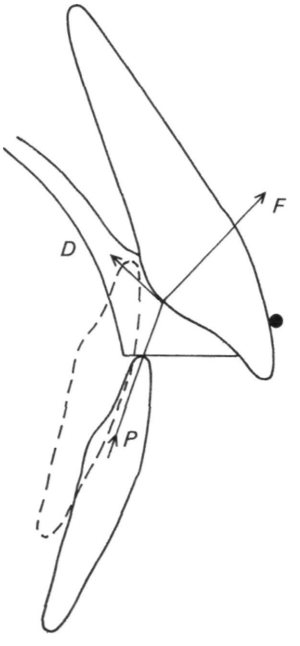


Fig. 8.1. The anterior bite-plane. Overbite is increased (dotted lines) and the anterior bite-plane is placed and the lower incisors bite upon it. The upper incisors are restrained by a labial bow. The pressure of the bite (P) acting on the sloping surface of the upper incisors produces a forward component *(F),* which tends to procline the upper teeth and a distal and upward component (D) parallel to the slope on the tooth. If the bite-plane sinks, the labial bow moves forwards with it and cannot restrain the upper incisors.

Investigation has shown that when the bite is propped on an upper anterior bite-plane, far from the anterior teeth becoming depressed, the posterior teeth, relieved of the pressure of mastication, erupt further and when the bite-plane is removed, it is found that the overbite of the anterior teeth is reduced (Richardson and Adams, 1963). This effect is known as 'opening the bite' and must be distinguished from a purely temporary propping of the bite for the purpose of facilitating tooth movement, such as moving an anterior tooth across the bite of the lower teeth.

The effect of the pressure of an anterior bite-plane falling on the sloping lingual surfaces of the upper anterior teeth, thereby proclining them, has long been recognized and various solutions devised one of which was the labial bow mentioned above. In 1944 Sved introduced a bite-plane which covered the incisal edges of the upper anterior teeth thereby ensuring that the pressure of the bite was transmitted axially to the teeth and eliminating the forward component of force tending to their proclination *(Fig.* 8.2).

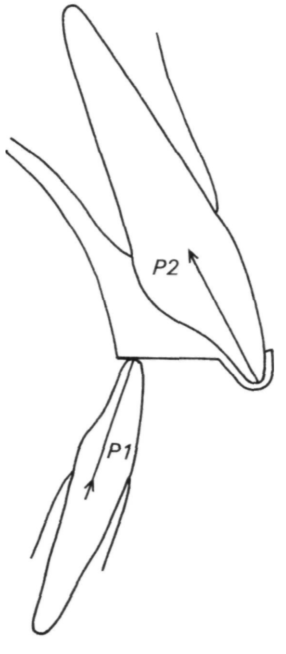


Fig. 8.2. A Sved bite-plane caps the upper incisors and the bite pressure (PI) is transmitted axially (P2) to the upper incisors. Any forward component is resisted because the Sved plate prevents tipping labially of the upper incisors. After a period of wear, eruption of back teeth will result in a reduced overbite when the appliance is removed *(Fig.* 8.3).

The Sved bite-plane is the most satisfactory answer to the problem of supporting the bite while the posterior teeth are allowed to erupt and thereby to open the bite or reduce the anterior overbite. It is necessary to ensure that oral hygiene is scrupulously maintained and the appliance must be worn at all times and in particular at mealtimes. It is necessary that the patient adapts to eating with the appliance in place and cuts up food so that this can be done. The plate and mouth must be meticulously cleaned after meals and the patient must not eat sweets.

The question has to be considered as to what happens after an anterior bite-plane, as just described, is removed. It has been noted that the effect of such planes is to increase the height of the face by permitting the posterior teeth to erupt and if the appliance is then removed, the pressure of the occlusion will fall on the back teeth alone.

In theory, the position of the mandible is an element or link in the muscular chain made up of the postcervical musculature, through the epicranial aponeurosis and its musculature, the facial and masticatory musculature and the precervical system, linking all anteriorly to the thorax and sternum. Moreover, theory has it that face height is only one dimension in this chain and that the development of the dentition takes place within the constraints of the face height so imposed, but cannot actually influence face height. This would mean that an increase in face height produced by causing eruption of back teeth must return to its original dimension after appliances used to produce the change are withdrawn.

In practice there is greater flexibility in the human organism than is implied by these ideas. Experience shows that anterior overbites reduced by the use of anterior bite-planes may remain reduced after appliances are withdrawn, and in others they may not. It is, therefore, important not to use such a bite-plane without a plan as to what is to be done when overbite has been reduced (*Fig.* 8.3).

It would seem, therefore, that, in young patients having a full complement of teeth and growing actively, considerable changes are taking place in the shape and size of the face as a whole and modifications induced in the pattern of the dentition by functional appliances, such as bite-planes, can become incorporated in the occlusal morphology as permanent features. When growth slows down and ceases, modifications of the face and occlusion are less easily produced by

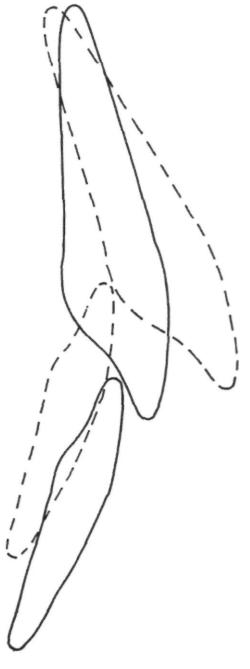


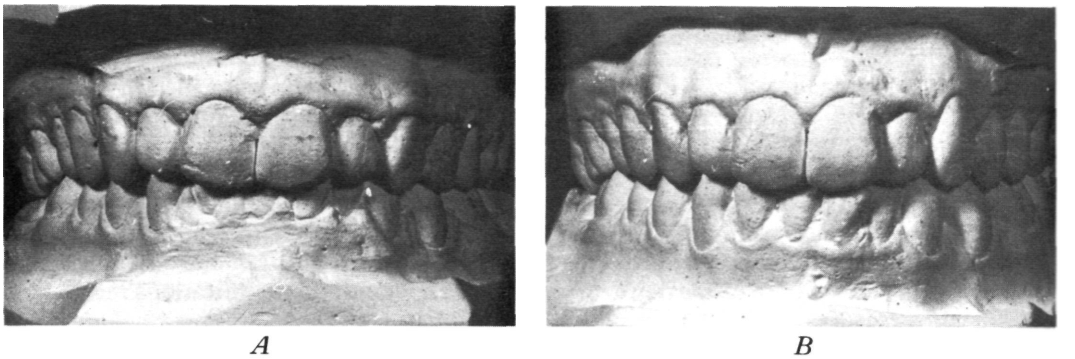
Fig. 8.3. After the overbite has been reduced, the upper incisors may be retroclined, space conditions permitting, and the new incisor relation, in the presence of normal soft tissue and function, remains stable.

means of bite planes and less easily maintained when appliances are withdrawn.

Fig. 8.4 shows the casts of a patient aged 14 years who was referred because of a close bite of the Angle Class II division 2 type with trauma to the lingual gingival margin of the upper incisors. The patient was given a Sved bite-plane for 4 months by which time the overbite of the incisor teeth had markedly diminished. The appliance was worn for a further 9 months at night-time only and then discarded. The new overbite relationship remained stable.

The uses of anterior bite-planes

The most frequent use of the anterior bite-plane is to reduce the overbite of the anterior teeth as a preliminary to the reduction of overjet associated with proclination of the upper anterior teeth. In these circumstances, the lower incisors may be biting on the lingual surfaces of the upper anterior teeth at points towards the cingula of these teeth or at the gum margins of the upper teeth or at points on the palatal mucosa some distance behind the gum margins. It is clearly necessary to reduce the overbite before retroclining the proclined upper anterior teeth. The Sved bite-plane will do this. There must also be space in the upper dental arch to make the distal and lingual movements of the upper anterior teeth possible {*Fig.* 8.3).



A *B*

Fig. 8.4. Reduction of incisor overbite relationship. The overbite relationship of the incisors is a complex of interincisal angle, dental base relationship, face height, soft-tissue posture and function. The patient in this record had a favourable environment apart from interincisal angle. As the lower incisors were traumatizing the upper lingual gum margin *(A),* the patient was given a Sved anterior bite-plane and the overbite reduced and remained stable without any further treatment *(B).*

It may be that the upper anterior teeth are already spaced as well as proclined, but if not, then space must be created by extraction of teeth at appropriate points. Extraction of first premolars provides space at a convenient place in the arch but extraction of other teeth may be more appropriate.

In correcting proclination of upper incisors, the incisors are retroclined but canine, premolar and molar teeth are moved mesiodistally to make available the necessary space.

Important points in the eventual stability of overbite reduction and correction of incisor relationship are the interincisal angle and the resting posture and function of the tongue and lips. If the interincisal angle and degree of overbite are average, and lip and tongue posture and function are normal, the conditions for stability are present. Excessive interincisal angle and anomalies of lip and tongue posture and function militate against a permanent result.

Other uses of anterior bite-planes

The treatment of pain associated with the temporo-mandibular joint sometimes entails the use of bite-planes designed to free existing occlusal contacts which often are abnormal due to loss of teeth and tilting of the remaining teeth and the presence of high spots in the occlusal planes. Often there is an increased incisor overbite of considerable degree. It is not unusual simply to fit a thin overlay over all the teeth in one dental arch in order to eliminate abnormal and premature contacts on closure and to mitigate the possible effects of clenching the teeth, whether during the daytime or at night.

One possible drawback of an overlay over the back teeth can be that depression of these teeth may take place thus worsening any tendency there may be to increased incisor overbite.

In these circumstances, the use of an anterior bite-plane of the Sved type has advantages in that premature and abnormal contacts are eliminated and any effect on occlusal levels in the dental arches can only be of a beneficial nature, tending as such an effect may do to a reduction of incisor overbite.

THE LOWER INCLINED PLANE

The lower inclined plane is an appliance used for the treatment of an incorrect biting relationship of the upper and lower incisors, when one or a number of upper incisors bite lingually to the lower incisors. The appliance consists of a polished metal or acrylic resin plane inclined at about 45° to the occlusal plane and placed between the upper and lower incisors in such a way that the upper incisor or incisors bite on the plane and are guided into their correct position labially to the lower incisors *(Fig.* 8.5).

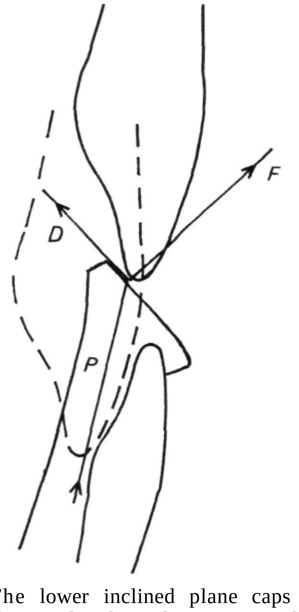


Fig. 8.5. The lower inclined plane caps the lower incisors and is inclined at about 45° to the occlusal plane. On closing, the upper incisors, which formerly bit behind the lower incisors, bite on the plane and the pressure of bite *(P)* develops a component at right angles to the plane *F* and a component along the plane *D.* The pressure (F) proclines the upper incisors. If there is any element of forward displacement of the mandible, the amount of movement of the upper incisors needed may be quite small.

Indications and Contra-indications for the Use of the Lower Inclined Plane

The lower inclined plane is useful when the incisor teeth are at a relatively early stage of eruption and where there is a good degree of overbite. In cases where many deciduous teeth have been removed, rendering the temporary propping open of the bite difficult, the inclined plane is useful.

If there is a marked degree of mandibular prognathism and the overbite of the incisors is not great the inclined plane should not be used. It may be impossible to produce the necessary degree of upper incisor proclination and if the overbite becomes reduced it may be impossible to produce correct incisor relationship in the end.

Design and Construction of the Lower Inclined Plane

The most satisfactory inclined plane is the removable, clear acrylic plane. Sometimes cemented inclined planes and planes in a cast metal such as silver are recommended, but both have drawbacks. If a plane is cemented, it is impossible to check progress in the tooth movement unless the appliance is removed, and this may entail damaging the plane. Cast metal planes are not worth the time and expense of construction.

A removable acrylic plane is made on a stone model from an alginate impression.

Clasps should be used if there are suitable teeth present (*Fig.* 8.6). If all the lower back teeth have been removed, as occasionally happens, the baseplate should be thickened a little and carried over the occlusal surface of the gum pads. The resulting flanges help the patient in retaining the appliance.

The inclined plane is built up, capping the incisor and canine teeth, and the appliance is made in clear acrylic material.

When fitting the appliance, any undercuts in the resin due to tilted or imbricated teeth should be removed until the appliance goes in easily.

The inclined plane is adjusted for height and angulation by grinding the slope against a 3 in. rotating lathe wheel. The plane is finally polished.

Fig. 8.6. A lower removable inclined plane clasped on 6 6. If there are no back teeth the buccal gum pads should be covered with extensions of the baseplate.

The appliance should be worn full-time and the patient instructed to cut up food and adopt a soft diet until the incisor relationship is correct and the appliance can be removed *(Fig.* 8.7).

Treatment should only take a matter of weeks and if improvement does not appear to be taking place soon, a check should be made on the wearing of the appliance and the diagnosis of the case.

THE ORAL SCREEN

The oral screen is a functional appliance by virtue of the fact that it embodies no active elements designed to produce forces acting on the teeth but produces its effects by redirecting the pressures of the muscular and soft-tissue curtain of the cheeks and lips.

The oral screen is also used at times to counteract deficiencies in lip posture and function by providing a covering for the anterior teeth and their adjoining gingival tissues and to prevent oral respiration when anterior and posterior oral seals are inadequate.

The value of the oral screen in producing improvements in tooth arrangement and occlusal relationship, in training the labial musculature to improvement in posture and function, in improving the health of the

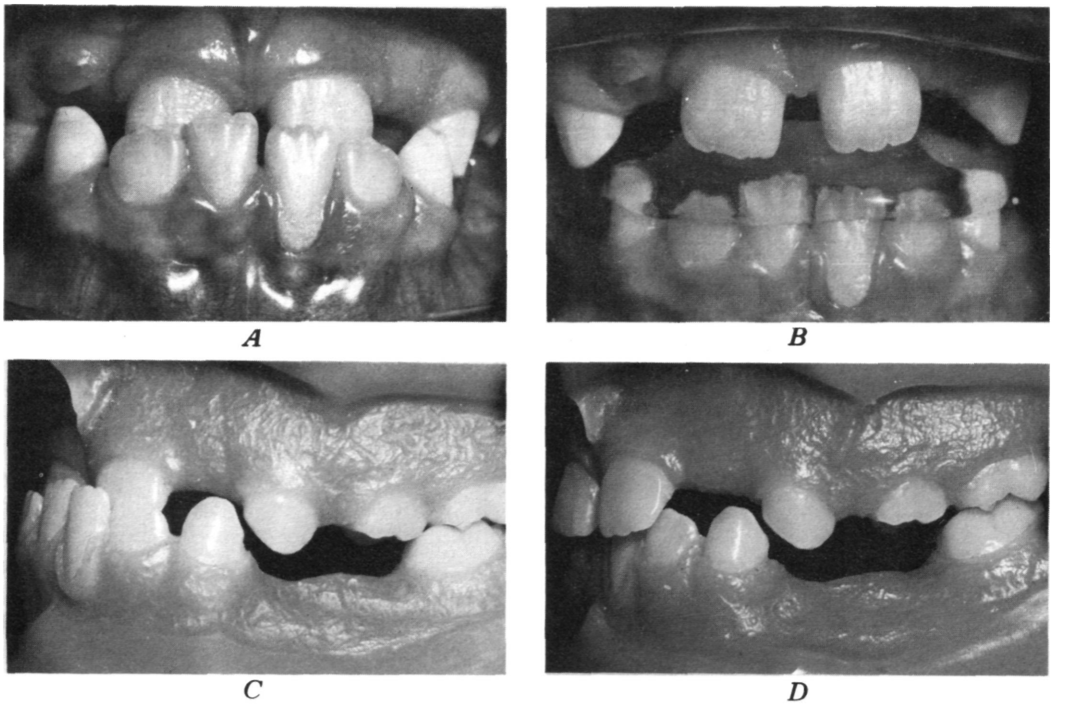


Fig. 8.7. *A,* Lingual occlusion of 1 1 which are recently erupted. *B,* The inclined plane in position with the upper incisors biting on it. *C, D,* Photographs of acrylic models of the treatment of the patient shown in *A* and *B. C,* Before treatment. *D,* After treatment.

pharyngeal tissues by preventing oral respiration, and through all these means promoting the greater well-being of the patient, this has long been a matter of debate. The evidence for the more remote effects and wider implications of treatment with the oral screen has been largely subjective, difficult to record precisely and to distinguish among the changes which could be attributed to growth, development and variations in the health of patients treated with this appliance.

It is in the region of the lips and labial segments of the dental arches that the oral screen can be used to produce predictable treatment results, and here the effects which the oral screen produces can be recorded with some accuracy and objectivity.

If the upper incisors are proclined and spaced and there is an increase in overjet and the oral screen is made so that it touches only the proclined incisors and is not in contact with the teeth in the buccal segments, the pressure of the lips and of the cheeks which lie in contact with the smooth divergent lateral wings of the oral screen will all be concentrated on the labial surfaces of the proclined incisors near the incisal edges *(Figs.* 8.8, 8.9, *A).* If the lower incisors are in contact with the upper incisors in the position of centric occlusion, pressure of the oral screen will be transmitted also to the lower incisors when the teeth are brought together as in swallowing, and this contact of the upper incisors with the lowers will prevent retroclination of the upper incisors *(Fig.* 8.95).

The use of an oral screen in circumstances such as these is not without risk to the upper incisor teeth, which are pressed from in front by the oral screen and intermittently tapped from behind by the lower incisors at each

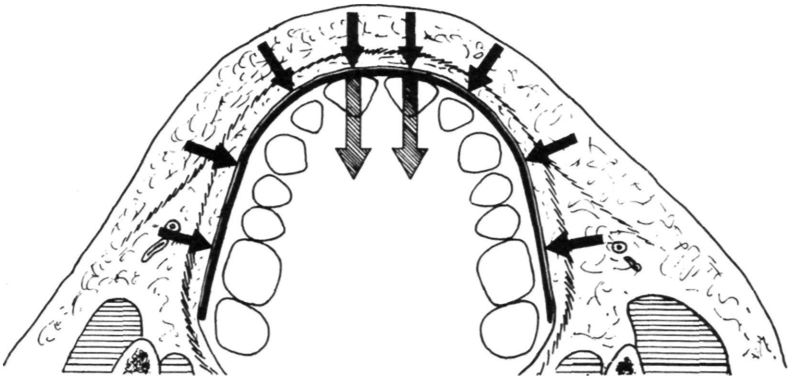


Fig. 8.8. The oral screen. The entire pressure of the soft tissues of the lips and cheeks is concentrated on the central incisors. The lateral pressure of the cheeks on the smooth sloping surface of the screen is resolved in a posterior direction. The appliance may be designed to act upon the lateral incisors as well.

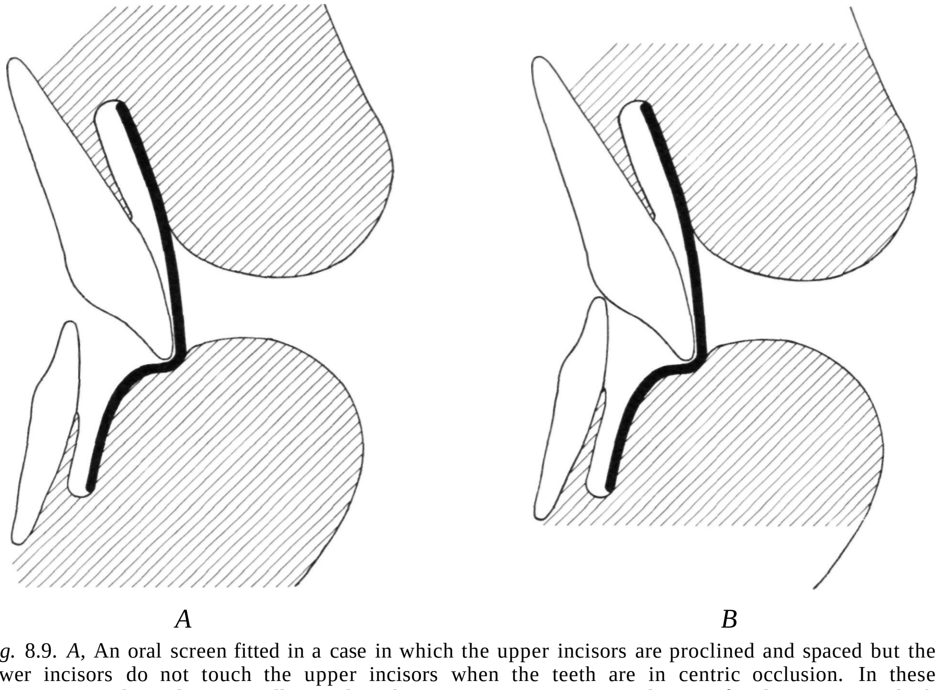


Fig. 8.9. *A,* An oral screen fitted in a case in which the upper incisors are proclined and spaced but the lower incisors do not touch the upper incisors when the teeth are in centric occlusion. In these circumstances the oral screen will retrocline the upper incisors. *B,* An oral screen fitted in a case in which there is proclination of the upper incisors and the lower incisors touches the upper incisors when the teeth are in centric occlusion. In this position the pressure on the upper incisors is also transmitted to the lower incisors. It is doubtful whether the upper incisors can be retroclined in this way.

closure of the teeth into occlusion. In the course of time resorption of the upper root apices may occur.

If, when the posterior teeth are in occlusion, there is no contact between the upper and lower incisors, there will be no obstacle to a lingual movement of the upper incisors *(Fig.* 8.9, *A)* and the upper incisors may be retroclined by means of the oral screen.

In designing an oral screen the relationship of the lower lip to the labial segments of the dental arches is important. In cases in which there is such a degree of overjet that it is only with difficulty that the lower lip can be brought out over the upper incisors, care must be taken to curve the oral screen inwards towards the lower incisors sufficiently to allow the lower lip to slide easily upwards and outwards labially to the oral screen. If, in these circumstances, the screen is brought downwards in a continuous curve over the upper incisors the lower lip may not succeed in reaching out in front of the screen and, lying inside it, may force the screen out of position and expel it from the mouth, or else, reaching out in front of the screen, it may exert such pressure on its labial surface as to rock the upper edge forwards out of control of the upper lip. In either event, the screen cannot be tolerated by the patient.

The mechanical action of the oral screen can be seen, therefore, to be in producing a lingual pressure on the upper incisors, and lingual inclination of these teeth if there is no mechanical obstacle to such a movement. The possibility of producing more far-reaching alterations in occlusal relationship, such as reduction in overbite and correction of postnormality of the occlusion, has been suggested from time to time, but the author has not found the oral screen to be effective in these respects.

Construction of the Oral Screen

The oral screen is constructed on upper and lower working models fixed together in centric occlusion. The impressions from which the models are cast must reproduce the full depth of the labial sulcus.

One thickness of pink wax is applied to the labial aspect of the teeth and the alveolar processes and extended to the limits of the sulcus vertically and distally, allowance being made for the labial and buccal fraena by trimming the wax as required. This layer of wax is sealed in position and then scraped down over the incisal third of the labial surfaces of the upper incisor teeth which it is desired to retrocline *(Fig.* 8.10). The thickness of modelling wax is not standardized

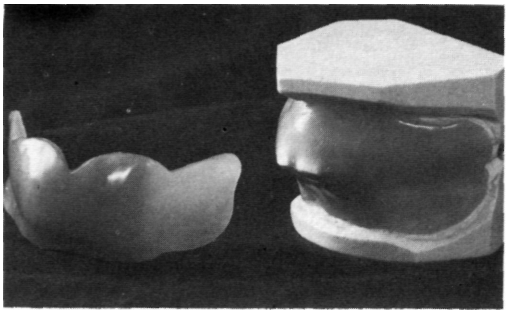


Fig. 8.10. The models are fixed in centric occlusion with plaster or wax and covered with a layer of wax labially. Note how the wax curves inwards below the upper incisors. The waxed oral screen is on the left.

and if the wax used is not thick enough, additions must be made to the sides of the wax layer in order to leave sufficient clearance between the oral screen and the teeth and alveolar tissues in the buccal region.

Attention must also be paid to the contour of the wax between the incisal edges of the upper incisor and the lower labial sulcus to ensure that the correct curve is provided to accept the lower lip.

The oral screen is then constructed in a single thickness of wax over the surface provided on the working models. The edges of the wax model of the oral screen are made a little less than the limits of the buccal vestibule and allowance is made for the labial and buccal fraena *(Fig.* 8.11). The wax of the oral screen can be thickened as may seem necessary to make the final appliance strong enough.

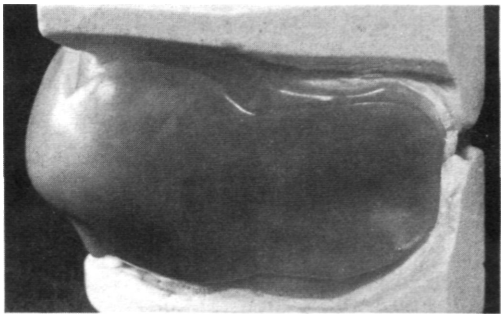


Fig. 8.11. The oral screen waxed up on the models.

The screen is then chilled and invested, outer aspect downwards, in thin cold plaster. As a precaution against warpage during investment, the screen, while still on the model, may be coated with a layer of plaster. When the plaster has set, the coated screen is removed and invested in the deep part of the flask {*Fig.* 8.12). The second half of the flask

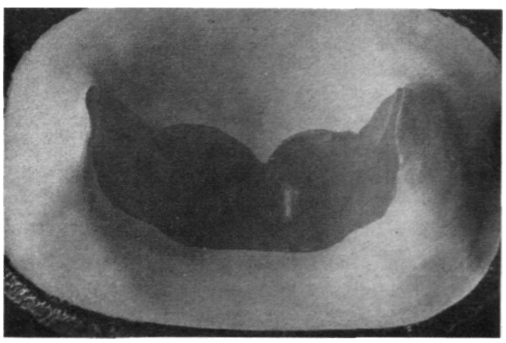


Fig. 8.12. The oral screen encased in the flask before casting the top half.

is poured into the inside of the screen. The appliance is finished in clear acrylic resin and smoothed and polished.

If the oral screen is being used to retrocline the upper incisor teeth, additions of clear, cold-curing acrylic material may be made to the inside of the appliance as tooth movement takes place, to maintain pressure on the anterior teeth.

The effect of the oral screen in retroclining the upper incisors is shown in *Fig.* 8.13.

FUNCTIONAL JAW ORTHOPAEDICS

Functional jaw orthopaedics* is the system of orthodontic treatment which makes use of forces which act in and about the human dentition during the activities of the masticatory face. In suitable cases treatment with functional appliances offers a means of treating severe malocclusions simply, but it should also be borne in mind that such treatment applied to conditions for which it is not suited can be ineffectual.

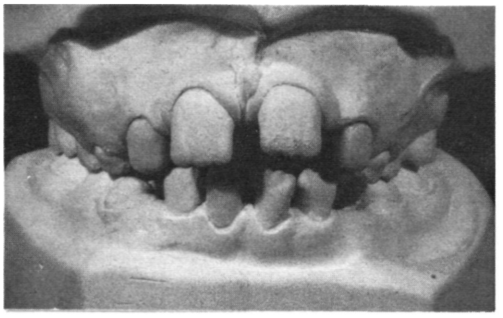
Functional jaw orthopaedics embraces treatment with any of the appliances in which loose-fitting devices are placed between or about the teeth, so redirecting the pressures of the facial or masticatory muscles on to the teeth and their supporting structures in such ways as to produce improvements in tooth arrangements and occlusal relations.

The most well-known systematic approach to the design and use of functional appliances was that of Andresen (1936), although Robin (1902) anticipated the general shape of the appliance or 'monobloc' that is used in the Andresen system. Whatever the name of the appliance that is used, the purpose is to produce a redirection of the forces of mastication that are already at play within and about the oral cavity until such time as premeditated changes in tooth arrangement and occlusal relationship have been brought about.

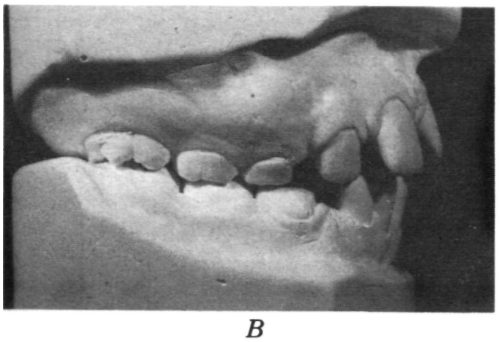
While the functional appliances of Andresen redirect the pressures produced by the muscles of mastication on the teeth, the approach of Frankel (1966) is different

* *Funktionskieferorthopadie,* also known as F.K.O.

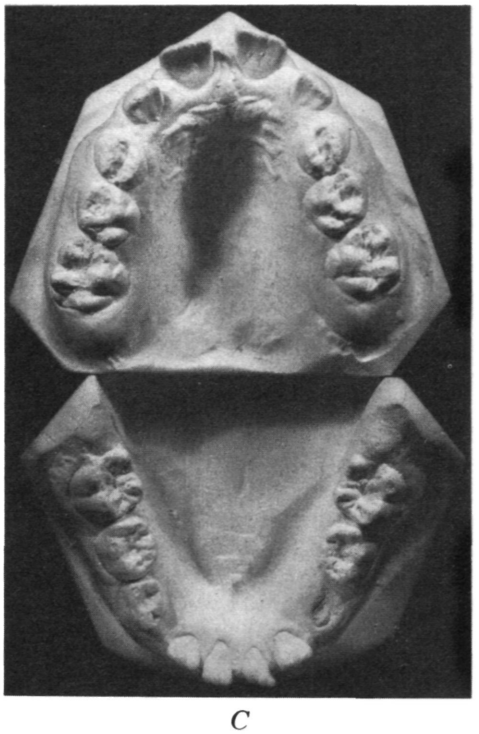
Fig. 8.13. *A,B,C,* Patient aged 8 years who sucked her thumb and also had incompetent lip posture. *D,E,F,* An oral screen was used and at age 12 the condition had completely resolved. It is probable that the oral screen acted as a substitute for the thumb habit and that soft-tissue patterning matured over the ensuing years. From records kindly lent by A. Richardson.



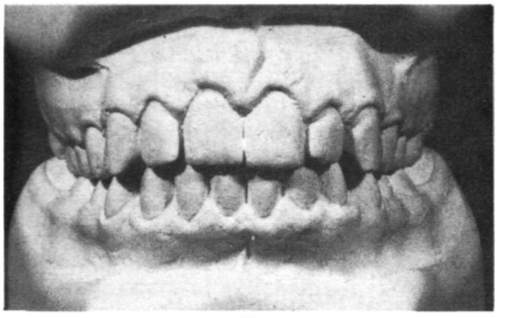
A



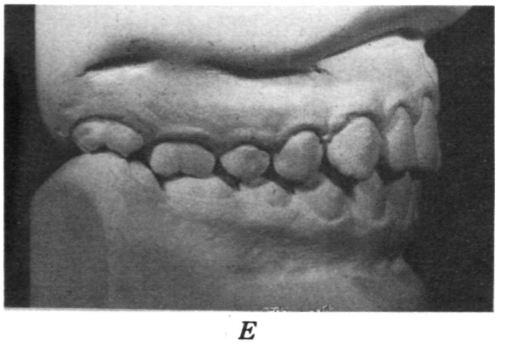
B



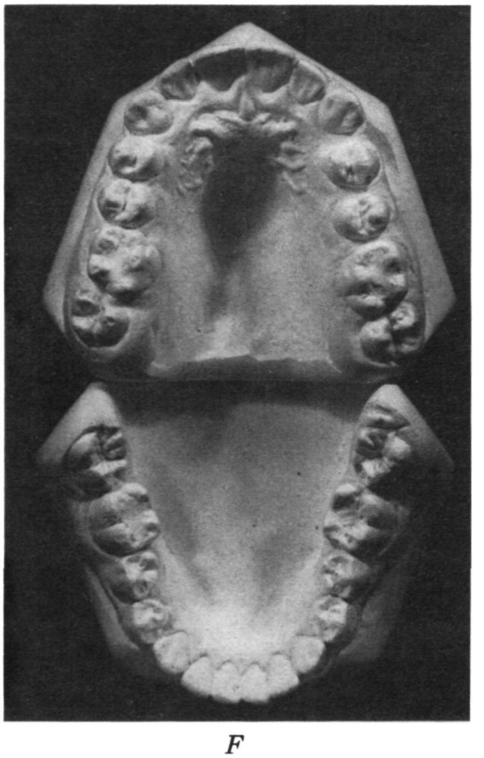
C



D



E



F

in that his method is one in which the pressures of the tongue, lips and cheeks are prevented from impinging upon the teeth and alveolar processes by means of a 'Function Corrector' or 'Function Regulator', and so produce changes in the growth patterns of these structures.

Theoretical Principles

The foundation on which functional orthopaedics of the jaws rests is the theory of 'functional adaptation' evolved by Roux (1895) conceived as a principle which determines the arrangement of the teeth and the form of the jaws in which the dentition is placed. Haupl et al. (1952) have embodied the conception of the treatment of malocclusion by functional means in their statement that: 'Tissue-forming functional stimuli originate from the activity of the tongue, lip, facial and masticatory muscles. These stimuli are transmitted to the teeth, paradontal tissue, alveolar bone and mandibular joint through a passive, loose-fitting appliance inserted between the teeth, the result being that the transmitted stimuli induce the desired changes in the tissues affected.'

The theoretical basis of the system of functional treatment suggests that the new **pattern** of function dictated by the appliance or activator leads to the development of a correspondingly new morphological pattern, not only of tooth arrangement and occlusion, but also of facial size and proportions. If this is so, then it should be possible from the study of treated cases to show at what sites and to what degree changes in form have taken place within the jaws, temporo-mandibular joints and dento-alveolar structures.

Today it is acknowledged that dramatic and permanent improvements in occlusal relationships can be produced by functional appliances in some cases. The changes in the occlusion can be seen and estimated clinically with considerable accuracy by means of the teeth, which do not alter in size and shape, but the nature and extent of the accompanying changes in the shape of the jaws and face are less easy to measure, especially as growth in these areas may have taken place at the same time as the treatment procedures were carried out.

It is believed by many advocates of functional jaw orthopaedics, on the basis of clinical experience, that changes occur at the condyle of the mandible as a result of stimulation of growth at this site leading to increase in mandibular length. Korkhaus (1960), from the cephalometric examination of Class II division 1 malocclusion treated by activators, suggested that the changes in mandibular conformation rapidly produced correction of the occlusal relationship, and hence no changes in tooth position within the jaws were necessary; not only did this make for a more stable end-result, but also there was no risk to the periodontal tissues as a result of the orthodontic treatment.

An investigation into the effects produced by functional appliances in the treatment of Class II division 1 malocclusion had previously been carried out by Softley (1953) with the aid of cephalometric X-ray analysis.

This author found that while after treatment with activator appliances considerable changes had taken place in tooth inclination, particularly upper incisor inclination and in alveolar prognathism, changes in basal prognathism, other than changes attributable to growth, could not be detected.

Moss (1962) analysed the results of activator treatment of 30 cases of Class II division 1 malocclusion. Using cephalometric X-ray films, Moss found that in 76 per cent of cases there was a forward growth difference of the lower jaw in relation to the upper, the lower jaw growing forwards more rapidly than the upper by 1 mm per year. Moss explained this result in terms of a releasing of inhibiting factors in the growth of the lower jaw through the use of the activator.

Bjork (1963) has shown by the cephalometric X-ray study of growth and development in Class II division 1 cases that while the dental base relationship may remain unchanged as growth proceeds, this relationship may in some cases improve towards normality and in others deteriorate to a more severe degree of postnormality. Such growth changes as these modify to a great degree the response of cases of postnormal occlusion when treatment is carried out by activators. Favourable growth changes, taking place during treatment, accelerate the improvements in occlusal relationship brought about by functional appliances. In contrast, the absence of favourable growth changes or the deterioration in dental base relationship will delay or prevent entirely any correction of occlusal relationship by means of activator treatment.

According to Bjork, 'Treatment is divided into three types according to the growth trend of the sagittal jaw relationship.

'1. If the sagittal jaw relationship is postnormal but is growing towards normality, that is to say, if lower prognathism is increasing in relation to upper prognathism, then prognosis is good. In such circumstances, an activator or even a bite-plate will be sufficient to produce the required result. The appliance will function by growth adaptation in that it removes distal intercuspidation and thereby makes it possible for the occlusion to develop in the normal direction in the same degree as the sagittal jaw relation. Occipital traction on the upper molars will have the same effect during growth adaptation in that the distal intercuspidation is removed. Tooth movement of other kinds is not required. In cases with normal spacing, extraction is not necessary and the treatment should be done before the end of puberal growth.

'2. Where prognathism is developing at the same rate in both jaws, the jaw relationship remains unchanged. Here it is necessary to treat the malocclusion by means of tooth movement. Fixed appliances are most useful in combination with occipital traction. In such cases, occipital traction moves the teeth, and tooth movement may be easier if certain teeth are extracted in one or both jaws. Removable appliances such as the activator can be used with good prospects where there is considerable growth in alveolar height, but in these cases treatment must then be done before the end of puberal growth.

'3. If prognathism of the upper jaw is increasing in relation to the lower, treatment is difficult. Removable appliances are contra-indicated if they remove the intercuspidation which is the natural compensatory occlusal mechanism. Treatment has to be done by tooth movement with fixed appliances in combination with occipital traction and extraction in both jaws. Tooth movement has to compensate for increased deterioration in the sagittal jaw relation. For this reason, treatment may be done late, after puberal growth, and the finished treatment has to be retained with occlusal stabilization.'*

It is clear that while the decision to carry out orthodontic treatment by means of functional appliances must rest to a great extent upon a multitude of clinical observations and assessments, the effects of treatment cannot be explained by anything less than the most precise measuring methods available, and much remains to be discovered about the details of the effects produced by functional appliances.

Further theoretical advantages arising from the use of functional appliances concern the reaction of the periodontal tissues to the influence of activators in pressing on the teeth. The pressure exerted by activators differs from the pressure exerted by active appliances, or appliances embodying sources of stored pressure, in that activator pressure is intermittent even while the appliance is being worn, and also this intermittent pressure is only applied for a proportion of the 24 hours, as activators are usually only worn at night. The pressure exerted by active appliances is continuous, the appliances being worn all of the 24 hours. The effect of activators is to impose impulses or shocks to the teeth and their surrounding structures, such impulses being under the

* Quoted by kind permission of Arne Bjork and *Sveriges Tandlakarforbunds Forlagsforening,* Stockholm.

control of the masticatory muscles and hence 'physiological' in character. It is thought that the physiological and momentary nature of the impulses avoids the stretching and compressing of the periodontal membrane found with the continuous pressure of active appliances. In the functional appliance system the periodontal tissues enjoy periods of rest between impulses and longer rest periods when the activator is out of the mouth, as is usual for the greater proportion of the 24 hours. The result of this cycle of impulse and resting phase is thought to be a lessening of possible ill effects on the tooth roots and periodontal tissues, tooth movement by activators being characterized by a maintenance of normal periodontal thickness throughout the period of tooth movement (Haupl et al., 1952).

The Design and Construction of Functional Appliances

The functional appliance as originally designed was a loose-fitting appliance inserted between the teeth, lying against them at selected points and also making contact with the palate and soft tissues covering the inner side of the mandibular alveolar processes. Through these means functional stimuli were brought to bear on the teeth and through the teeth on the periodontal tissues, alveolar bone and mandibular joint. What is sometimes not quite clear is whether the stimuli applied to the alveolar bone and mandibular joint result from pressures applied to the teeth only or whether it was originally intended to apply stimuli to the alveolar bone through its covering soft tissue also. It is noted by Haupl et al. (1952), on the basis of clinical observation, that: 'these appliances function even when no longer in contact with the teeth, since the latter had already changed position due to their influence. The results, therefore, were not due to the plate pressing on the teeth.'*

*This and the quotation on p. 118 are by kind permission of William Grossmann and Henry Kimpton, London.

A fundamental practical and doctrinal consideration concerning the design and use of functional appliances is whether active or pressure elements should or should not be incorporated in the appliances. The principle of functional appliance design and use is that the appliances act through the functional stimuli applied to the teeth, alveolar bone and remoter parts of the dentofacial complex and through the guiding of the teeth during their normal eruption and growth paths. From the doctrinal point of view the addition of active parts to the appliances may be regarded as an illogical complication of the clear fundamental principle of functional stimulation (Watry, 1947). From the purely practical point of view, the addition of active parts to a functional appliance creates technical difficulties in construction and adjustment, and the required looseness of the appliance may lead to imprecision in the application of individual pressures to teeth or may impair the proper functioning of the activator. As, however, teeth may be moved by active pressures, and the vast majority of tooth movements are carried out in this way, if active parts can be incorporated in functional appliances without reducing the efficiency of the appliance as a functional device, there seems to be no real objection to the combination of the two methods of treatment within the same appliance. The true objections to such an amalgamation lie in the possibility that an appliance may be produced that is neither functionally nor actively effective.

The degree to which the scope of a functional appliance may be extended and elaborated by the addition of active parts must lie with the designer and user of the appliance, and when the combination of functional and active pressures in the same appliance becomes too complicated to be efficient, discretion will rule that treatment should be broken down into stages and either active appliances or functional appliances used, depending on the nature of the tooth movements required.

The Andresen Appliance

The Andresen appliance or monobloc is probably the most frequently used of the activator group of appliances because of the dramatically successful treatment of Class II division 1 malocclusion that it can effect in some cases. In such cases the true idea of the monobloc as a functional appliance holds good for the reason that the appliance is designed to fit the occlusion only when the mandible and lower dentition are in a forward functional position and the muscular effort used to bring the mandible to its position of centric relation produces the pressures which determine the morphological changes which ensue (*Fig.* 8.14).

The use of the monobloc to produce changes in other directions, either a distal shifting of the lower dentition in relation to the upper or changes in lateral direction, is fraught with difficulties which do not arise where the treatment of postnormal occlusion is concerned.

In Class III malocclusion it is not easy to produce such definite functional pressures in the desired directions as it is possible to produce in postnormal occlusion because the mandible cannot be displaced distally in the same way as it can be displaced forwards. The forward position of the mandible used in the functional treatment of postnormal occlusion is a functional position for which there is no equivalent functional distal position in Class III malocclusion, a position which would be available for the functional treatment of this malrelationship. In the circumstances the best that can be done is to construct an activator which is split horizontally, the two parts being connected by a horizontally-working screw which, when opened, displaces the two portions of the appliance, the lower part distally, the upper mesially by small degrees. When worn as a functional appliance, mesial pressure on the upper teeth and distal on the lower can be brought to bear only when the opposing upper and lower dentitions are brought together in a vertical direction by the muscles of mastication, through the action of inclined planes in the activator.

The limitations of the activator in the treatment of Class III malocclusion are emphasized by the inclusion in the appliance used in such treatment, by most authorities, of arches or springs intended to bring about

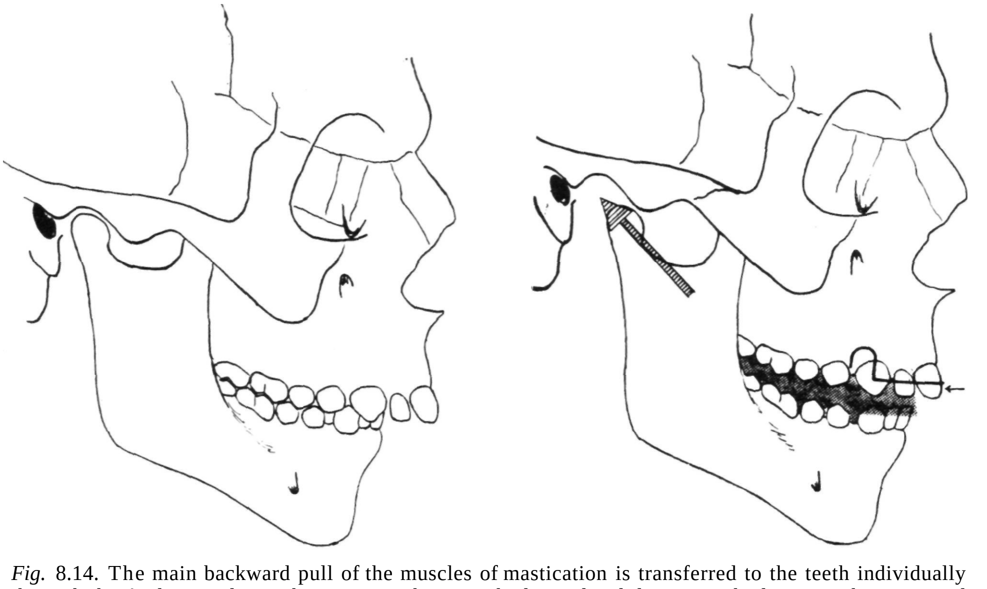


Fig. 8.14. The main backward pull of the muscles of mastication is transferred to the teeth individually through the Andresen plate. The upper teeth are pushed in a distal direction, the lower teeth in a mesial direction.

proclination of the upper labial segment and retroclination of the teeth in the lower labial segment. Such limited tooth movements in any case often constitute the sole treatment of certain Class III malocclusions, and it may be that these movements could be more effectively carried out by appliances other than the activator equipped with auxiliary bows and springs.

In the treatment of discrepancies in the occlusion in a buccolingual direction, again certain problems are to be found in connection with the use of activator appliances. It is sometimes suggested that different degrees of growth may be brought about in the condyle heads by taking the working bite for an activator with the mandible to one side, so leading to the correction of cross-bite conditions by the wearing of an activator constructed to such a bite. In the treatment of such conditions, however, means are usually shown for producing buccal movement of upper teeth and lingual movement of lower teeth by means of auxiliary attachments on activator appliances.

The success of the Andresen appliance in the treatment of straightforward Class II division 1 malocclusions is a strong recommendation for using the activator only in cases of this kind in the first instance. In restricting the use of the appliance in this way many advantages are to be obtained in that, under favourable circumstances, only one appliance may need to be used, inspections and adjustments may be carried out at relatively infrequent intervals, and at the end of treatment the appliance may simply be discarded or worn once or twice a week for 2-3 months before being discarded. Treatment may be completed within 6-12 months in favourable cases.

The term 'straightforward Class II division 1 malocclusion' is difficult to define, although what is intended may be comprehensible. The most important considerations are that the dental arches should be well arranged—that is to say, arranged in smooth curves without crowding or impactions in consequence of early loss of deciduous teeth; the upper labial segment may be proclined and spaced, the occlusal relation may be disturbed to the extent of a full unit antero-posteriorly, the overbite may be considerably increased.

Circumstances which indicate doubt as to the advisability of using the Andresen appliance include irregularities of the dental arches following early loss of deciduous teeth or due to disproportion in the size of the teeth and the size of the jaws; breaks in the dental arch following extraction of permanent teeth; open bite due to digit sucking or anomalies of function of the tongue or lips which persist through and after orthodontic treatment; inability of the lips to lie easily in contact when at rest. Such signs suggest difficulties in treatment and are warning signs as to the ultimate stability of the arrangement of the teeth produced in orthodontic treatment by any appliance method. Such signs indicate that the functional appliance may not be the most suitable apparatus for producing the kinds of tooth rearrangement that are looked for.

It is often advocated that very early treatment of postnormal occlusion using the activator, that is to say, in the deciduous dentition, brings benefits that are not available if treatment is delayed until the permanent dentition is in position. The suggested advantage of beginning treatment very early is that between the time of completion of the deciduous dentition and the accession of the permanent teeth lies a period of active growth and developmental activity in the face, jaws and dentition, and in such conditions the functional type of appliance could be expected to be more effective in directing the development of the occlusion than at a later age. This is theoretically true, and if a number of other important considerations are favourable there is everything to be said for giving the patient the advantages that may come from the utilization of as large a part of the most active growing period of the jaws and dentition as possible. The drawbacks to the very early commencement of orthodontic treatment are that the period of treatment and supervision becomes correspondingly prolonged, with consequent strain on the patient's interest and co-operation; the prolonged wearing of appliances brings its own problems in connection with side-effects arising out of oral hygiene difficulties; the changeover from deciduous to permanent dentition may necessitate a series of new appliances; the occurrence of early loss of deciduous teeth may involve a complicated appliance routine for the patient if space retention and active treatment are continued simultaneously; the later discovery of crowding, when the teeth in the labial segments eventually erupt, may be an unwelcome manifestation, necessitating a revision of the original diagnosis and plan of treatment.

Factors such as these, operating singly or in combination at different times over a prolonged period, can embarrass the course of treatment or nullify the possible benefits of commencing treatment at an early age. There is no clinical control in the individual case to show that early treatment necessarily confers the benefits of a more complete or more stable correction of the occlusal relationship than would be achieved by treatment later on, and it is a known fact that permanent dentitions, complete to the second molar teeth, exhibiting severe degrees of postnormal occlusion, can be quite easily treated by functional appliances to stable, normal occlusal relationship at the age of 11-12 years or older.

The age at which functional treatment of Class II division 1 malocclusion is commenced will be decided in the light of the foregoing considerations.

The construction of the Andresen appliance

The construction of a functional appliance, activator, monobloc or Andresen appliance for the treatment of Class II division 1 malocclusion requires working models and a wax bite. The impressions for the models should be taken in an alginate impression material and the edges of the impressions should extend to the limits of the labial and lingual sulci. It is important to see that the impression extends adequately into the lingual sulcus in the molar region in the lower denture and in the labial sulcus in the upper arch. Impressions that are short in these regions create unnecessary difficulties in the laboratory stages of appliance construction.

As starting points for the making of working bites for the treatment of Class II division 1 malocclusions the following details should be observed:

1. The mandible should be brought forwards until the buccal occlusal relationship is normal antero-posteriorly.
2. The bite should be open to a degree which separates the upper and lower labial segments, making it possible to cover the incisal edges of the lower incisors with the baseplate material of the appliance and leave room for modification of the appliance lingually to the upper incisors.
3. The centre lines should be made to correspond.

The working bite is taken in pink modelling wax, an adequate quantity of which is softened slightly and moulded to a convenient shape which may be varied according to the personal preferences of the operator. A solid transverse block of wax is less likely to become distorted during insertion and removal from the mouth, but may interfere unduly with the patient's tongue and cause difficulty in positioning the mandible. A horseshoe-shaped bite-block is favoured and has the advantage of leaving the lingual area of the mouth free during the taking of the bite, but must be carefully handled during insertion and removal from the mouth as it may easily become warped and hence difficult to place in an accurate position on the working models.

Some of the secrets of taking the working bite include the following points.

Have enough wax in the block and have the main body of wax soft but firm; the surfaces may be flamed just before insertion to ensure a sharp impression of the occlusal surfaces of the teeth. The patient should have something definite to bite on and should not find a completely unresisting mass between the teeth.

The patient should be told what is expected and opening, protrusive, closing and side-to-side movements rehearsed before putting in the bite-block. When actually taking the bite, the patient is told to open, protrude the mandible and close *very slowly* until told to stop closing, at which point movement should stop with the mandible held quite still. The occlusal relationship can then be checked and any adjustment made by protrusion, retrusion or sideways movement, without opening.

When the occlusal relationship is as required, a very small further closure may be made and the teeth immediately opened. The bite-block should then be removed and chilled in cold water for a minute or so and replaced in the mouth, the patient carefully finding the position of occlusion in the wax. The teeth are then pressed into the wax with gentle firmness and opened. The teeth should come out of the wax with a slight click which indicates that the impression has been confirmed on the fully chilled wax. This second taking of the bite has the advantage of removing any small occlusal obstructions or warps that may have been introduced into the wax when removed from the mouth the first time *(Figs.* 8.15,8.16).

The working models, which should be at hand, are placed in the working bite and firmly seated. At this stage the correctness and suitability of the bite relationship should be finally checked against the record models and the patient's occlusion. If all is correct, the models should be passed to the laboratory for construction of the appliance *(Fig.* 8.17).

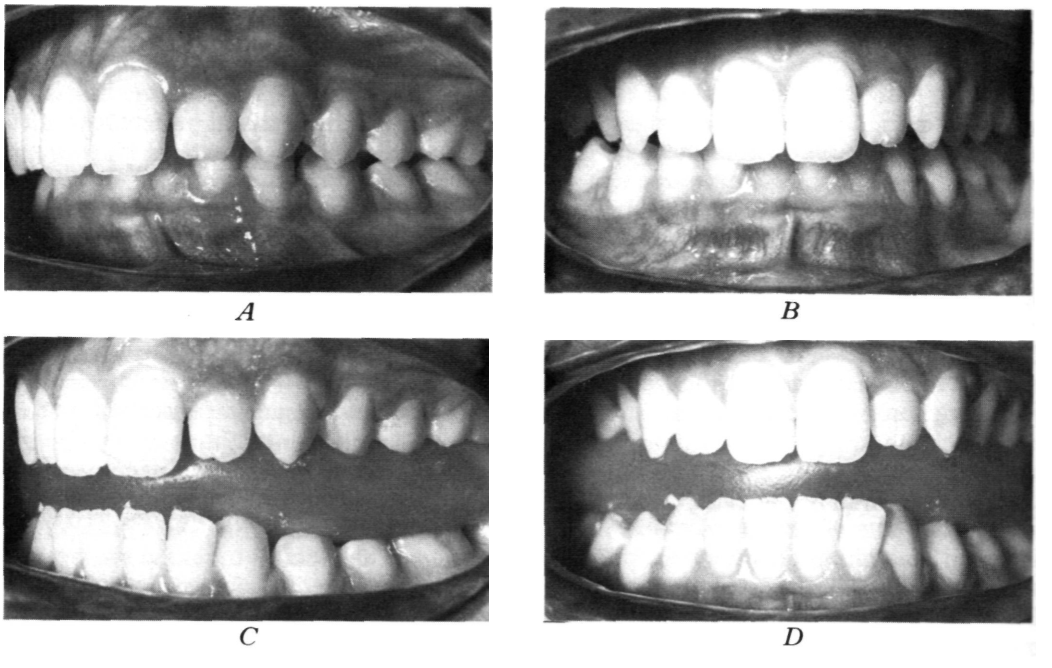


Fig. 8.15. *A,* This patient has increased overbite and one unit postnormal occlusion. *B,* The teeth have been opened slightly to show that the centre lines of the upper and lower arches do not correspond. *C,* The bite for an Andresen appliance. The buccal segments are in normal relation antero-posteriorly. The bite has been opened sufficiently to separate the incisors. *D,* The centre lines in the working bite position are made to correspond.

Fig. 8.16. The wax bite for constructing the Andresen appliance.

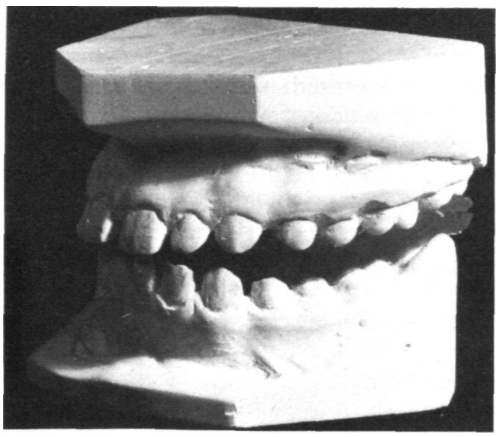


Fig. 8.17. Working models placed in a wax bite.

As a rule it is not difficult to obtain the working bite for an activator. As the procedure involves a voluntary action on the part of the patient, it is useful to consider patients and their reactions as falling into three categories:

1. The sensible, intelligent patient who understands what is required and can produce the bite relationship that is needed. With such patients the bite may be taken in a moment.

2. The patient who misunderstands what is required but who is over-anxious to help. In such cases much time may be taken up with a large number of incorrect bites and completely spoiled bite-blocks. The more the problem is explained, the more difficult it appears to be to achieve what is required from the patient.

3. The patient who does not understand what is required and who appears unable to carry out any of the movements requested. In such cases it may be possible for the operator to move the mandible into the required position and this may be the best that can be achieved, although with such a low degree of co-operation and understanding on the part of the patient the whole question of treatment with functional appliances in such cases should be carefully considered.

There are very few cases in which serious difficulty arises in taking a bite for the construction of a functional appliance.

Laboratory procedures. An Andresen appliance by tradition is a baseplate which fits both the upper and lower dentitions, with a simple bow which maintains control of the teeth in the upper labial segment.

The construction of such an appliance falls naturally into the following stages: articulating the models; construction of the labial bow; waxing the baseplates; inserting the labial bow; joining the baseplates together; fiasking, packing and finishing.

ARTICULATING THE MODELS. The easiest way of articulating the models is to use a standard, plane-line articulator with the incisor teeth facing towards the hinge of the articulator. The lingual aspect of the models faces outwards and this greatly facilitates the waxing up of the baseplate *(Fig.* 8.18). It is important to have the bases cut down enough to permit the insertion of the models, with the intervening working bite, between the blades or forks of the articulator when they are parallel. It is then possible to withdraw them from the articulator without separating them from the working bite or from the waxed-up appliance when this later stage is finished. The possibility of removing the models from the articulator in this way avoids damage to the articular surfaces

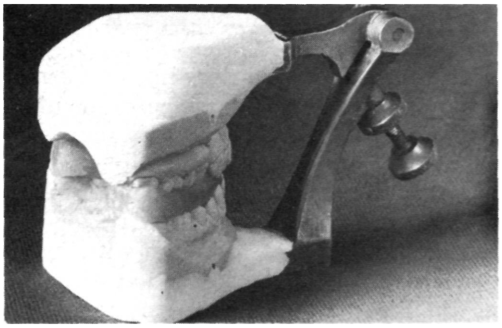
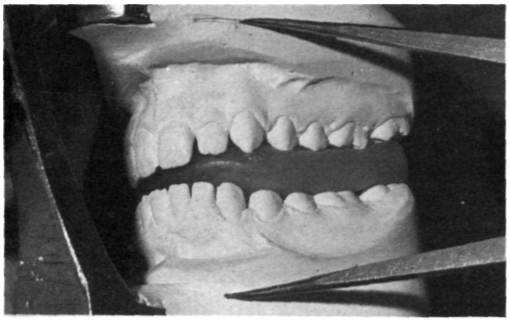


Fig. 8.18. Models have been placed on a plane-line articulator. The blades of the articulator are parallel.

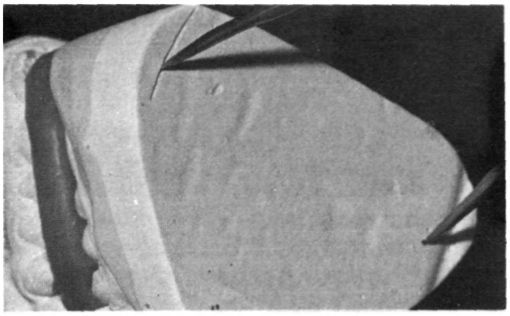
which might occur if the articulated models are simply opened from the wax bite or from the waxed-up appliance. If the models are taken off the articulator together they may be separated from the wax bite by slight warming, if necessary, and the waxed appliance may be gently eased off prior to flasking and finishing the appliance. When the models are fixed on the articulator the setting screw is locked, and as a further precaution the vertical dimension is measured and registered on the bottom of the lower model before the models are disturbed from their positions in the wax bite *(Fig.* 8.19).

CONSTRUCTION OF THE LABIAL BOW. The models are removed from the articulator and freed from the wax bite and from any particles of wax that may be adhering to them.

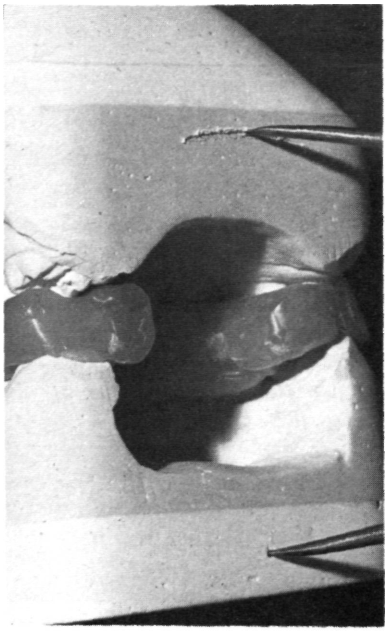
A plain labial bow is then constructed for the upper model extending distally to the centres of the labial surfaces of the canine teeth and with a U-loop at either side. The ends of the bow pass between the canine and first premolar teeth into the palate. The bow should be made of a robust gauge of hard stainless steel wire of about 0.9mm thickness. If a more resilient bow is required, a thickness of 0.8 mm may be used, in which



A

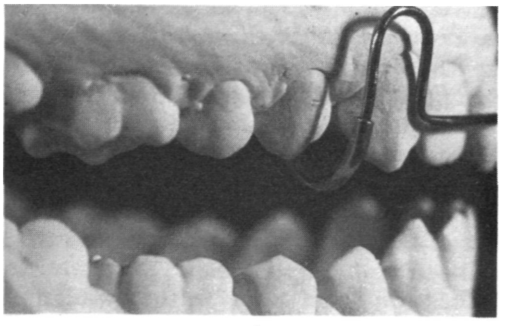


C

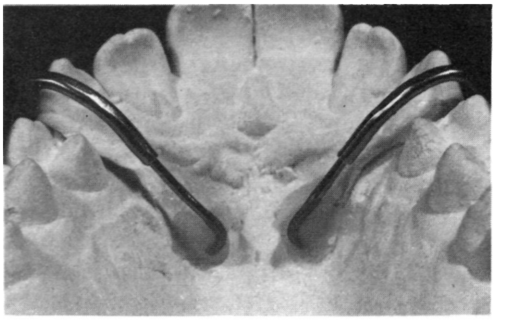


B

Fig. 8.19. The height of the bite is registered: *A.* Anteriorly; *B* Posteriorly. *C,* The recording is registered on the base of the models.



A



B

Fig. 8.20. *A,* The labial bow of 0.8 mm wire is reinforced with stainless steel tubing where it will enter the baseplate. Note that the tag of the bow runs well clear of the upper canine and premolar teeth. *B,* The tags of the labial bow are turned down at right angles to the palate. This simple attachment is perfectly satisfactory.

case it is advisable to reinforce the wire at the point where it enters the baseplate by sliding on a short length of annealed stainless steel tube of the correct internal diameter *(Fig.* 8.20). The thinner wire will be required if pressure is to be exerted on the upper incisor teeth by compressing the U-loops, as bows of the kind described are always relatively stiff and it is difficult to obtain sensitive control of the amount of pressure exerted by bows made of rather thick wires. The labial bow as described is used to cause the teeth in the labial segment to follow the movement of the teeth in the buccal segments as changes in the occlusal relation take place. The bow may also be activated a little to produce a lingual inclination of the teeth in the labial segment.

When bringing the ends of the labial bow through into the palate of the upper model, it is important to keep the wire clear of the teeth and to make the tags pass equidistantly between the upper and lower rows of teeth. Sometimes the tags are brought through to the palate in contact with the embrasure between the upper canine and first premolar teeth. In consequence, when the appliance is later trimmed with a steel bur there is danger of damaging the wire as it lies near the surface of the baseplate material. If the wire is passed midway between the upper and lower teeth it is deep within the baseplate material in this situation and the risk is less of cutting as far down as the wire when trimming the appliance.

The final anchorage of the ends of the labial bow in the baseplate can be quite simple, and if the tips of the ends are turned down against the palate this will ensure that the tag is held securely in the baseplate material.

WAXING THE BASEPLATES. This should be done in the following stages:

1. Wax up the upper and lower baseplates.
2. Insert the labial bow in the upper baseplate.
3. Join the baseplates together with the models on the articulator.
4. Smooth off the waxing of the complete appliance.

When the time comes to transform the wax prototype of the appliance into acrylic material this may be done in one of two ways. Either the wax may be sealed to the working casts on which it was constructed and models and wax embedded in the flask for completion of the packing and polymerizing procedures; or the wax image of the appliance may be removed from the plaster casts on which it was constructed and embedded in the flask by itself and subsequently converted into an acrylic reproduction.

The second procedure is the simpler and more satisfactory, but it is essential that the wax pattern of the appliance should reproduce accurately the fitting surfaces of the teeth and gingival margins of the casts on which it was constructed, and care must be taken to ensure that the wax pattern is not allowed to warp.

In waxing-up the upper and lower baseplates, therefore, it is essential to see that the wax is soft enough to take a good impression of the embrasures between the lingual aspects of the teeth.

The recommended procedure is to wet the dental casts in fairly warm water, but not to soak the plaster so long that free water remains lying on the surface when the models are left for a few moments in the air.

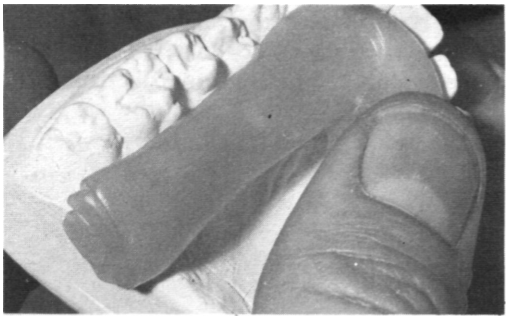


Fig. 8.21. The softened roll of wax is placed just below the occlusal surfaces of the teeth.

The wetting and slight warming of the casts have two objects. First, wax will not stick to the damp surface; and, secondly, the slightly warm plaster will not chill the soft wax and prevent it from spreading into the gingival crevices.

To adapt the wax to the tooth surfaces and the adjoining gingiva it is better to apply the wax as a roll about 1 cm in diameter with a well-softened outer layer.

This roll is curved to fit the dental arch lingually, lying just below the gum margin *(Fig.* 8.21). The soft surface is then pressed out against the teeth and into the embrasures between them and on to their occlusal surfaces *(Fig.* 8.22). It is necessary to work quickly when doing this initial adaptation of the wax. Care must be taken in the incisor region not to break off any of the teeth. If the wax is soft, light but sufficient pressure employed, and, as a precaution, the incisor teeth supported on the labial side with a curved forefinger, there will be no danger of breaking the teeth.

In the lower model the softened wax should be taken up to and over the incisal edges of the front teeth in a thin layer. It is important to avoid putting a thick layer of hard wax over the lower incisors at this stage, as when the baseplates are subsequently pressed into contact a spot of excessive pressure may occur over the lower incisors, leading to fracture of the plaster teeth *(Fig.* 8.23).

Fig. 8.22. The wax is pressed firmly into the embrasures between the teeth and spread down into the palate.

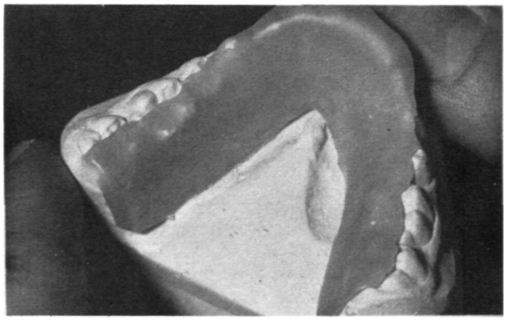


Fig. 8.23. The lower baseplate waxed up from a roll of softened wax. Note that the incisal edges of the front teeth are capped with a thin layer of wax.

When the wax has been adapted to the teeth and gum margins the remainder of the roll should be used for the construction of the baseplate areas of the upper and lower parts of the appliance. In the upper arch the wax may be stretched down into the palate and the segments from either side joined in the midline with a hot wax knife. It is important to avoid pulling the wax away from the teeth. If there is sufficient wax in the roll this method has the advantage that the upper part of the appliance is made in one piece of wax. If there is surplus wax, the palate area should be scraped down to a suitable and uniform thickness and smoothed with the flame. If necessary, wax can be added to complete the construction of the palate.

An alternative method for the completion of the construction of the upper baseplate is as follows. When the wax has been well adapted to the teeth it may be scraped down from the lingual aspect until only what is essential to fit the teeth and gum margin is left, after which a palate may be added as a single layer of softened wax. With this method it may be difficult to avoid leaving a noticeable line of junction between the two wax applications when the appliance is seen from the palatal aspect, and in scraping down the first application of wax great care must be exercised to avoid going too far and taking a cut off an underlying tooth.

In the lower arch the wax roll is usually sufficient to complete the construction of the baseplate; the wax is simply pressed down into the lingual sulcus and trimmed to shape.

INSERTING THE LABIAL BOW. The simplest method for placing the labial bow in the upper baseplate is to soften the appropriate area of the baseplate with a hot knife sufficiently to tack in the bow in its required position. The softened wax is cooled with an air stream and the bow fastened with pink wax flowed around the tags. The method of heating the tags of the bow and melting them into the baseplate is clumsy and liable to be inaccurate as it is difficult to heat the tags to the right temperature for long enough to give time to place the wire precisely. If the wire is not hot enough it will not melt the wax. If it is too hot an excessive amount of wax is melted and runs away, after which there is a delay while the wax cools enough to hold the wire; meanwhile, the bow must be held in place with great accuracy. The fact that the recommended fitting of the tags requires that they do not lie against the plaster, but only touch at their bent-down ends, means that the bow can usually be held in position by the turned-down tips for positioning purposes, after which the bow is properly secured with wax flowed around the tags, fastening them to the surface of the baseplate *(Fig.* 8.24).

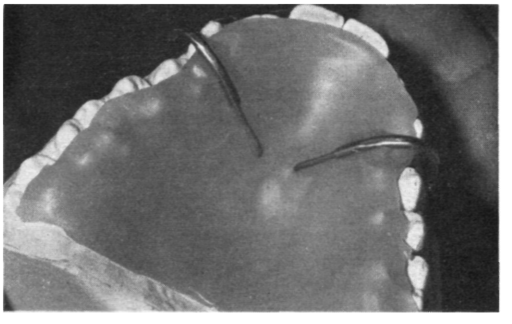


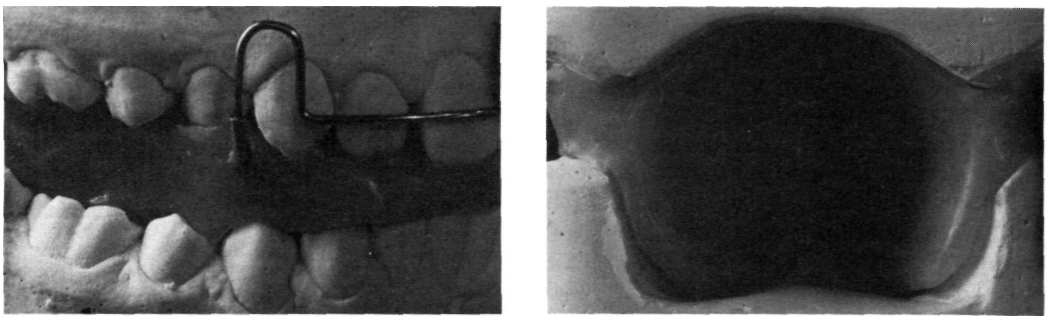
Fig. 8.24. The labial bow is waxed in position.

JOINING THE BASEPLATES TOGETHER. The models are replaced on the articulator and the articulator closed. At this stage it is important to examine the occluding surfaces of the two plates to make quite sure that they do not actually touch, but that there is at least 1 mm clearance between the wax overlying the occlusal and incisal surfaces of the teeth. The reason for this clearance is that, when softened wax is put between the models and the baseplates pressed together, there is a risk that if the baseplates touch at any point, excessive pressure at this spot may damage the underlying plaster, particularly in the incisor area.

The sealing together of the baseplates is done with a roll of very well-softened wax, the occlusal surfaces of the baseplates being flamed just before inserting the roll and closing the articulator.

When the articulator is being closed a check should be made on the vertical dimension between the upper and lower models, using the registration marks and recorded dimension originally provided. Care should be taken to see that the articulator is closed as far as, but not beyond, the original registration.

The waxing-up of the appliance is completed by smoothing off the joint between the upper and lower parts, attending to the fit and neatness of the waxing around the incisor segments, and smoothing the lingual surface of the appliance with a small fine flame of the blowlamp. The wax is then thoroughly chilled in cold water or left in a cold atmosphere until cold right through. The models are removed together from the articulator and then each model is very carefully taken off the wax appliance. Final trimming of the appliance may then be carried out: the lateral flanges may be reduced to half the width of the teeth in the buccal segments as this will save considerable time and labour in cutting the finished appliance; the lingual flange of the lower part of the appliance can be trimmed to the correct depth and smoothed and rounded. No other trimming of the appliance should be done at this stage. The models should then be finally seated in the appliance to ensure that no occlusal interferences have been introduced through the trimming of the buccal flanges, and the wax appliance is ready for flasking and finishing (*Fig.* 8.25).



A B

Fig. 8.25. *A,* The completed waxed-up Andresen appliance. *B,* The lingual view of the Andresen appliance. Note that the lingual undercuts in the molar region of the lower model have been plastered out and that in this area the appliance is constructed with well-rounded flanges against which the tongue lies comfortably.

FLASKING, PACKING AND FINISHING. The Wax pattern of the appliance is flasked upside down in the deep part of the flask with the plaster brought to the posterior edge of the palate and the lower edge of the lingual flange of the lower baseplate (*Fig.* 8.26).

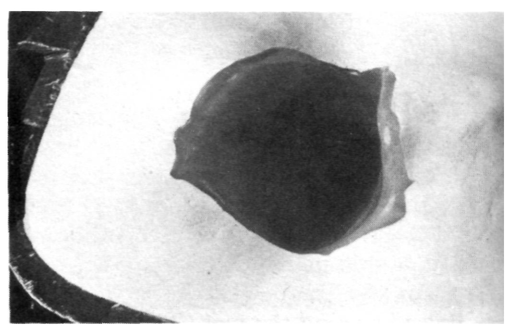


Fig. 8.26. The Andresen appliance embedded in the deep half of the flask. The appliance is packed from the lingual side.

During the flasking process a thin mix of the plaster should be brushed into the impression of the various tooth surfaces in the wax to ensure that air bubbles are not trapped. A wetting agent should also be used.

This method of investment ensures that the fitting surface of the appliance is in one half of the flask so that distorting the appliance is avoided. The second half of the flask is poured after applying separating medium to the lower half. When the plaster is set the flask is heated and the halves separated, the wax washed out, the flask packed and the baseplate material processed in the normal way. The acrylic materials in the pink colour are perfectly satisfactory.

After processing and cooling, the appliance is deflasked, cleaned and dried. Excess acrylic material, present as 'flash' around the lower and posterior edges, is removed and the appliance smoothed and polished. At this stage the acrylic appliance is placed on the models which are returned to the articulator and registration of the vertical dimension checked. The appliance should fit the occlusion of the patient exactly with the mandible forwards in the working bite position.

Fitting and adjusting of the activator

The activator is placed in the mouth exactly as it is received from the laboratory. If the teeth do not meet evenly and exactly in their impressions in the appliance, anteriorly and posteriorly, and there is any sign that the bite has been 'raised' or otherwise disturbed during the construction of the appliance, the appliance should be reconstructed as it never is possible to make an ill-fitting appliance fit satisfactorily by cutting or otherwise adjusting it.

Cutting the monobloc. If the appliance fits correctly it should then be cut to facilitate the tooth movements that are intended. The

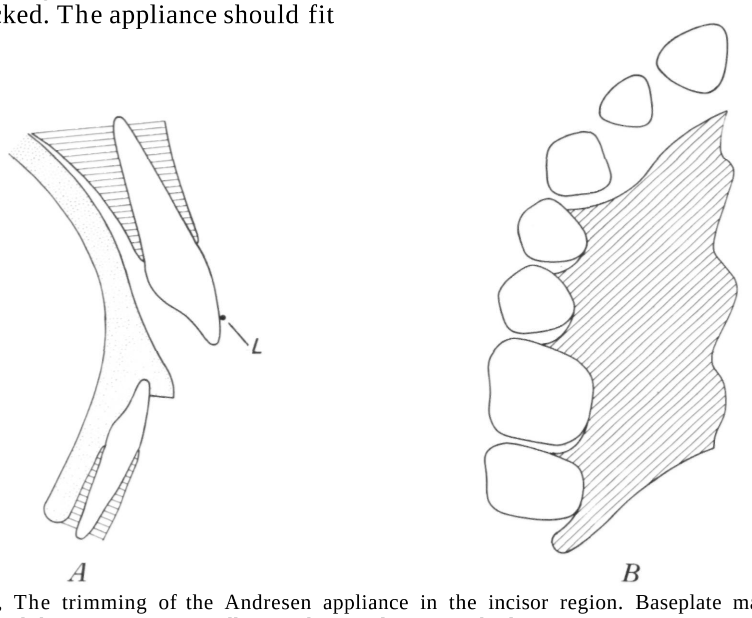


Fig. 8.27. *A,* The trimming of the Andresen appliance in the incisor region. Baseplate material is removed behind the upper incisors well up to the apical region. The lower incisors remain capped in the baseplate *(L,* labial bow). *B,* The trimming of the Andresen appliance in the upper buccal segments. Note that the appliance impinges on the mesial aspects of the premolar and molar teeth and is cut away behind the labial segment. In the lower arch the facets are made to touch the teeth in the buccal segments distally.

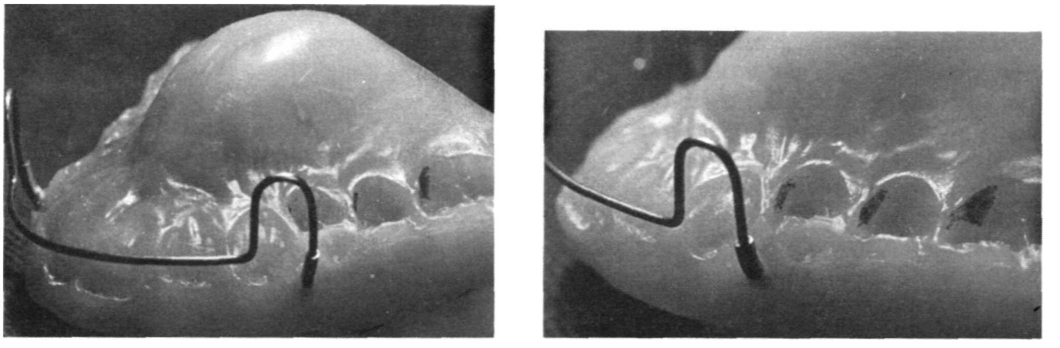


Fig. 8.28. *A,* The completed Andresen appliance. *B,* The areas intended as facets to impinge on the teeth in the buccal segments have been marked with lead pencil.

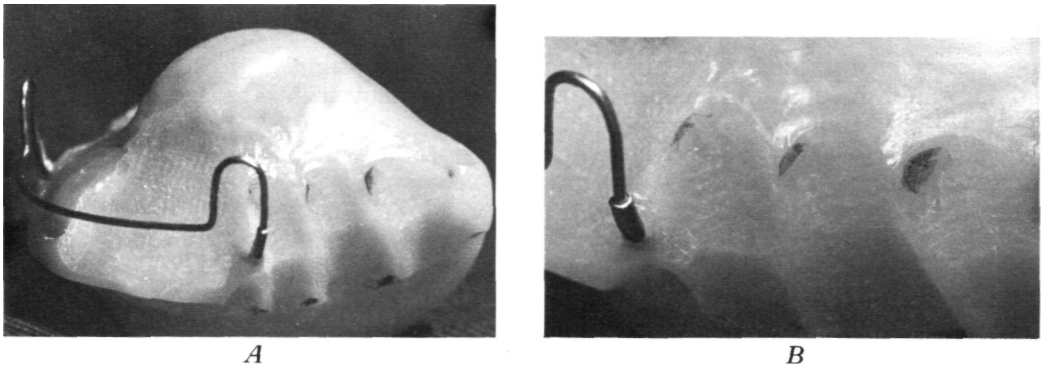
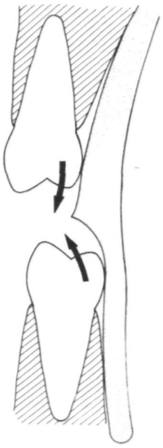


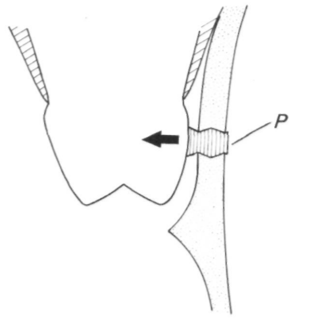
Fig. 8.29. *A,* The Andresen appliance after the left side has been trimmed in the incisor region and in the buccal segments. *B,* The pencil markings on the facets are still to be seen. Note the channels along which eruption of the teeth can take place.

cutting of an Andresen appliance means that baseplate material should be removed lingually to the upper incisors, distally to the teeth in the upper buccal segments, and mesially to the teeth in the lower buccal segments. The capping over the lower incisors should be left in position *(Fig.* 8.27). Trimming is best done with a steel bone bur in the straight handpiece, and if the facets which must be left in the buccal segments are marked with a soft lead pencil before cutting is started, the trimming may be done with great precision *(Fig.* 8.28). The channels which run between the upper and lower teeth in the buccal segments should run downwards and backwards *(Fig.* 8.29). If it is intended that there should be expansion of the buccal segments, the channels in the appliance may be constructed to guide the premolar and molar teeth buccally *(Fig.* 8.30). In these circumstances the buccal movement of the teeth can only take place if the teeth erupt farther.

Any sharp edges left by the cutting of the appliance are smoothed off and all is ready for final trial of the appliance in the mouth.



A



B

Fig. 8.30. *A,* If required, the channels in which the buccal teeth lie are curved outwards, so guiding the eruption of these teeth and creating expansion of the arches. *B,* Buccal movement of a molar tooth by means of a pad of rubber pulled into an undercut hole in the baseplate *(P,* rubber pad). The plug should project about 1-2 mm against the tooth and should be cut off flush on the lingual side of the baseplate. The rubber used is separating rubber, which is obtainable in strips about *I* in. square in section.

CASE REPORTS

A. C, aged 12 *years (Fig.* 8.31).

DIAGNOSIS. Dental base relation a little post-normal. Upper lip a little short, lower lip postures lingually to the upper incisors. The dental arches were complete with the permanent teeth to the first permanent molars, the upper incisors were proclined and spaced, the lower incisors were well aligned. The lower buccal segments were one unit postnormal to the upper, the overbite was increased and complete. 6J occluded lingually to 6|(Fig.8.31,A).

TREATMENT. A Sved plate was worn for 3 months as an experiment in patient co-operation. The overbite was reduced and there was a slight improvement in the occlusal relation. An Andresen appliance was then fitted. Cephalometric X-rays and record models were made. Eighteen months later the occlusal relation was correct antero-posteriorly. The incisor relation had improved very greatly. The relationship of 6| to 6 was corrected by means of a rubber plug pulled into the appliance lingually to 6 (Hopkin, 1958) *(Fig.* 8.30, *B).* A Hawley retainer with inclined plane was fitted and worn for 6 months. Final records were taken 1 year after completion of the treatment with the Andresen appliance.

Table 8.1 details the cephalometric measurements before and after treatment. From this it can be seen that SNA-SNB difference had hardly changed. The upper incisors were retroclined by 22°, the lower incisors proclined 6°. Both upper and lower prognathism was slightly less after than before treatment.

Table 8.1. Cephalometric analysis

	Before	*After*	*Difference*
SNA	78.0°	76.0°	-2.0°
SNB	74.5°	73.0°	-1..5°
SNA-SNB difference	3.5	3.0°	-0.5°
1 1 to SN	122°	100°	-22°
1 1 to mandibular plane	89	95°	+ 6°

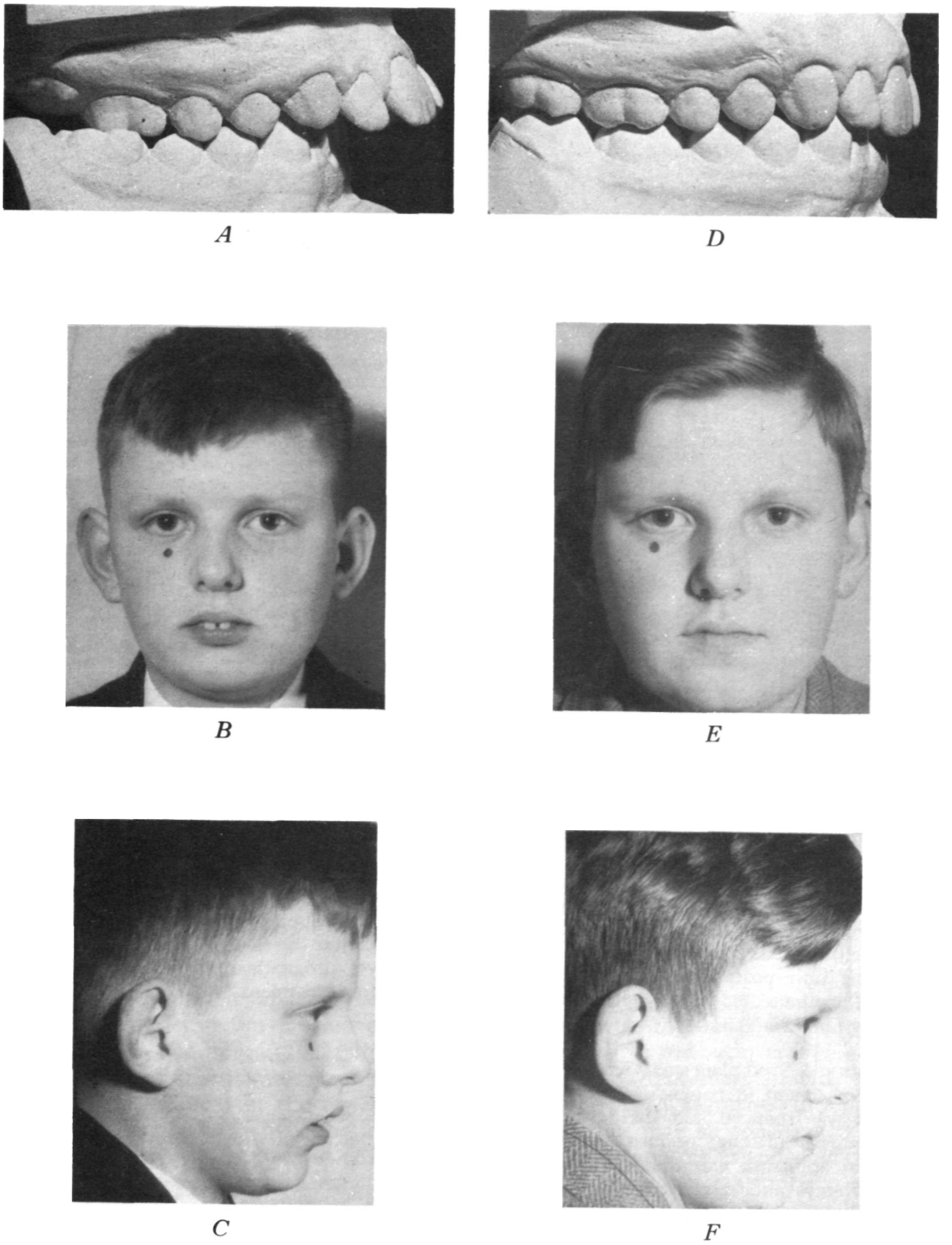


Fig. 8.31. Post-normal occlusions with lingual occlusion of 6| to 6|. Age 12 years. The condition was treated with an Andresen appliance and the upper molar was moved bucally by means of a rubber plug pulled into a hole drilled in the Andresen appliance. *A, B, C,* Before treatment. *D, E, F,* After treatment.

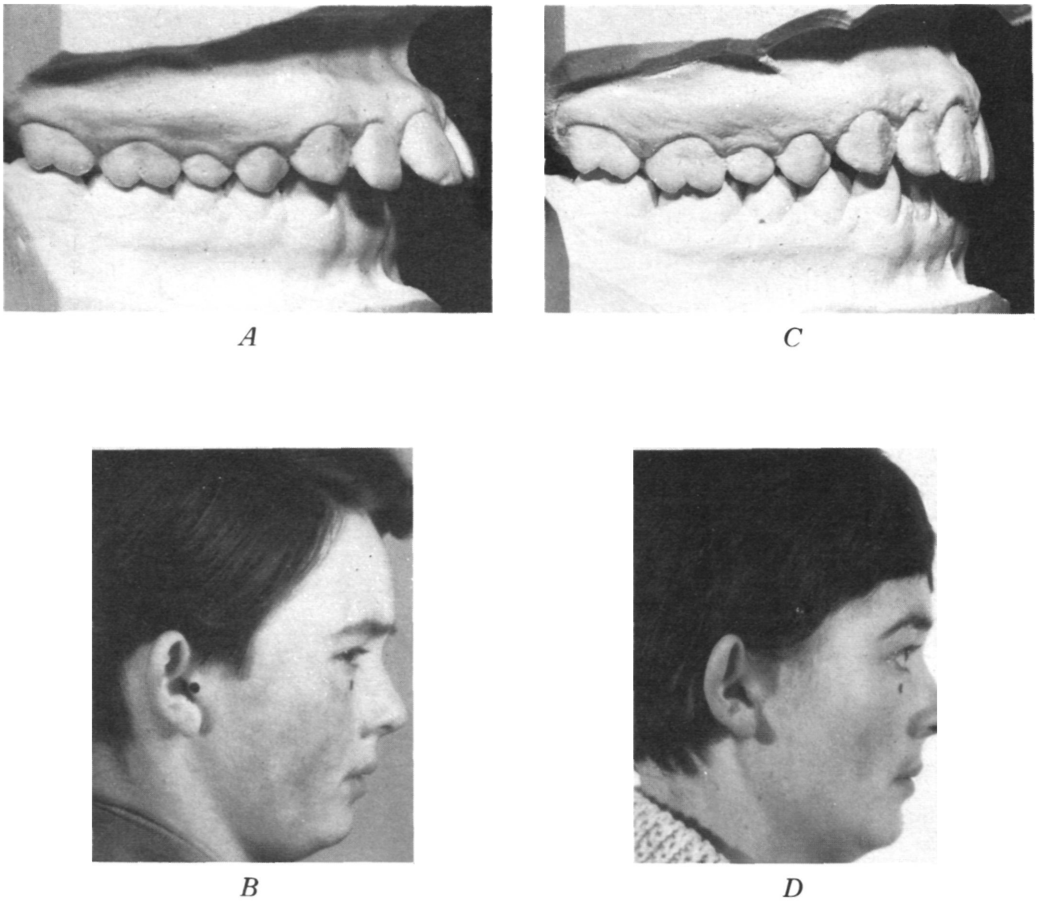
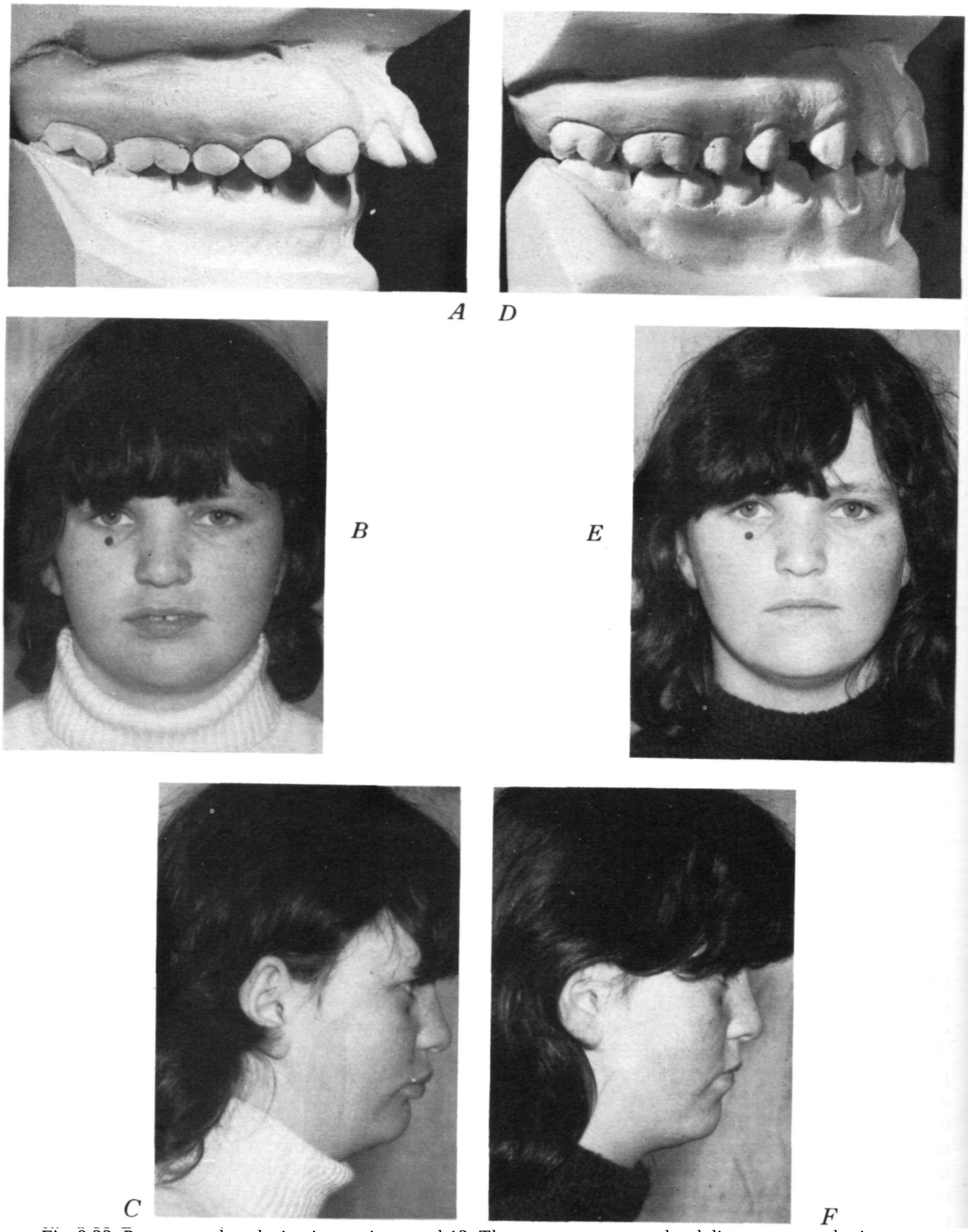


Fig. 8.32. The classical Class H division 1 malocclusion treated with an Andresen appliance over a period of 18 months. *A, B,* Before treatment (p. 13). *C, D,* After treatment. The final record was taken when the patient was 18 years of age.

Fig. 8.32(A,B) shows casts before and after treatment of a classic Class II division 1 malocclusion with regular dental arches and proclination and spacing of the upper anterior teeth. The third molars were absent; the lips were potentially competent. Dental base relationship was slightly postnormal. The patient was treated over a period of 18 months and normal occlusion was produced with retroclination of the upper incisors and lip seal at rest. The new occlusal relationship has remained stable *(Fig.* 8.32, *C,D).*

Fig. 8.33 shows a patient aged 13 years with classic Class II division 1 malocclusion with a full dentition up to the second permanent molars present and with considerable spacing and scissors bite on the first premolars. Dental base relationship was postnormal and the lips potentially competent *(Fig.* 8.33, *A, B,C).*

The patient was treated with an Andresen appliance and the condition responded rapidly and favourably; the occlusal and incisor relationships became corrected and lip posture became normal. There was some spacing between the labial and the buccal segments in the upper arch which it was hoped to use to improve the incisor relationship further, but the patient was so gratified with the improvement to date that she ceased attending for supervision and appeals to keep any further appointments fell on deaf ears *(Fig. 8.33, D,E,F).*



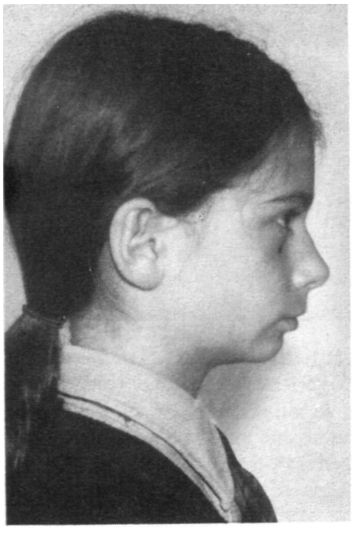
A D

B E

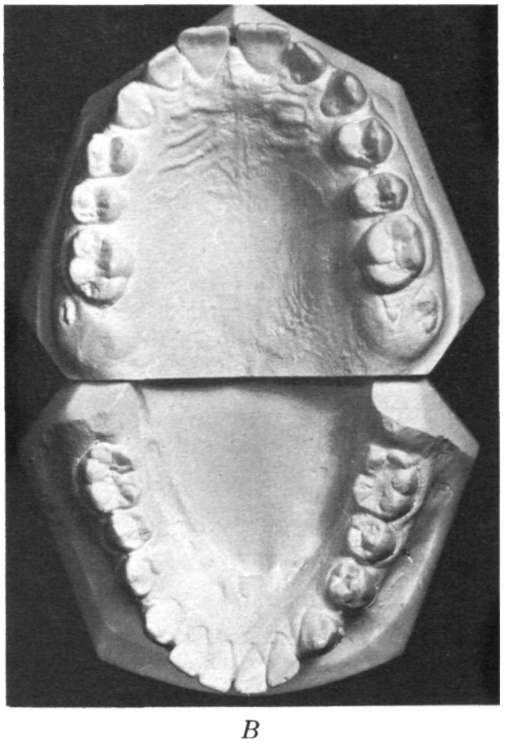
C F

Fig. 8.33. Post-normal occlusion in a patient aged 13. There was a severe occlusal discrepancy and scissors bite of the right premolars. The patient had excellent dental arches with spacing in both upper and lower labial segments. Treatment was started with an Andresen appliance and the condition rapidly improved. The patient was so pleased that she discontinued the treatment before it was fully complete. *A,B,C,* Before treatment. *D,E,F,* After treatment.

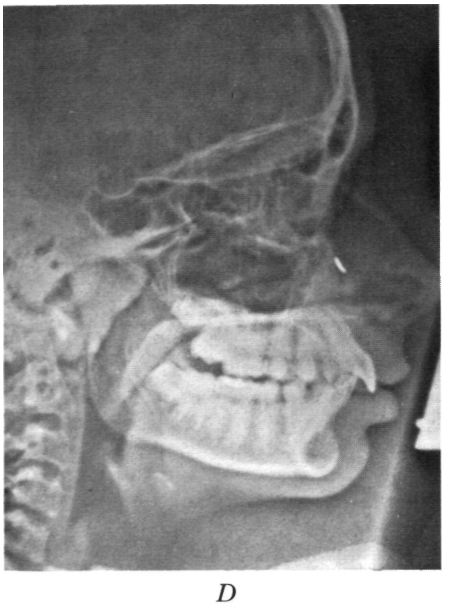
A



C

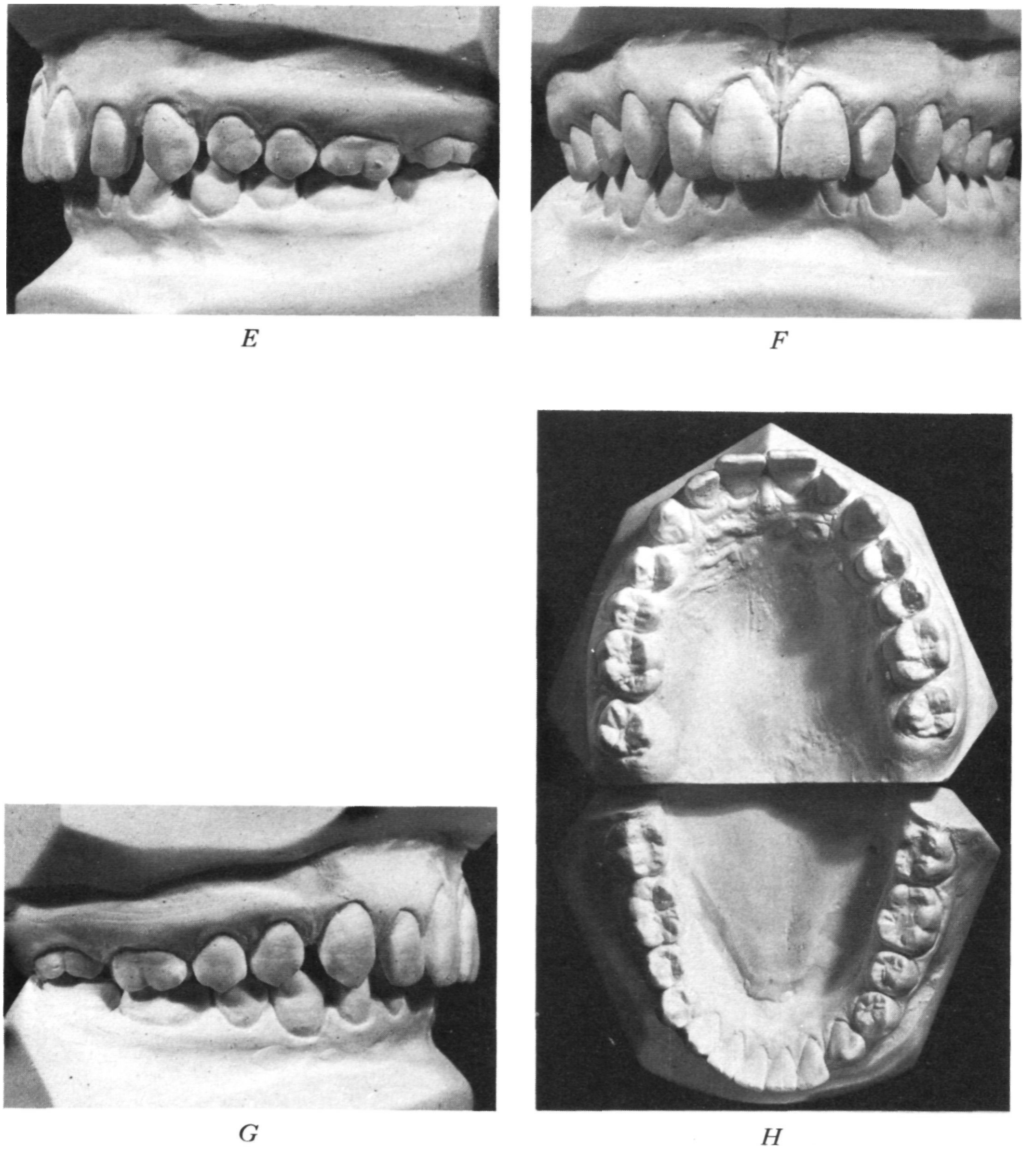


B



D

Fig. 8.34. A patient aged 12 years with post-normal occlusion, low Frankfort/mandibular and maxillo/mandibular angles, proclined lower incisors and scissors bite of the premolars. Treatment was by expanding the lower arch, using extra-oral traction with removal of the upper second molars and completion with an Andresen appliance. *A,B,C,D,* Before treatment. *E,F,G,H,* After treatment.



E F G H

Fig. 8.34 *(cont.)*

Fig. 8.34 shows the records of a patient aged 12 years having individually excellent dental arches but with one unit postnormal occlusion, postnormal dental base relationship, low Frankfort/mandibular angle and competent lip posture. Both the upper and the lower incisors were proclined and there was a considerable degree of spacing. There was also scissors bite on all the premolars *(Fig.* 8.34, *A, B,C,D).*

The malocclusion was treated with expansion of the lower arch, extra-oral traction to the upper arch with extraction of the second molars and a final period of treatment with an Andresen appliance *(Fig.* 8.34, *E,F,G,H).*

The Function Corrector

The Function Corrector, sometimes referred to as the 'Vestibular Appliance' or the 'Frankel Appliance', was originated by Dr Rolf Frankel of Zwickau, East Germany, about the middle of the present century.

The basic theoretical principle underlying the mode of action of this appliance is the idea that within the jaws and dento-alveolar processes there is, at practically every site, the possibility of bone deposition and resorption, especially during the growing period. It is further held that the amounts and directions of bone deposition are influenced by variations in the pressure environment of the jaws and alveolar processes brought about by the posture and activity of the tongue, lips and cheeks. The function corrector, therefore, seeks to modify the soft-tissue positions and activities and thereby to influence the amounts and directions of bone deposition that are taking place within the dento-alveolar complex.

Function correctors are shields which lie in the vestibule of the mouth and stand clear of all portions of the dento-alveolar system which are underdeveloped. The wire elements unite the lateral shields with the lip pads and serve also as guiding, stabilizing and reflex-inducing factors.

It is from the physical nature of the appliance and its theoretical mode of action that the appliance derives its name, 'The Vestibular Appliance or Function Corrector'.

The following extract* from the writings of Dr Frankel embodies what appear to be the main theoretical principles which underlie the mode of action of the appliance and determine its application to the treatment of various kinds of irregularities and malocclusions.

Configuration and structure of the toothbearing gnathic skeleton are subject to mechanical influences of the environment which have the effect of modifying the growth sites and leading to the formation of a supporting structure. Such mechanical modification and activation of the growth sites may be due to the following four types of factors:

1. Mechanical factors which are associated with the development, i.e. the influence of growth-linked changes in the size and shape of skeletal and environmental soft tissues.

2. Mechanical factors of a functional nature, i.e. the influence of physical functions such as oral seal, mastication, deglutition, play of features, respiration and so on.

3. The mechanical potential of the atmospheric pressure which by acting on the soft tissue mass is responsible, to a considerable extent, for the mechanical situation in the gnathic region.

4. The potential of the force of gravity, which exerts its influence especially on the tongue and the mandible.

It should therefore be the chief aim of orthodontic therapy to trace and eliminate any abnormal mechanical potentials in the environmental soft tissues. Mechanical factors of a functional nature are the most serious of those mentioned above, and any dysfunction or complete absence of oral seal deserves our closest attention.

In dealing with this we should bear in mind the fact that a physiologically normal oral seal is only ensured if three requirements are fulfilled:

1. Anterior oral seal, brought about by lip seal with normal tension.

2. Posterior oral seal, brought about by the contact between soft palate and root of the tongue.

3. Median oral seal, brought about by the contact between dorsum of the tongue and hard palate.

In this connection I would refer to the investigations made by Donders (1953), Korbitz (1914), Noltemeier (1949), Eckert-Mobius (1962) and Frankel (1964). According to these authors, the natural rest position of the tongue against the roof of the palate is not due to muscular action but is maintained solely by the action of the atmospheric pressure. Their investigations revealed that the deglutition reflex, which is accompanied by lip seal, results in the air being 'pumped out' of the cavum proprium by the tongue's peristalsis, thus creating a partial vacuum which is completely filled by the soft tissue of the tongue, under the action of the atmospheric pressure. In this way we get a completely enclosed space between tongue on the one hand and lips and cheeks on the other hand.

*This extract from the *Transactions of the European Orthodontic Society* (1966) is reproduced by kind permission of Dr Rolf Frankel and the Editor.

This space must be regarded as the most appropriate site for directing the morphogenesis of the tooth-bearing alveolar process.

But the above-mentioned environmental mechanical factors and their importance for the morphogenesis and configuration of the gnathic skeleton should not be interpreted in terms of functional influences alone. The neuromotor functions of respiration, food intake and digestion are not acquired, like motor functions, but are congenital, that is to say, they are perfect from birth owing to the unconditioned-reflex control mechanism. This functional mechanism therefore is a hereditary feature. Moreover, the individual and hereditary characteristics become clearly evident in the play of the features and in this respect one may say that, given a normal environment, its mechanical influences assume the quality of genetic information. Thus the genotypical arrangement of the soft tissue and its neuromotor functions affords an excellent explanation for all cases of striking family likeness. But as the phenotype invariably constitutes a combination of hereditary and environmental factors the appearance of orofacial soft tissue and especially the play of the features should not be taken merely as the result of a hereditary disposition. They should also be regarded as the reflection of the individual's psychic development, which results from his confrontation with the environment. This is the background which gave rise to our optimistic view that any soft-tissue atypia will be amenable to functional treatment.

If we subscribe to the principle of a 'proper education of the jaw', an analysis of the above will show that the first and foremost object of orthodontics should be a normalization of the environment of the growing jaw. Our therapeutic measures should chiefly be directed at eliminating any atypical features in the threefold oral seal and acquired habits, especially any abnormal functioning of the perioral muscles during deglutition. Normalization of the oral seal also creates the main prerequisites for a normalization of respiration. Teleradiographic examinations showed that this kind of treatment resulted frequently in a significant dilatation of the epipharynx and recession of the swelling of the nasopharyngeal tonsil.

The function corrector has been shown to be an effective appliance for the treatment of malocclusions of certain kinds and where such malocclusions are encountered the use of the function corrector should be considered. Malocclusions of the Class II division 1 and Class III type and anterior open bite have reacted favourably to treatment in the author's experience.

Design of the function corrector

There are three types of function corrector.

***Type I function corrector or F.R.* 1**. This type is used in the treatment of Angle Class I and Class II division 1 malocclusions.

The lower lip shields are supports for the lower lip and prevent the action of the mentalis muscle in producing pressure on the lower incisors. The action of the lower lip shields is valuable in situations where there is retroclination or crowding of the lower incisors whether the occlusion as a whole is normal or postnormal.

The buccal shields relieve pressure on the lateral aspects of the dental arches which leads to expansion, especially in the upper arch.

In Class II division 1 cases the lower lip shield encourages a forward position of the lower lip which embraces the shield on closing the lips.

The action of the U-loops in the lingual bow is important in the reduction of distocclusion. If the lower jaw slips back from the protruded position in which the regulator is made, the U-loops on the lingual bow make contact with the mucous membrane on the lingual surface on the lower anterior alveolar tissues, thereby initiating a reflex which encourages the lower jaw to adopt the forward position.

In the treatment of postnormal occlusion, whether division 1 or 2, a forward positioning of the lower jaw in taking the functional bite is necessary.

The F.R. 1 appliance is also used in the treatment of open bite. When used for this purpose, Frankel advises that lip pads should be placed below both the upper and the lower lips and states that it is not necessary to place any screen or wire to limit the projection of the tongue between the incisor teeth.

Type II function corrector or F.R.2. This is used for treatment of Class II division 2 malocclusion, and retroclination of the upper incisors is dealt with by a lingual arch in the upper part of the appliance behind the upper incisors; activation of this arch will produce proclination of these teeth. Otherwise, the action of the corrector is the same as in Class II division 1 types of cases, in that the labial pads at the lower incisors relieve pressure of the lower lip on the lower incisors, and the correct occlusal relation is established by the bite with which the appliance is made.

***Type III function corrector or F.R.* 3.** In this type the pressure of the upper lip on the upper incisors is relieved by pads which are placed over the upper alveolar process, and the action of the labial bow on the lower part of the appliance has the effect of correcting the incisor relationship, if necessary, by the retroclination of the lower incisors.

Construction of the function corrector

Clinical procedures

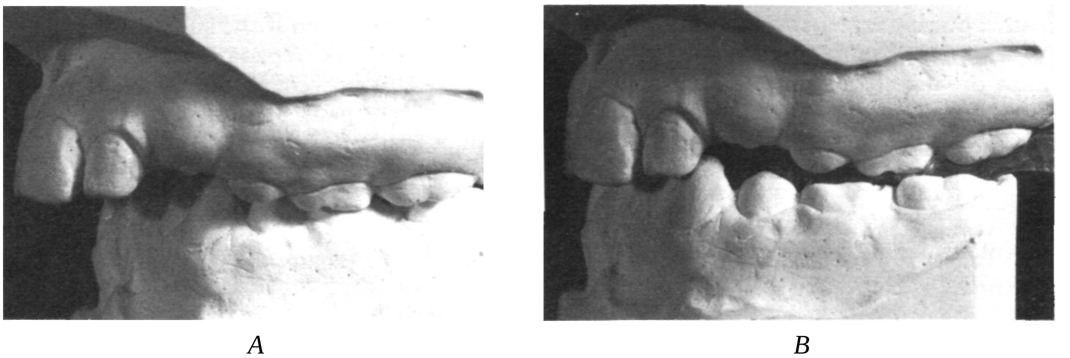
1. *Preparation of dental casts.* Impressions are taken in alginate material of the upper and lower dental arches and adjacent tissues. The impressions must extend to the full depth of the buccal and lingual sulci and cover the palate to the posterior limit of the hard palate. The impressions are poured in a hard or stone plaster and the working casts should be at hand when the bite is being taken.

2. *Taking the bite.* An adequate roll of softened pink wax is used and the nature of the bite registration will vary with the type of malocclusion being treated. The molar part of the bite must be adequately registered *(Fig.* 8.35).

Class I malocclusion: The bite is taken with the incisors edge-to-edge and in contact.

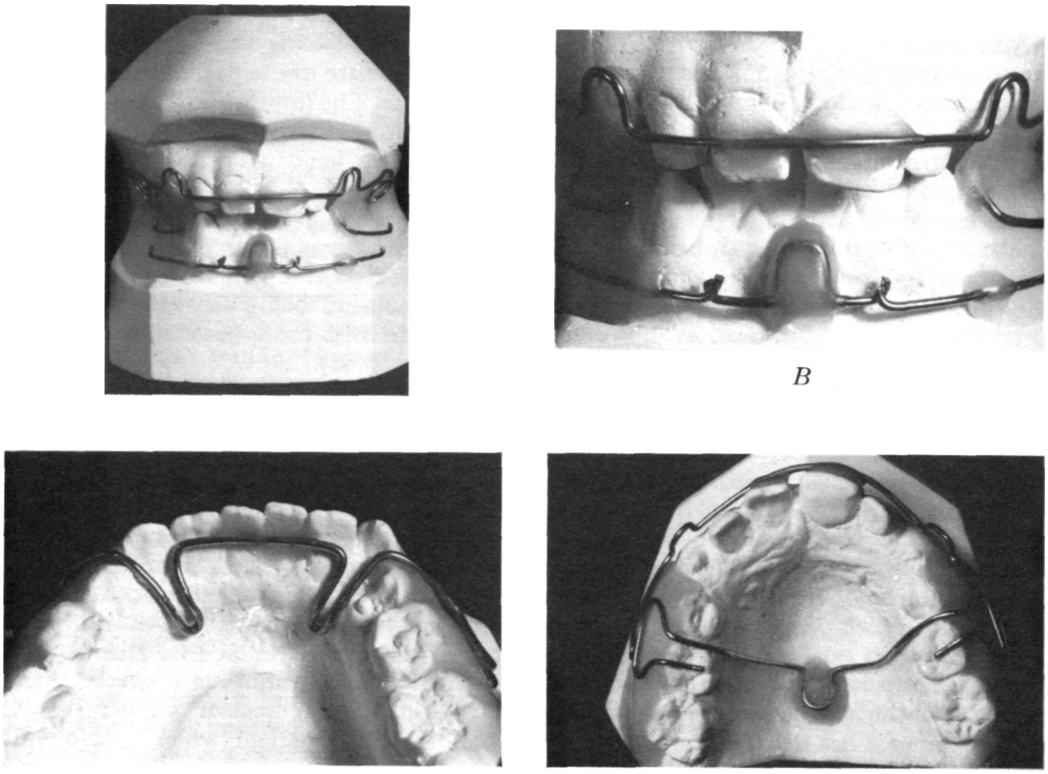
Class II malocclusion (divisions 1 *and* 2): In taking the bite the mandible is moved forwards to bring the buccal segments into a normal antero-posterior relationship and the teeth are closed together into contact. The amount by which the mandible is moved forwards is influenced also to some extent by the overjet and overbite and inclination of the incisor segments. The comfort of the patient when wearing the appliance must be considered and to bring the mandible too far forwards will mean that the appliance may not be worn.

Class III malocclusion: The bite is taken as nearly as possible with the incisors edge-to-edge, no protrusion of the mandible being allowed. It is sometimes advisable not to close the teeth fully together into contact if the lower incisors overlap the upper to any



A *B*

Fig. 8.35. Construction of the function regulator. Taking the bite. *A,* Postnormal occlusion. *B,* The mandible is brought forwards and the teeth brought together into contact.



B

C

D

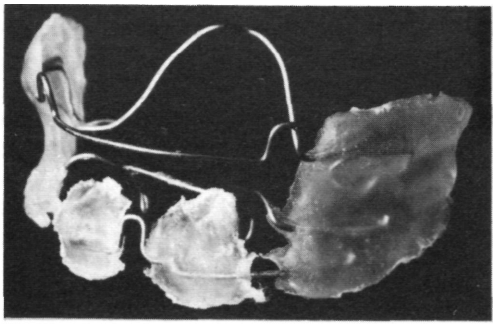
Fig. 8.36. Construction of the wire assembly of the function corrector. *A,* The casts are placed on an articulator, the buccal segments are covered with a layer of wax, and the wire parts are prepared. *B,* The upper and lower labial bows. C, The lower lingual arch with loops. *D,* The upper labial bow and the palatal arch with central loop and occlusal rests. *E,* The complete appliance with the resin polymerized. *F, G, H,* The appliance trimmed down, polished and replaced upon the dental casts.

marked degree and, when constructing the appliance, to place bite-blocks between the upper and lower buccal segments attached to the buccal screens. Such bite-planes or blocks prop the bite open sufficiently to allow the upper incisors to procline without the obstruction of the lower incisor teeth. If the lower incisor teeth do not overlap the uppers it is not usually necessary to put bite propping planes in the buccal segments.

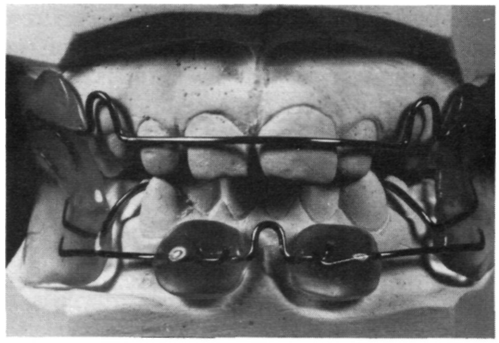
3. *Adjustment of the lower dental cast for F.R.* 1. The lower labial sulcus on the working model is compared with the appearance of the sulcus clinically. The working cast is trimmed with a round vulcanite cutter to ensure that the sulcus is sufficiently deep. If the impression does not record the full depth of the labial sulcus in the lower incisor region the labial pads when constructed will not hold the lower lip away from the lower incisor teeth. Even if the sulcus is deepened too much the labial pads which result can be trimmed to prevent irritation of the labial sulcus, but pads which are too shallow cannot easily be added to at a later stage.

Laboratory procedures. The following notes apply to the construction of a F.R. 1 appliance.

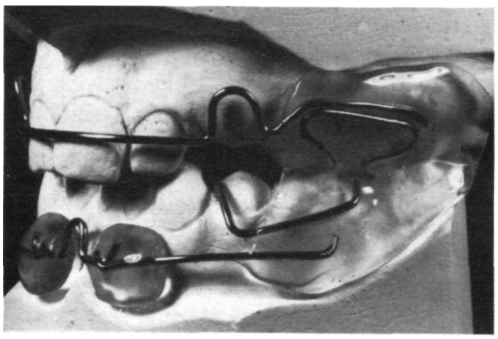
1. The working casts are mounted on a plain articulator using the working wax bite.
2. In the buccal segments wax of the



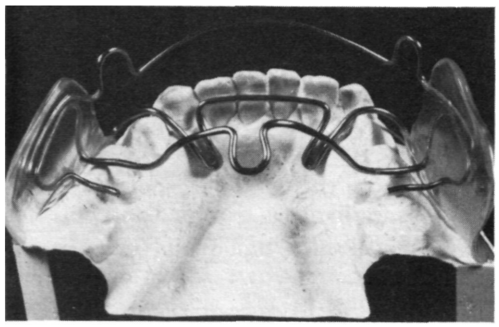
E



F



G



H

Fig. 8.36 *(cont.)*

thickness of 1.5 mm is placed over the buccal segments of the teeth and the adjacent mucosal covering of the alveolar process. When the buccal screens are subsequently constructed they will then be clear of the teeth and soft tissues.

3. The wire work, consisting of the following parts, is constructed in 0.9 mm hard stainless-steel wire *(Fig.* 8.36, *A-D):*

A. Casts on the articulator.

B. Upper labial arch with U-loops opposite canine teeth. Wire work for labial pads. This can be made in one piece but it is quicker and easier to use three pieces of wire for this part.

All the wires are attached to the casts with hard wax at points which will not subsequently interfere with the application of the cold curing resin. All the tag ends of the wires are brought buccally for anchorage in the buccal shields.

C. It is recommended by Frankel that the lower lingual arch be made in 0.9mm soft wire. It has been found in practice that hard wire may be used and that arches made of hard wire do not become distorted or broken.

D. Palatal arch with central U-loop. This arch must stand clear of the palate by 1-2 mm and pass buccally between the occlusal surfaces of the cheek teeth. The ends of the archwire are formed into loops for anchorage in the buccal shields and then brought towards the midline to make rests lying on the occlusal surface of the upper second deciduous molars. If these teeth are not present the rests should lie upon the first permanent molars.

4. The articulator is closed and the buccal wax padding made good at the line of the occlusion. A separating medium is applied to the plaster where the labial pads are to be constructed.

5. Cold curing clear acrylic material is used to build up the buccal wings and labial pads.

6. Curing of the resin may be accelerated by the use of a hydraulic pressure flask filled with lukewarm water. To get the appliance into the flask, the casts are removed together from the articulator and their bases cut down as much as necessary by means of a model grinder.

Using a hydraulic flask the resin sets rapidly, is free of porosity, and the heat involved is not enough to soften the wax and disturb the relative positions of the casts *(Fig.* 8.36, *E).*

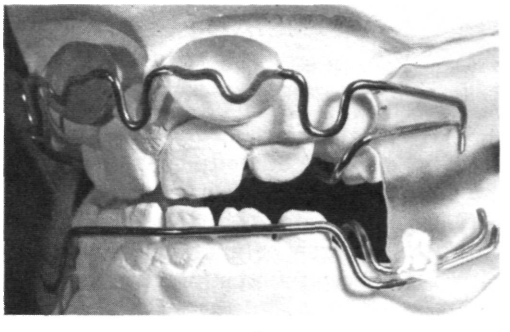
7. When the resin has set all the wax is removed from the casts with hot water.

8. The appliance is trimmed and polished *(Fig.8.36,F,G,H)-*

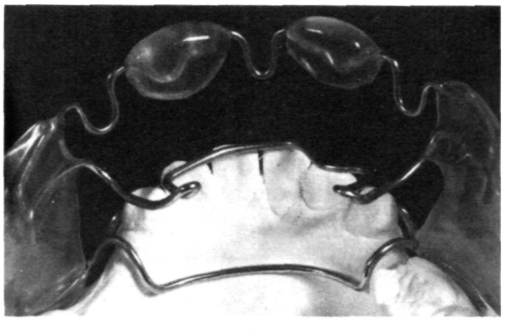
spots of discomfort or excessive pressure on teeth or soft tissues. Any such defects must be removed by adjusting the wire or easing the acrylic material away from the labial mucosa. Pressure points under the screens or pads show as areas of blanching visible through the clear resin. The labial pads will, of course, lie against the alveolar mucosa when the appliance is first fitted and it is necessary to trim away an even thickness of from 1 mm to 2 mm from the alveolar surface of the pads. The depth to which the pads project into the labial sulcus must be carefully watched and, if there is any irritation of the mobile mucosa, the pads should be trimmed back at the offending spot and the trimmed surface polished.

Most patients will be able to wear the appliance full-time from the first visit and to carry on a normal daily routine, apart from eating, with the appliance in place.

A patient who is self-conscious may for an initial period of a fortnight wear the appliance only on coming home from school and



A



B

Fig. 8.37. The F.R. 3 appliance. *A,* The labial pads are lying under the upper lip and a labial bow lies against the lower incisors. *B,* Note that the lower lingual arch stands away from the lower incisors and alveolar process. There is an upper lingual arch which touches the upper incisors.

9. An F.R. 3 appliance is shown in *Fig.* 8.37.

Management of the appliance

When the appliance is fitted the patient will be able to say at once whether there are any

at night. Thereafter it must be worn at all times except when eating. Very little maintenance or adjustment of the appliance is required apart from repair of accidental damage.

*Indications for the use of the function corrector**

The following set of case reports is the material of an investigation into indications for the use of functional correctors (Adams, 1969). The material has been grouped in the following way:

1. Postnormal occlusion (16 cases).
2. Prenormal occlusion (2 cases).
3. Anterior open bite (1 case).

The postnormal occlusions treated were all of the Class II division 1 type and, as will be recognized, this includes a great many variations. Further classification of this group of 16 cases was carried out as follows.

Subdivisions of Class II division 1 malocclusion:

1. Slight uncomplicated (2 cases).
2. Severe uncomplicated (5 cases).
3. With thumb sucking (4 cases).
4. With crowding (5 cases).
5. With early loss of deciduous teeth (3 cases).

Some cases came into more than one group and were therefore considered under more than one heading.

The postnormal occlusions and the open bite cases were treated with the F.R. 1 type of appliance and the prenormal occlusions with the F.R. 3. The results were as follows:

Postnormal occlusion	
Good result	4 cases
No improvement	12 cases
Open bite	
Good result	1 case
Prenormal occlusion	
Good result	2 cases

Before discussing these results it is necessary to examine in more detail a few of the cases that were successfully treated and what occurred in them.

*The remainder of this chapter, from the heading 'Indications for the use of the function corrector' to the end, including all illustrations, is reproduced from the *Transactions of the European Orthodontic Society* (1969) by kind permission of the Editor.

Postnormal Occlusion

The cases in question were:

1. A girl in whom a severe malocclusion existed from the time of eruption of the deciduous dentition until the problem was treated with the F.R. 1 at age 10 (category 2).
2. Two boys in whom there was crowding of the dentition, early loss of deciduous teeth and a severe postnormal occlusion (categories 4 and 5).
3. A boy aged 3 years 2 months with a gross postnormal occlusion and with lip sucking habits. Otherwise there was adequate room in the dental arches (category 2).

CASE REPORTS

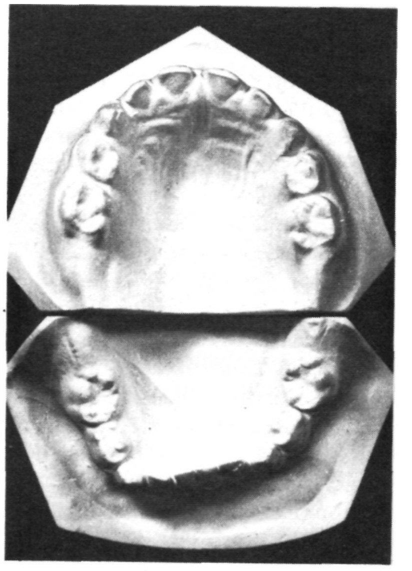
1. *J. M.* (*Figs.* 8.38-8.41). This patient attended aged 3 years 6 months with a history of lip sucking but not thumb sucking, although the appearance of the teeth strongly suggested a digit-sucking habit. The patient's mother was emphatic that any thumb sucking that took place was very occasional. The subsequent treatment result confirmed that the digit habit was of no importance in this case and the parent's assessment was absolutely correct.

DIAGNOSIS. A marked discrepancy in facial proportions was found with postnormality of the mandible and although the lips were of adequate proportions the lower lip lay continuously under the upper incisors and on swallowing the lower lip contracted firmly against the tongue (*Fig.* 8.38, *A*).

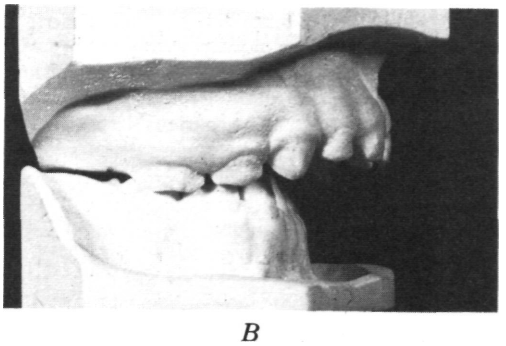
A simple cephalometric analysis revealed that the SNA/B difference was high, 8°, lower incisors retrocjined to 73° to mandibular plane, and the upper incisors proclined to 114-5° to the maxillary plane. There was a large overjet and incomplete, non-increased overbite (*Fig. 8.38, B,C,D*).

TREATMENT PLANNING. The patient was so small and so young that no active treatment was initiated at this stage, but yearly visits were instituted to observe growth progress and record by casts and cephalometric films the changes that were taking place.

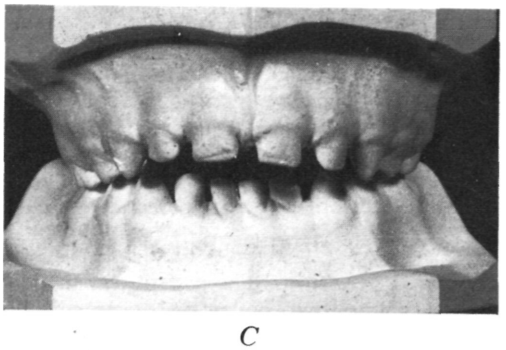
A



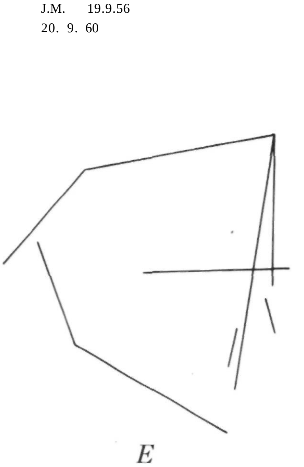
D



B

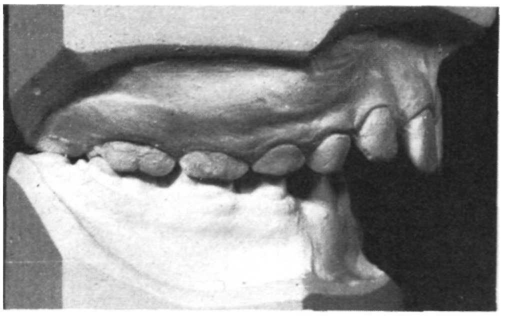


C

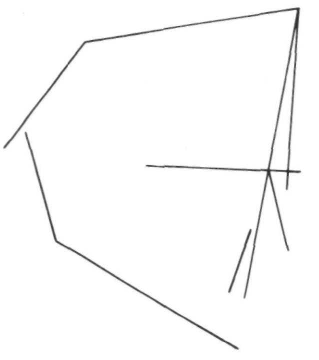


E

Fig. 8.38. J. M., aged 3 years 6 months. *A*, Profile. *B, C, D,* Dental casts. Note that in occlusal view the lower incisors appear to be pushed lingually, especially on the left, and the upper incisors are forwards on the right. *E,* Tracing of cephalometric X-ray film.



A



B

Fig. 8.39. J.M., aged 7 years 8 months. *A,* Models, right view. *B,* Cephalometric tracing.

At the age of 7 years the occlusion, facial pattern and soft-tissue activities were just as they had always been; the only difference was that permanent lower incisors were up instead of deciduous ones *(Fig.* 8.39, *A, B).* At this stage it was felt that something must be done to mitigate the condition and an attempt was made to align the lower labial segment to a more forward position. The movement required being a simple proclination a removable appliance was used, but it was not possible to produce the tooth movement as planned; the teeth would not move but instead became loose and it was deemed wiser after a short time not to continue with this line of treatment.

Subsequently an Andresen appliance was placed for a period of 9 months at the age of 8 years, but as this treatment produced not the slightest change in the occlusion the appliance was abandoned. An oral screen was also used for a short time but was also withdrawn quite soon.

Finally, it was decided that the function corrector might help the patient and at the age of 10 years the child was put on to function regulator treatment and within a few weeks improvements in the occlusal relationships began to take place. At the end of 14 months, both upper and lower dental arch arrangement was excellent and incisor relationship was nearly normal, mainly due to proclination of the lower incisors, although the upper incisors had retroclined to some degree *(Fig.* 8.40, *A, B).*

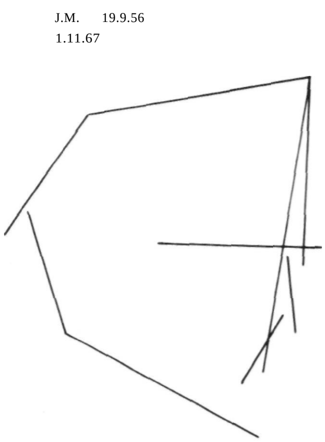
The Frankel appliance was continued for a further 7 months, at the end of which time no further improvement in occlusal relationship had taken place and, as the molar relation was still postnormal, treatment was changed to the use of an Andresen appliance which produced some further occlusal improvement. The Andresen appliance was being worn until the age of 12 years 9 months *(Fig.* 8.41, *A-E).*

ASSESSMENT OF THE RESULT. There is no doubt that in this case a rapid and dramatic improvement was made in the occlusion for this patient, although the appearance of the patient in profile does not appear greatly different before and after treatment as regards the relative prognathism of the upper and lower dental bases. The angle ANB at the end of treatment was 6°, a little less than the original 8° when the patient was first seen and 1° less than the 7° at the beginning of treatment. The mandible appears to have swung a little downwards and forwards during the time the patient has been under supervision and this may account for the change in ANB. The change in this angle of 2° appears to be due to an increase in the angle SNB of 2°, although the intermediate reduction in ANB of 1° seems to be due to a reduction in SNA of that amount.

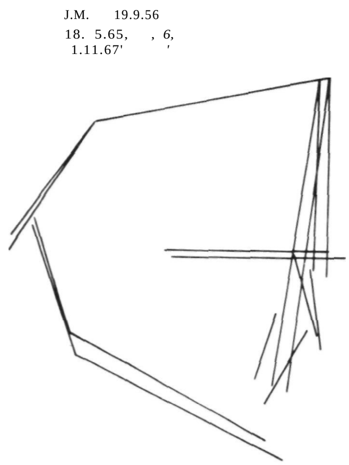
The strong impression remains that the improvements that are to be seen in the occlusion are not due to changes in the basic face shape but to changes in the arrangement of the teeth within

A

Fig. 8.40. J.M., aged 11 years 2 months. *A*, Models, right view. *B*, Tracing at 11 years 2 months. *C*, Superimposition of tracings at 8 years 8 months and 11 years 2 months.



B



C

the facial outlines. During the course of treatment the lower incisors have become proclined from 72-5° to the mandibular plane to 92-5°, a change of 20°, and the upper incisors have been retroclined by 6° to the maxillary plane. The changes in the molar region have been noticeable but by no means as striking. The patient's ability to keep a normal lip position and activity has been greatly improved and will be an important factor in the ultimate stability of the new occlusal relationship.

2. *G. J. (Figs.* 8.42-8.44).

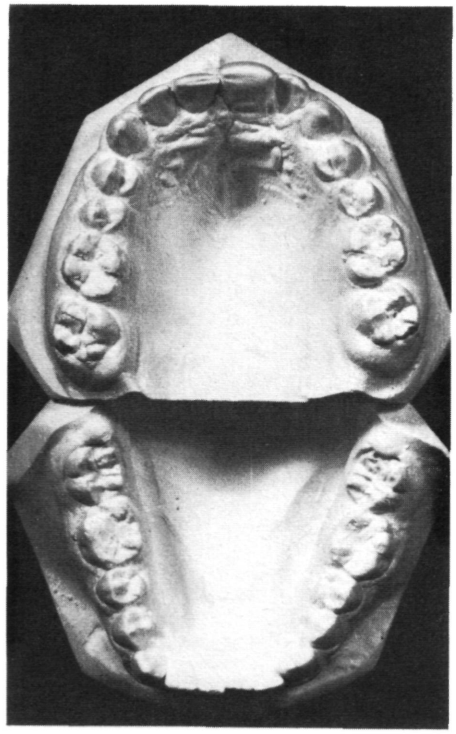
DIAGNOSIS. This patient, a boy aged 8 years 8 months, attended showing a severe degree of postnormality of dental bases and a similar discrepancy in the occlusion aggravated by early loss of deciduous teeth and closure of spaces for the unerupted premolar teeth. In this case there was no recorded anomaly of function of the orofacial musculature apart from a posture of the lower lip below the upper incisors. It was envisaged from the outset that teeth should be removed as part of treatment eventually to deal with the problem of crowding *(Fig.* 8.42).

TREATMENT. A Frankel 1 appliance was used in view of the severity of the overjet and overbite in an attempt to produce some improvement pending the eruption of the permanent canine and premolar teeth.

Changes for the better began to take place within a few weeks and by the time 8 months had passed there was a very marked improvement *(Fig.* 8.43). The appliance was worn for a further year because improvement appeared to be continuing. The premolars were then beginning to erupt and after a further 6 months extraction of the upper first premolars was advised to allow the canine teeth to erupt *(Fig.* 8.44).

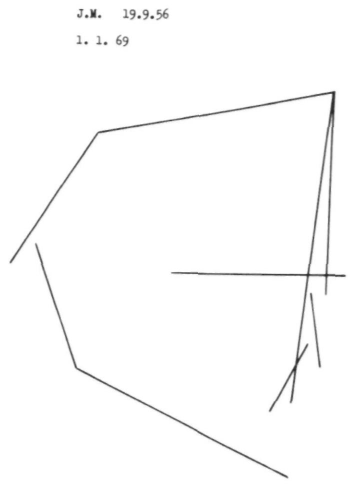
ASSESSMENT. What were the changes that took place in this case? There is no doubt of the

A

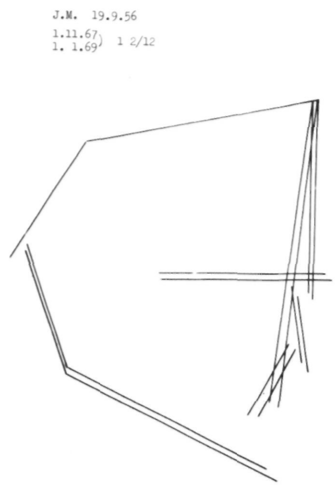


B

C



D

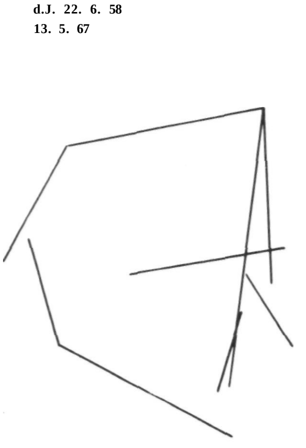


E

Fig. 8.41. J. M., aged 12 years 4 months. *A,B,* Models, right view and occlusal view. Note in occlusal view the symmetrical well-arranged arches. *C,* Profile. Compare with *Fig.* 8.39. *D,* Tracing at 12 years 4 months. *E,* Superimposition of tracings at 11 years 2 months and 12 years 4 months.

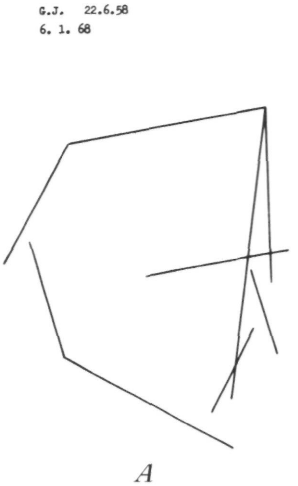
A

B

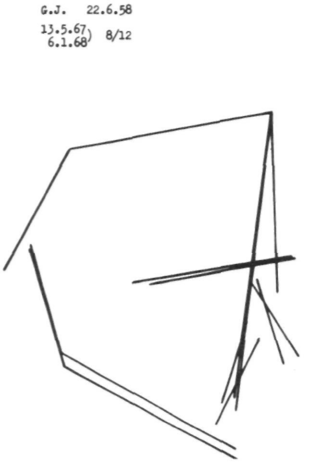


C

Fig. 8.42. G. J., aged 8 years 11 months. *A*, Profile. *B*, Models, right lateral view. *C*, Tracing of X-ray.

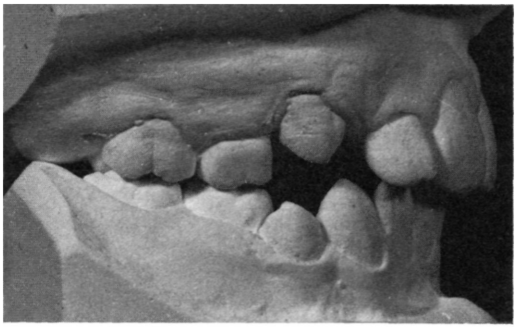


A

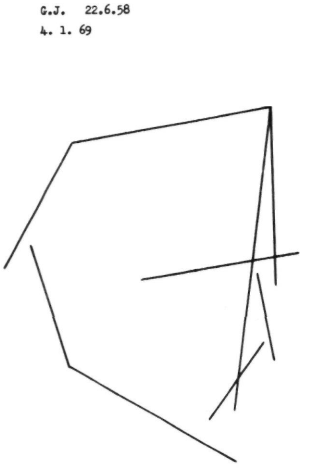


B

Fig. 8.43. G. J., *A*, Tracing at age 9 years 7 months. *B*, Tracing at 8 years 11 months and 9 years 7 months superimposed. Upper incisors are retroclined, lower incisors are proclined.



A



B

Fig. 8.44. G.J. *A,* Models at age 10 years 7 months. *B,* Tracing at 10 years 7 months.

improvement that occurred in the incisor relationship and the tracings of the cephalometric films seem to show that the change is due to alteration in axial inclinations. It is impossible to say about which point the teeth inclined because the bone areas in which the teeth are supported have changed in position. It should, however, be noted that the relative positions of the anterior part of the jaws themselves as indicated by SNA and SNB remained the same.

The relationship of the molar teeth on the two sides did not behave in the same way. On the right there was little if any change, while on the left a postnormal molar relationship of one unit improved to a half-unit postnormality. There was no obvious explanation as to how this had come about.

PROGNOSIS. It was noted in this.case that there was no anomaly of function apart from a resting of the lower lip below the upper incisors—a condition which no longer obtains as the new incisor relationship now permits correct lip posture at rest. In these circumstances conditions are favourable for stability of the new incisor relationship. The crowding of the dental arches is to be treated by removal of first premolars and the final occlusal relationship of the buccal segments has yet to be worked out.

3. *W. McK. (Figs.* 8.45,8.46).
DIAGNOSIS. This boy, aged 3 years, was brought for advice because of an open bite condition and marked retrognathism. On examination the patient was found to have a postnormal dental base relation, incompetent lips, and a marked lower lip-sucking/tongue-thrusting oral activity. The occlusion was markedly postnormal and there was a considerable overbite. There was no thumb sucking *(Fig.* 8.45).

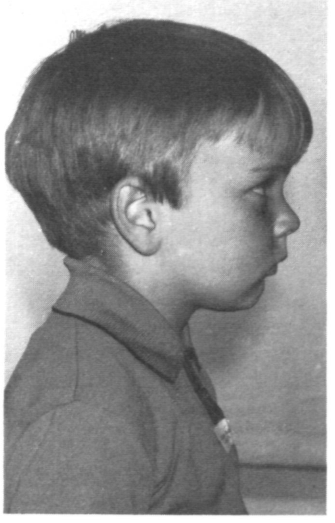
TREATMENT. The patient was given a F.R. 1 appliance and took to it at once and has worn the appliance without any difficulty for 1 year 3 months.

There was considerable improvement in the occlusion in that time and the patient is to continue to wear the appliance as long as improvements continue to take place *(Fig.* 8.46). The author is not sure that it would be wise simply to continue to use the appliance indefinitely and if a static condition is reached a resting period from treatment should be allowed, in all probability during the eruption of the permanent dentition, and when these teeth are erupted the whole problem should be reviewed in the light of the circumstances then found.

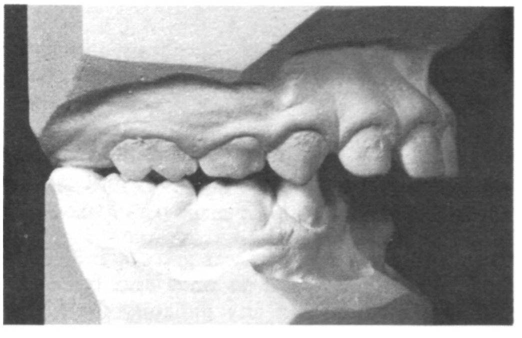
Prenormal Occlusion

CASE REPORTS

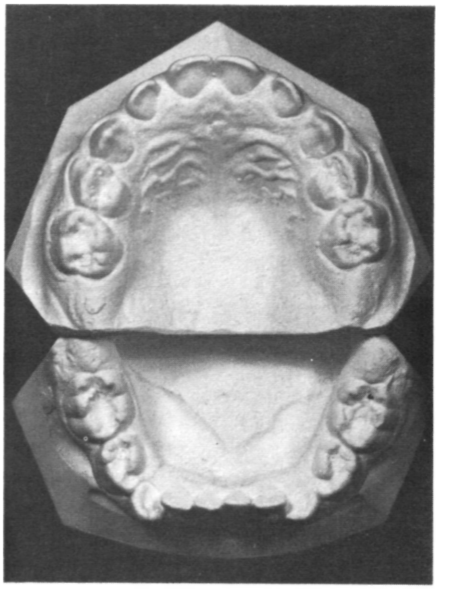
T.K.(Figs.8A7,8A8).
DIAGNOSIS. This patient, aged 9 years, had a severe Class III malocclusion due in part to a



A

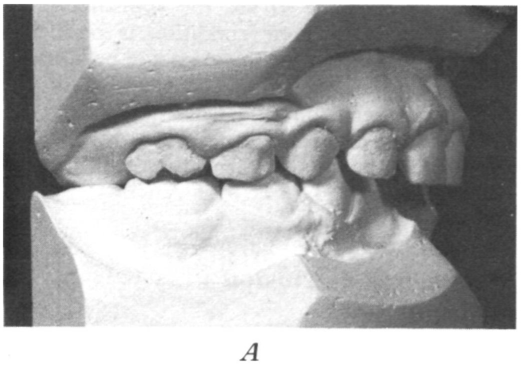


B

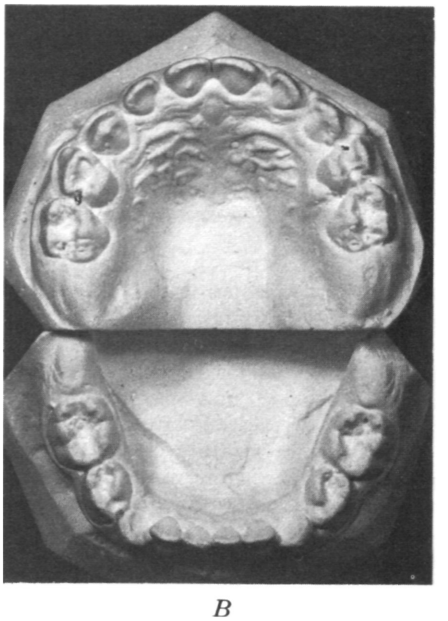


C

Fig. 8.45. W.McK., aged 3 years. *A*, Profile. *B,C*, Models, right and occlusal views.



A



B

Fig. 8.46. W. McK., aged 4 years 3 months. *A,B,* Models, right view and occlusal view. Note slight improvement in arrangement of lower incisors.

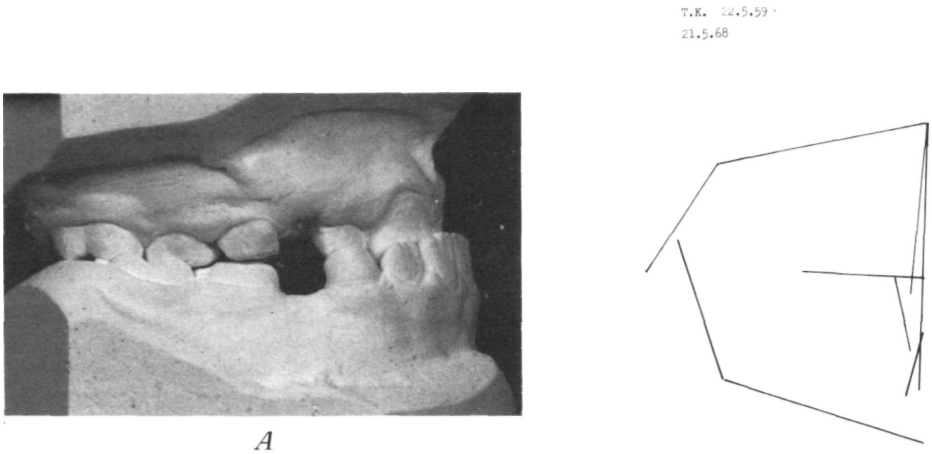


Fig. 8.47. T. K., aged 9 years. *A,* Models, right view. *B,* Tracing.

mesial displacement of the mandible on closing from the position of rest to the centric occlusal position, and also to a basic discrepancy in facial proportions in the direction of a mandibular prognathism. The large degree of overlap of the incisors and the break up of the occlusal line in the buccal segments suggest that there is some overclosure in this case, a condition that goes with premature contact, muscle spasm, failure of eruption of teeth in the buccal segments, and reduction of the normal maxillo-mandibular vertical height dimension *(Fig.* 8.47).

TREATMENT. The condition was treated with a F.R. 3 appliance and after a period of 4 months from the time the appliance was fitted a great improvement in the occlusion had taken place; so much so that correct incisor relationship had been produced. The appliance was worn for a further 8 months because the degree of overbite of the incisors was not judged to be sufficient to ensure stability. After a total period of 12 months the appliance was withdrawn and the second cephalometric film was taken 2 months later *{Fig.* 8.48).

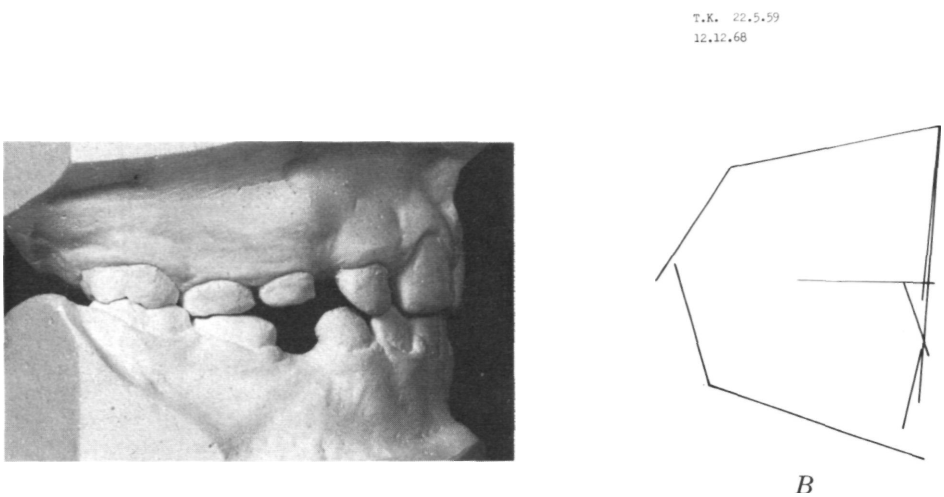


Fig. 8.48. T. K., aged 9 years 7 months. *A,* Models, right view. *B,* Tracing.

An examination of the dental casts and the cephalometric tracings showed that the changes that had taken place were due to a repositioning of the mandible distally and to a slight proclination of the upper incisor teeth. The maxillo-mandibular separation also appears to have increased considerably, although the angular position of the mandibular body has not appreciably changed.

A second case of prenormal occlusion was also treated with the F.R. 3 appliance and it is interesting to note that there were strong similarities in the general appearance of the occlusion and also in the reaction to treatment. It seemed that in both cases there was an element of displacement so that it is impossible to say from the evidence of these cases what is the effect of the appliance on true Class III malocclusion, that is to say, mandibular prognathism uncomplicated by any mesial displacement.

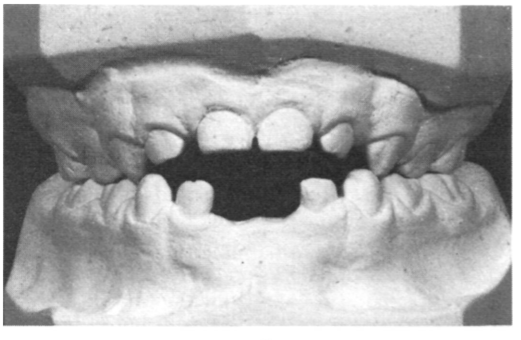
Anterior Open bite

CASE REPORT

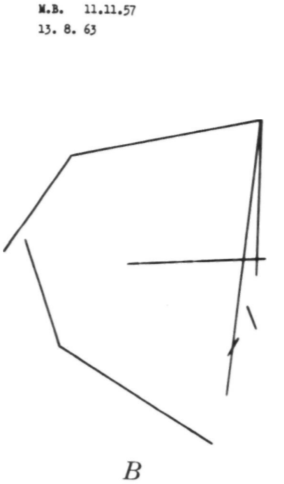
M.B.(Figs. 8.49-8.51).

DIAGNOSIS. This boy was brought for advice at the age of 6 years with a marked open bite, a tongue thrust and lip contraction on swallowing and speech *(Fig.* 8.49).

It was felt that little could be accomplished by any form of active treatment in this case and the

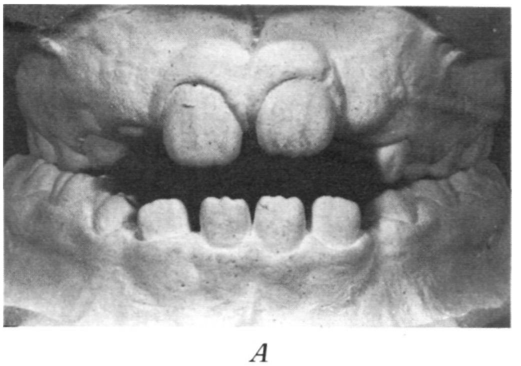


A

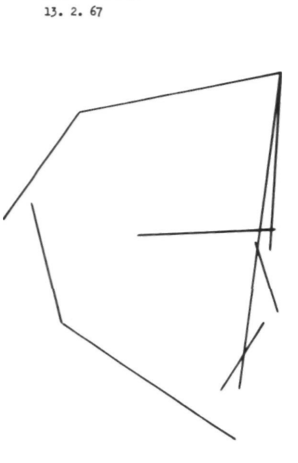


B

Fig. 8.49. M. B., aged 5 years 9 months. *A,* Models. *B,* Tracing.



A



B

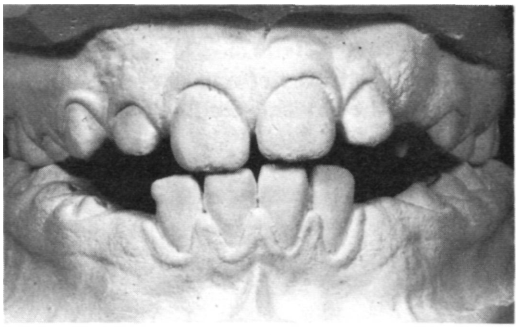
Fig. 8.50. M. B., aged 9 years 3 months. *A,* Models. *B,* Tracing.

patient was dismissed for a period of 3 years, returning at the age of 9 years 3 months *(Fig.* 8.50).

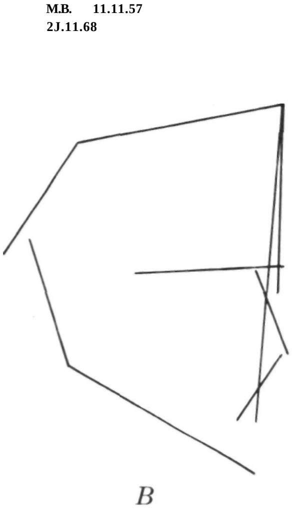
The permanent incisors had erupted but the open bite condition remained much as it had been when the patient first attended. The patient was dismissed for a further year after which, at the age of 10 years 3 months, a F.R. 1 appliance was fitted and worn for a period of 11 months. During this time a considerable improvement in the open bite condition occurred, after which the appliance was left out *(Fig.* 8.51).

A record of this patient taken 7 months later showed no further change in the overbite relationship. It appeared reasonable to conclude that it is very likely that the improvement in the overbite relationship was caused by the use of the appliance rather than that the change was taking place naturally during the time the appliance was being worn.

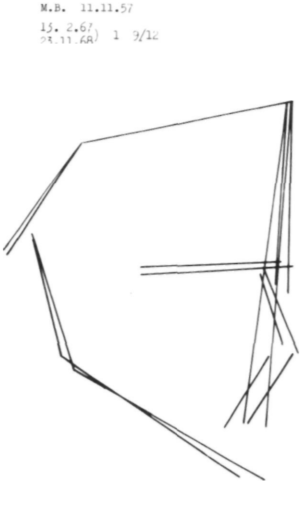
It is interesting to note that during the time when the appliance was being worn there has been, apparently, a forward and upward developmental change in the outline of the mandible. It is tempting to conclude that this must account for the improvement in the overbite. A study of the final stage of 7 months over which records were taken shows that the change in mandibular positioning has continued, although the incisor relationship has not continued to improve.

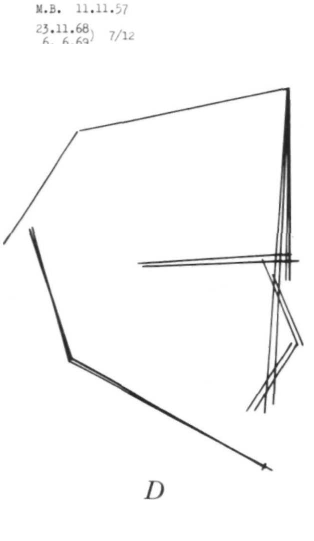


A



B





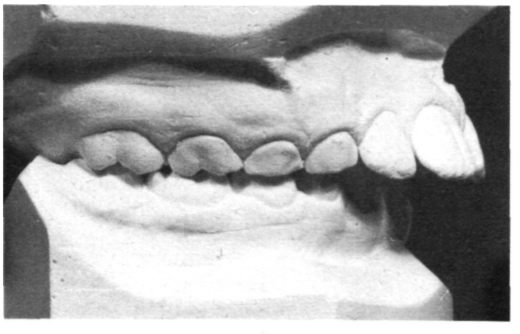
D

Fig. 8.51. M. B., aged 11 years. *A,* Models. *B,* Tracing. *C,* Superimposed tracings at 9 years 3 months and 11 years. *D,* Superimposed tracings at 11 years and 11 years 7 months.

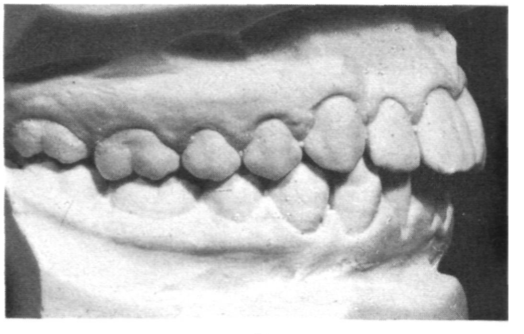
The remaining successful cases. The other cases in which good results were obtained showed many of the features which have been described in these 4 subjects. A degree of open bite was often present, possibly due to tongue and lip activities, occlusal relationship markedly disturbed mesially or distally, and discrepancies in incisor relationships usually severe—postnormally or prenormally. In all the cases that have been examined the changes that have been found to take place appeared to be limited to the dento-alveolar structures. In no case could it be said there was any evidence to suggest that basic jaw relationship had changed in any marked degree. This is surprising in view of the large changes in occlusal relationships, especially in the incisor region, that were observed clinically. Closer examination by means of cephalometric films only revealed changes in tooth inclinations.

Changes in skull base angle and in mandibular posture within the craniofacial complex were found but these changes were not reflected in any change in the measurements by which relationship between upper and lower dental bases is usually judged. These observations support the idea that the Frankel appliance acts by mediating the apposition of bone on surfaces rather than by promoting change in the relationship of the two parts of the masticatory face as a whole.

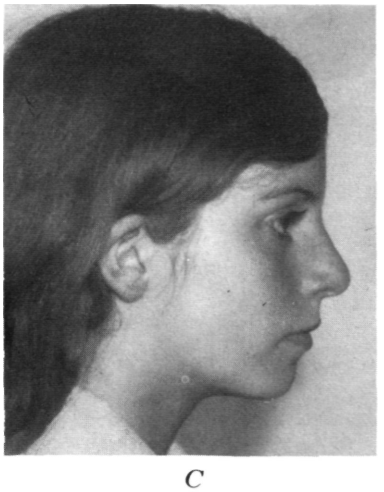
Fig. 8.52 shows a patient of 9½ years in the mixed dentition. There is a well-marked Class II division 1 malocclusion with increased overjet and overbite but no spacing in the anterior teeth. It was decided



A



B



C

Fig. 8.52. Postnormal occlusion and the functional regulator. This patient's treatment was started at the age of 10 years in the early stages of the changeover to the permanent dentition. The final result fulfilled the highest hopes as treatment by any other means was not compatible with the patient's career as a performing artist. *A*, At age 10 before treatment. *B*, Profile at age 15. Final records, age 15.

in this case to treat with a functional regulator and this proved most successful producing, in the end, normal occlusion with improvement of overbite and overjet. It can be seen that the patient has a slightly postnormal dental base relationship but competent lip posture.

The cases that failed. What can be said about the cases that did not improve with the use of the function corrector?

The first thing is that in the material available for this investigation the cases that failed were all in the Class II division 1 group. The subjects did not differ greatly from those in whom the treatment was a success, with one important exception, and this is the group of 3 subjects in whom there was a thumb-sucking habit. To some extent it appeared that the influence of the thumb did not counteract the effect of the appliance as such, but rather because the appliance interfered with the activity of the thumb, which was one of the aims of treatment, in the cases in question it was not the thumb which gave way but the appliance.

In one case in which the parent was more than usually active and interested in the progress of treatment it was stated that the appliance was felt to be an affront to the thumb-sucking activity and the thumb was greatly preferred to the appliance. In the other thumb-sucking cases no effect was produced by the appliance at all and, although the day-to-day use of the appliance was not reported and documented, it seemed very likely that the appliances were not worn.

As regards the other four categories, these may be divided into those in whom there was non-cooperation in wearing the appliance, although the malocclusions seemed basically amenable to treatment by the system, and those in whom there was co-operation. In the first of these groups of cases appliances were left out, lost and broken so that the time during which the appliances were in position must have been very small. It seemed clear that in some of these cases the fault did not lie entirely with the patient. It was found that the appliance was sometimes not comfortable to wear because it was unstable and the screens did not, in consequence, lie in the proper positions or stood too far out from the alveolar process or the tooth crowns. Sometimes the mandible had been brought too far forwards, so producing discomfort and difficulty in speech and causing the appliance to tilt and hold the lips in a completely wrong position.

In the remaining cases, as far as could be ascertained, there was good co-operation and parental interest and anxiety to achieve a good result.

Even so, the results were disappointing, with small changes only or no change at all after wearing the appliances. Two further aspects of these cases in which there was co-operation appeared to be of significance, one of which was that there was a well-defined dental base discrepancy and usually associated with this was the fact that there was no anomaly of tongue or lip activity.

Conclusions

(1) What should the Frankel appliance be used for? (2) In what kind of cases may success be hoped for? (3) What is one entitled to expect from the appliance if properly used?

1. The Frankel appliance has been shown to produce improvement of the occlusion in Class II and Class III malocclusions and in open bite so that any cases of these types may be considered for treatment by the function corrector. It has not been the author's experience that the appliance helps the condition of crowding as such, although in some of the successfully treated Class II division 1 cases crowding was present. The need to extract teeth for the relief of crowding remained and this need was foreseen, although the malocclusion as a whole improved. So far, treatment of Class II division 2 cases has not been attempted by the present author.

2. The appliance has been found to work successfully in cases in which there is a severe discrepancy of dental base and occlusal relationship; in which there is a severe anomaly of function of the tongue and lips; and in which there have been crowding and early loss of deciduous teeth. In cases in the present series in which there was a thumb-sucking habit no improvement was produced. This may be an indication for caution in the use of the appliance in such cases.

3. What may one expect from the use of the appliance?

a. It is the author's experience that, if the appliance is going to work, changes will take place rapidly. If this does not occur, it is likely that the appliance is not going to be successful and after a period of about 4 months the diagnosis and treatment plan should be carefully reconsidered.

b. The changes that take place are mainly to be seen in the anterior teeth and are produced by changes in axial inclination of the teeth.

c. Changes in the antero-posterior occlusion of the teeth in the buccal segments will be small and it is the author's practice to produce such changes by other means than the function corrector.

d. Changes in the relationship of the teeth appear to be produced by rearrangement of the dento-alveolar structures and not by changes in the basal relationships of the jaws.

e. The appliance seems to have a valuable part to play in certain cases in the mixed dentition stage of development when the fitting of precisely constructed removable or fixed appliances may be disturbed by the loss of deciduous teeth.

/. The appliance can be used in young subjects and, when severe malocclusions are present, a start can be given to improvement of occlusal relationship.

g. The relationship between the orthodontist and the patient is important in eliciting co-operation. It is important that the patient should accept the appliance and virtually forget that it is being worn.

The function corrector is a most useful appliance in the treatment of a proportion of cases of certain types. The number of cases included in the present investigation is very small—so small as to make it perhaps unwise to try to draw any general conclusions from them. A careful, accurate and dispassionate appraisal of the effects of treatment in even a small number of cases can be shown to be informative, revealing and helpful in the planning of future applications of the system.

THE WAY FORWARD WITH FUNCTIONAL APPLIANCES

In this chapter, attention has been given to two of the best known types of functional appliances which operate in basically different ways; the Andresen appliance and the Frankel appliance. These appliances have been widely used for many years in Europe and more recently in America and have been the .subjects of hypotheses, investigation, experimentation and modification.

Functional appliances have their proponents and their opponents but the advantages of treatment of major malocclusions by what might be considered comparatively non-invasive means are too great for functional treatment methods to be left out of the available schemes of management of malocclusion.

There are many mixtures of the principles of action of functional appliances in the various apparatuses that are available today, and each mixture strives for greater efficacy in producing better and more permanent results. It may be, indeed, that as in medicine, in a combination of agents, adjuvant effects occur and the whole effect may be greater than the sum of the individual parts.

In assessing how a functional appliance is working, it is well, therefore, to think of where the influences are coming from; the masticatory muscles, the facial and lingual muscles, the placing of the mandible out of its usual relationship with the maxilla, the influences of pressure elements embodied in the appliance and of extra-oral traction, if applied.

In determining the effects produced by any functional system of treatment, it is necessary to evaluate the changes produced in tooth position within the jaws, in the shape, size and relationship of the jaws and in the muscular and other tissues investing and connected to the jaws. It is also above all necessary to discount the changes that must be expected in growth during the period when treatment was being done.

The Harvold Andresen Appliance

An evaluation of this kind has been done by Harvold and Vargervik (1971) in relation to an Andresen appliance of design different from the pattern that has been widely used in the past (*Fig.* 8.53).

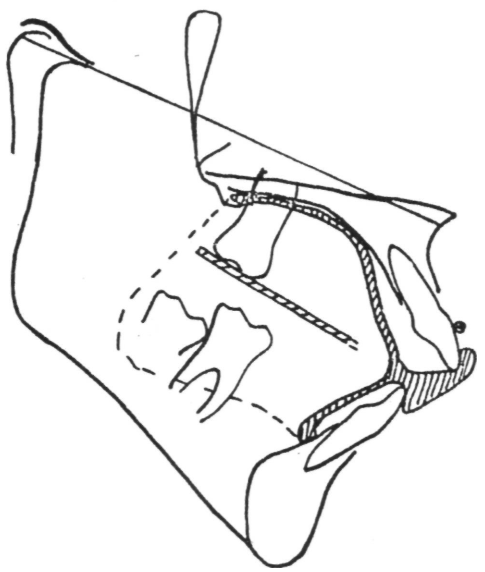


Fig. 8.53. This diagram shows the principal features of the Andresen appliance as modified by Harvold (1974). The working bite is taken fairly widely open, the appliance cut away from the anterior teeth and from their bony support so that the teeth can incline freely. There is an upper labial bow which can be activated to produce retroclination of the upper incisors. The occlusion is propped mainly on the incisal edges of the anterior teeth and on the upper molars, which rest on platforms to prevent their eruption or 'extrusion' as it is referred to. The lower molars are free to erupt. *{Reproduced by kind permission of E. P. Harvold and C. V. Mosby Co.)* .

The Andresen appliance advocated by Harvold (1974) is used in the early mixed and mixed dentition.. The bite is taken in a very open position and is supported on the anterior teeth which are at the same time left free to incline. The upper molar teeth are propped on a plane to prevent eruption and the lower molars are encourged to erupt further.. The hypothesis underlying these arrangements is that correction of the occlusal relationship in Class II division 1 malocclusion is dependent less on changes in jaw relationship or in antero-posterior tooth position than on eruption of the lower molar teeth and that this is what should be aimed at through treatment with this functional appliance.

Other improvements in the orofacial complex which are part of the treatment plan by this method include the correction of incisor inclinations, overjet and overbite and strengthening and adjusting muscle activity to maintain the new tooth arrangements.

It is also thought that these improvements will, lead to improvements in nasal respiration.

Other Functional Appliances

Other functional appliance systems combine, in varying degree, means to posture the mandible, screen the dentition from the pressures of tongue and lips, exert individual pressures on teeth or groups of teeth, and invoke the aid of traction using the head and neck as a base for anchorage.

One such system has recently been put forward by Clark (1982) which invokes all these factors mainly in the treatment of Class II division 1 malocclusion.

Functional appliance treatment is at the very root of orthodontics or, as it is sometimes termed, dentofacial orthopaedics. Perhaps the most important aspect of the functional approach to treatment is that treatment regimens which take control of the occlusion and place the teeth and dental arches in predetermined positions must sooner or later let go. The functional forces of the occlusion then take over and finally determine where everything shall come to rest. Perhaps by producing the treatment changes by functional means in the first place there may be less settling to take place after treatment and the treatment result may be nearer to the final position of settlement than if that result were obtained by more mechanical means.

Chapter 9

Technical Procedures

Orthodontic technique is essentially a matter of skill in the bending of wire. The importance to the orthodontist of gaining skill and facility in bending wire cannot be overstressed, but all too often the development of ability is left to chance. As a rule much time is wasted and the best and easiest methods of bending wire are never applied.

WIRE-BENDING METHOD

The problem of bending wires to the various shapes required for orthodontic purposes may be approached in two ways. A number of special pliers may be used, each designed to serve some particular wire-bending purpose. Such pliers are made with specially formed beaks, grooves, serrations, or additional parts about which the wire can be bent, so making the bending operation automatic. In some types of pliers simply grasping the wire firmly between the beaks will produce the required bend.

Specialized pliers have the advantage that they perform the bending operation for which they are designed quickly and easily, but they have corresponding disadvantages. Special pliers perform only one or two operations; the more specialized the pliers the fewer the bends that can be performed. Consequently there is a tendency for an operator who uses this method of wire bending either to multiply his stock of pliers to widen the range of bends he can make or else to limit his technical procedures to the limitations of his pliers. Special pliers are sometimes limited in the thickness of wire they can bend.

These physical limitations of specialized pliers may also impose a limitation on the imagination of their user through a failure on his part to appreciate the possibilities of applied basic wire-bending method in the construction of appliances.

The alternative approach to wire-bending problems is based on three foundations. First, the use of one or two basically simple pliers; secondly, the study of wire-bending methods; and, thirdly, the elimination of unnecessary complications from wire work in appliance construction.

Adams Universal Pliers

Universal pliers (*Figs.* 9.1-9.4), in conjunction with a study and application of wire-bending principles, will perform every wire-bending operation required for removable appliance construction, with the exception of the formation of loops in springs.

The essential features of these pliers are:

1. The distance between the hinge pin and the tips of the blades is short: 23 mm is the optimum length.
2. The handles are large and comfortable. In particular, it should be possible to place the thumb of the hand gripping the handles on or very near the tip of the blades, while at the same time applying a strong grip (*Figs.* 9.9, 9.14, 9.20).
3. The taper of the blades should be accurately ground to the angle shown.
4. The sides of the beaks should be perfectly flat.

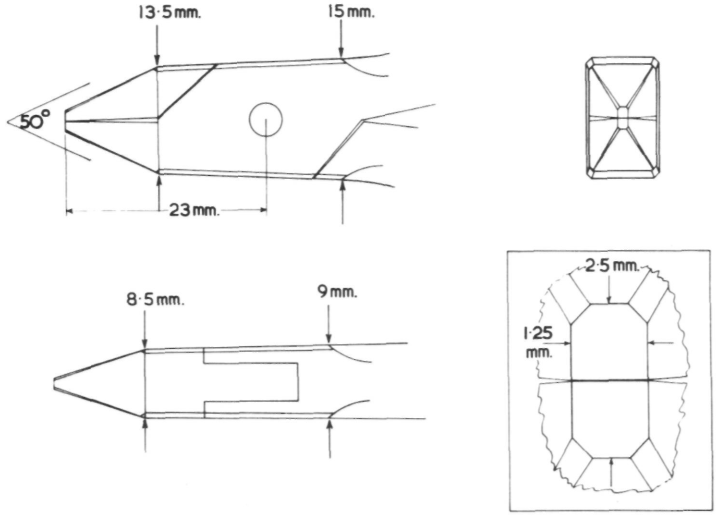


Fig. 9.1. Universal pliers. The blades of these pliers must be accurately ground to the dimensions indicated. The tips of the beaks should not be less in size than shown, but may be slightly more if the metal is not adequately hard and tough.

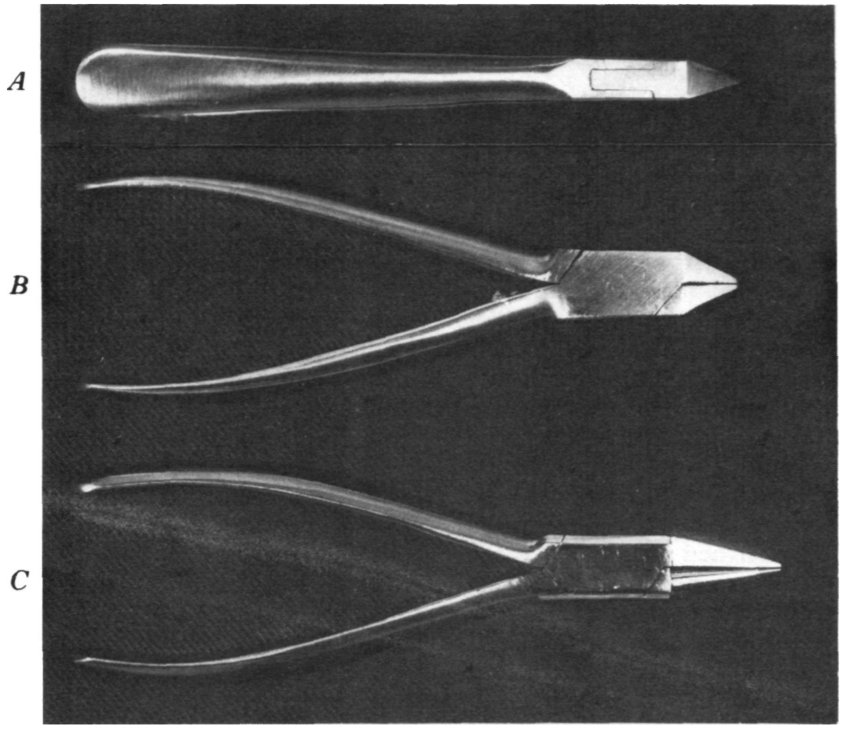
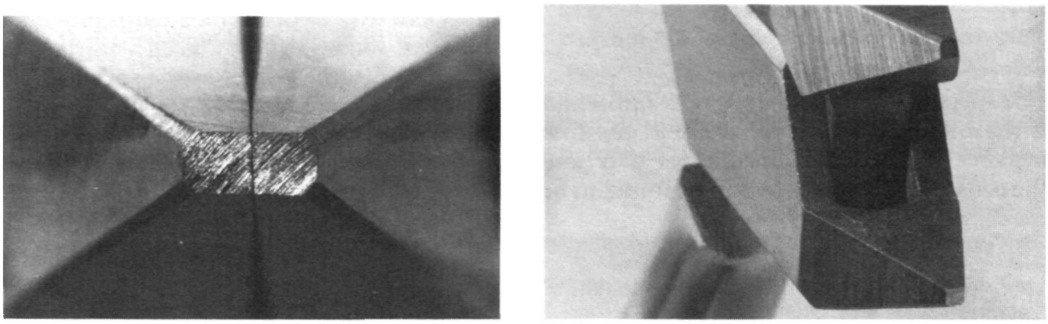


Fig. 9.2. Universal pliers measure 5¼ in. overall and have gracefully curved handles designed for a maximum pressure with minimum expenditure of energy. *A*, The handles are comfortably broad to distribute the pressure over a wide area of the palm and fingers. *B*, The handles have a spread of 48 mm and the inner surfaces of the beaks taper to a gap of 0·6 mm at the hinge. *C*, Spring-forming pliers have the same handles and hinge as Universal pliers.



A B

Fig. 9.3. *A,* The tips of the pliers are ground very accurately to 1·5 mm square. The outer corners are slightly chamfered. *B,* The inner surfaces of the beaks are not polished; the edges of the beaks are quite sharp and must not be bevelled or rounded.

5. The outer edges of the blades are very slightly chamfered, but not rounded.

6. The edges of the grasping surfaces of the beaks must be left sharp after the final grinding operation in manufacture and *must not be bevelled at all.* This point is very important.

7. The grasping surfaces of the beaks should be matt finished. *They must not be polished* but equally they must not be grooved or serrated. The finish left by fine filing or grinding is satisfactory provided that the subsequent chromium plating is not polished either. Sometimes the grasping surfaces of the beaks will be found to have been coated with a fine metallic dust. This provides an exceedingly satisfactory surface.

8. When the pliers are closed, the tips of the beaks should be in contact, but there should be a slight gap at the hinge end of the beaks tapering down evenly to contact at the tips. This gap should be 0.6 mm at its widest part, so that when the tips of the beaks are open to 1.0 mm the inner surfaces of the beaks are parallel. It is thus possible to grasp a 1.0 mm wire with the whole length of the beaks, so securing a powerful grip. Again, when a wire is grasped only at the tips of the beaks, the tendency for the wire to shoot out from the beaks is reduced (*Fig.* 9.4).

9. The hinge of the pliers should be strong without being too bulky and the handles wide and comfortable without making the pliers heavy and clumsy to handle. An overall length of 13 cm (5¼ in.) is about right.

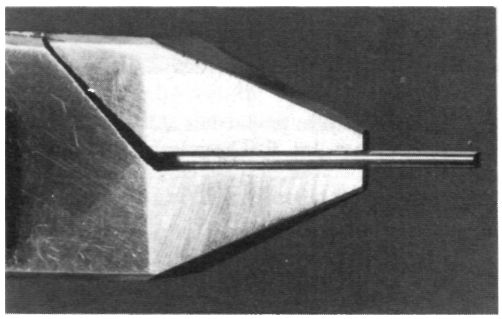


Fig. 9.4. When a millimetre wire is grasped the inside surfaces of the beaks are parallel.

These pliers depend for their action on the power with which it is possible to grasp the wire with a moderate hand pressure. A slight additional grip is given by the sharp edges of the beaks when the wire is bent. The absence of serrations on the beaks avoids injury to the wire, and the absence of grooves and nicks makes it possible to grasp the wire in an infinite number of positions. Grooving the beaks of pliers makes them into special pliers and greatly limits their usefulness.

Universal pliers will bend any of the wires used for orthodontic purposes with ease and are particularly useful for clasp construction (*see* pp. 176, 177).

Correction and maintenance of Adams universal pliers

The specification of these pliers is simple and if the pliers are correctly made in the first instance the accurate bending of wire and the construction of clasps will be found to be quick and easy to perform. Adams universal pliers are sometimes produced with lack of attention to some points in the specification and in consequence wires can only be held with difficulty and effort, and the user quickly becomes tired and irritated with his lack of technical success.

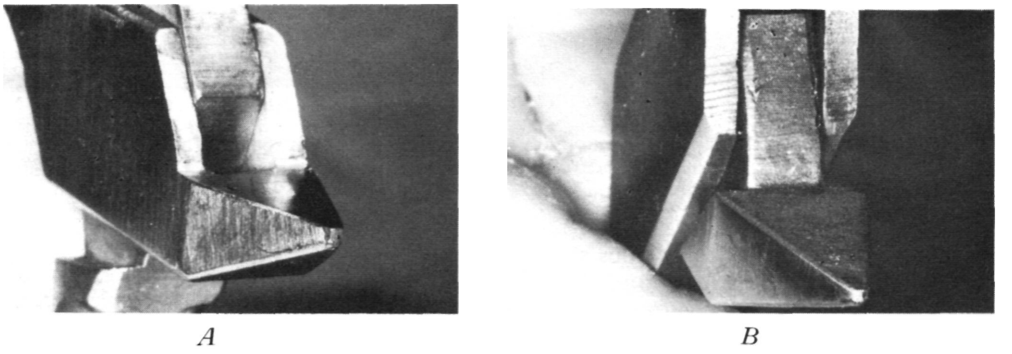


Fig. 9.5. Faults in production. *A,* There is a polish in the grasping surfaces of the beaks and the grasping edges are bevelled. *B,* The grasping surfaces of these pliers are correctly matt finished but there is a very large bevel on the grasping edges. Both these pliers are new and unused. The first pliers are virtually useless and the second pliers require correction before use.

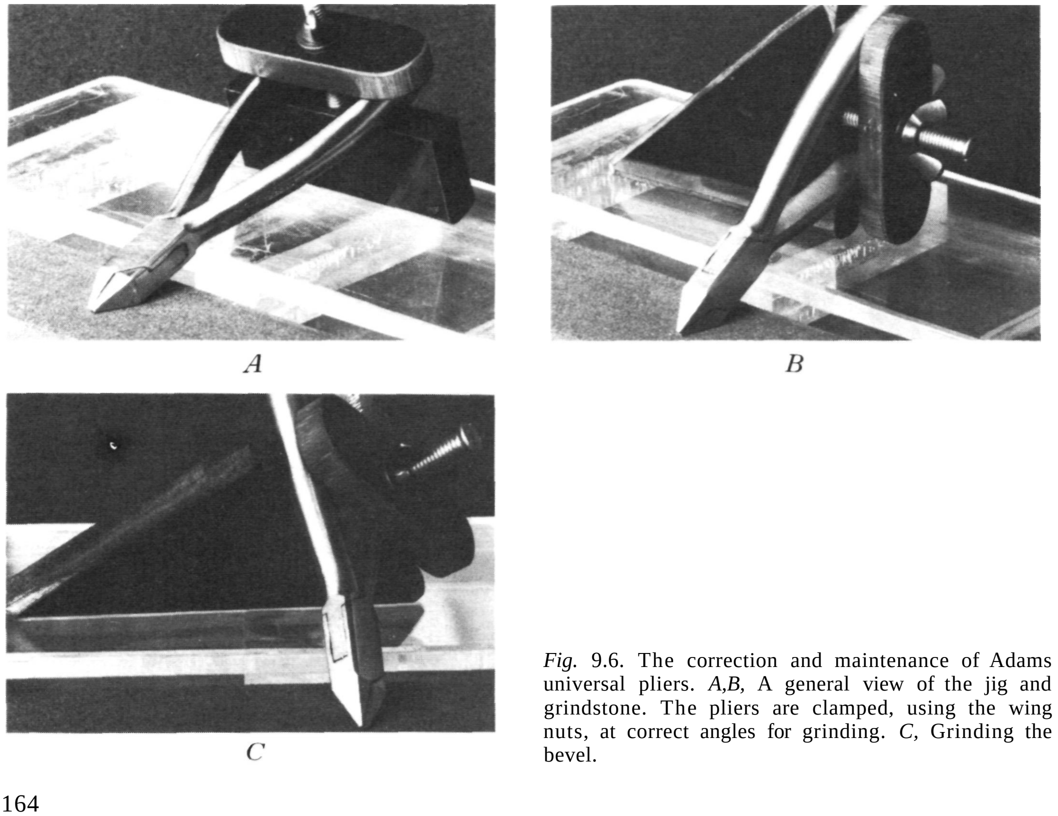


Fig. 9.6. The correction and maintenance of Adams universal pliers. *A,B,* A general view of the jig and grindstone. The pliers are clamped, using the wing nuts, at correct angles for grinding. *C,* Grinding the bevel.

Faults that may be met with in these pliers are that they may be made of inferior stainless steel, the handles may be too long or too short, or the beaks may be polished on the grasping surfaces and the inner edges of the beaks may be bevelled or rounded *(Fig.* 9.5).

The form of the beaks may be corrected by grinding off the sides just sufficiently to make a sharp edge. While the correction can be made on a grinding machine, it is more satisfactory to do the job using a small jig *(Fig.* 9.6) and rubbing down the beaks on a carborundum stone under a stream of water to keep the stone clean and cutting freely. In this way the operation can be done with complete certainty in a matter of minutes. By the same method the top and bottom surfaces and the bevel on the outer corners can be touched up.

If, after these adjustments, the tips of the beaks are found to be too fine they should be ground back carefully by holding them against a fine grinding wheel on a dental lathe run at low speed.

If the inner surfaces of the beaks have been polished in manufacture the polish must be removed using a very small mounted stone in a straight handpiece. It is, of course, vital that the grasping surfaces of the beaks should be fiat and great care should be taken not to round these surfaces *(Fig.* 9.7).

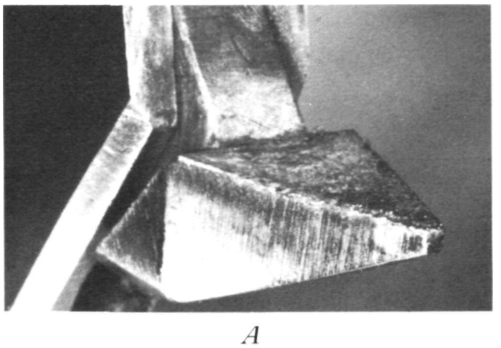
The adjustments that have been mentioned may be carried out on pliers that have been in use for some time and have become worn at the edges and smooth on the grasping surfaces of the jaws *(Fig.* 9.7). Well-made and hardened steel pliers will last for years, but if the metal is not good or properly hardened wear will soon show up in use.

Spring-forming Pliers

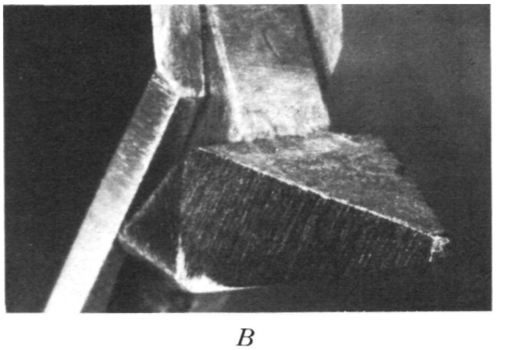
Other essential pliers for removable appliance construction are spring-forming pliers. Those illustrated in *Fig.* 9.8 have distinct advantages. A tiny coil in a 0-3 mm wire up to a large coil in a 07 mm wire can be formed. Coils can be opened and adjusted by placing the square beak into the coil and gently closing the round beak on the outside of the coil.

It is important when using spring-forming pliers not to bend too thick a wire too near to the tips of the pliers. The use of spring-forming pliers to make sharp bends in heavy wires is one of the most common abuses of pliers.

One of the most important features of pliers is that they should be made of good steel. Properly made pliers will last indefinitely without wearing. Inferior pliers wear rapidly and cause great difficulty in wire bending.



A



B

Fig. 9.7. The correction of pliers that are bevelled or worn at the grasping edges. *A,* Adams universal pliers after some years of use; note the turning over of the working edges. *B,* The same pliers after grinding the sides of the beaks. Note the straight sharp edge of the beak.

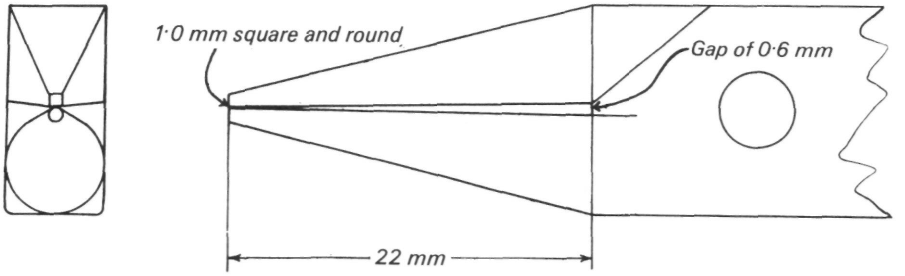


Fig. 9.8. Spring-forming pliers should be accurately ground to dimensions shown. The tips should be at most 10 mm square and round in size, but may be less if desired and the quality of the metal will permit.

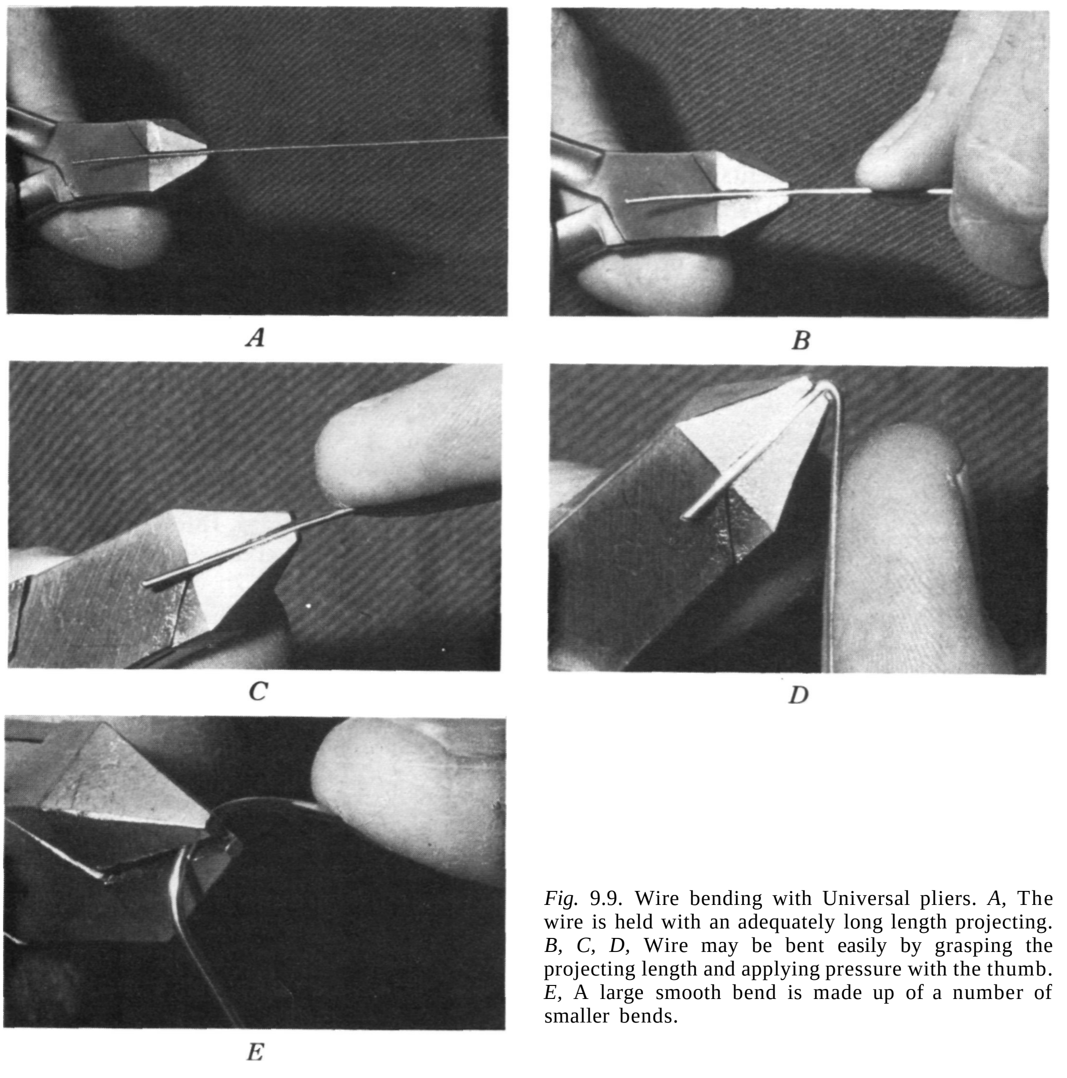


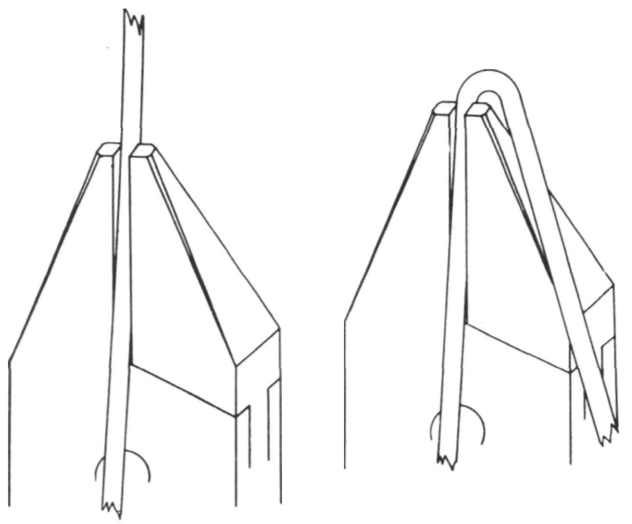
Fig. 9.9. Wire bending with Universal pliers. *A*, The wire is held with an adequately long length projecting. *B, C, D,* Wire may be bent easily by grasping the projecting length and applying pressure with the thumb. *E,* A large smooth bend is made up of a number of smaller bends.

Problems in the Bending of Wire and Their Solution

The bending of fine wires does not present much difficulty as the resistance of these wires to bending is slight in comparison with the strength of the fingers and the pliers.

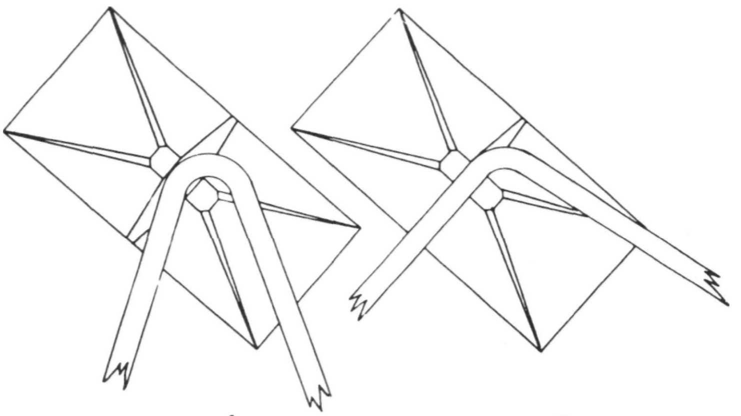
Heavy stainless steel wires are difficult to bend because the material is strong and tough and because it is necessary to bend the wire sharply and with great accuracy. The basic difficulties in bending heavy stainless steel wires are therefore:

1. The making of sharp bends in heavy wires.
2. The accurate placing of such bends.
3. The construction of complicated shapes for bows, arches and clasps.



A B

Fig. 9.10. Diagrammatic representation of *Fig.* 9.9 showing relation of wire and pliers.



A B

Fig. 9.11. The correction of sharp bends in heavy wire. *A,* The incorrect part of the bend is grasped in the tips of Adams universal pliers and squeezed firmly. *B,* This will straighten this portion of the wire. The sharp edges of the beaks of the pliers prevent the wire from slipping but do not injure the wire. The wire is then bent where required.

The principles and methods of wire-forming are as follows:

1. An adequate length of wire should be used so that a long end or 'tail' is available for manipulation, while the formed part of the wire is held in the pliers and so away from any possibility of accidental distortion *(Fig. 9.9, A).*

2. The pliers should be used to hold the wire firmly and still. The wire is then bent, using the long free end or 'tail' for this purpose. Bends can be made much more accurately and sharply if the pliers are held still and bending done by moving the wire *(Fig.* 9.9, *B, C,D).*

3. It should always be arranged that the free end of the wire is held in the hand in such a way that the thumb is used to bring pressure on the wire, the other fingers being wrapped around and grasping the wire. The wire should be bent with the *thumb;* the fingers cannot apply such a strong and controlled pressure as the thumb.

4. Sharp bends are made by bending the wire over the corner of the end of the plier blade, *not around the end of the blade (Fig.* 9.10, *A, B).*

5. If the wire has been sharply bent at a slightly incorrect position, a correction may be made if the wire is straightened as indicated in *Fig.* 9.11, *A, B.* The incorrect portion of the bend is gripped in the tips of the plier beaks and squeezed. This has the effect of straightening the small section of wire selected without interfering with the remainder of the bend. The wire is then re-bent at the correct spot at the other side of the original bend. This method of correcting bends is better than straightening the whole bend and starting again as this is liable to overstress the wire and render it crystalline and liable to break.

6. The bending of 0.7 mm wire sharply as required for the modified arrowhead clasp should be carefully studied *(see* pp. 176-178). These bends are not made around the ends of the plier beaks but are made *outside* the tips of the beaks.

7. Smooth bends are made from a large number of small bends *(Fig.* 9.9, *E).*

8. The working of a wire into corners requires a method that is illustrated in *Fig.* 9.12. This kind of bend is needed when constructing lingual arches. The principle is to prefabricate the bend that fits in the corner and gradually work it down into place.

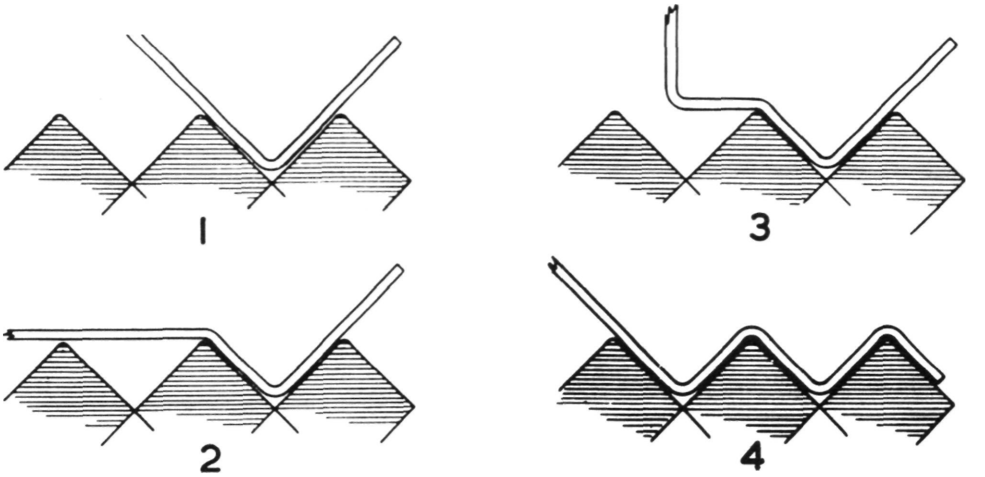


Fig. 9.12. Bending wire into corners (Exercises 2 and 3). *(See also Fig.* 9.13, *C, D.)* The secret is to preform the bend that is to be worked into the corner. The left-hand bend (Stage 3) is formed and then turned down to fit into the corner (Stage 4). If it is not certain where to make this bend (Stage 3) make it a little short of the corner in Stage 4 and then, by applying a correction as in *Fig.* 9.11, the bend can be worked down accurately into the corner.

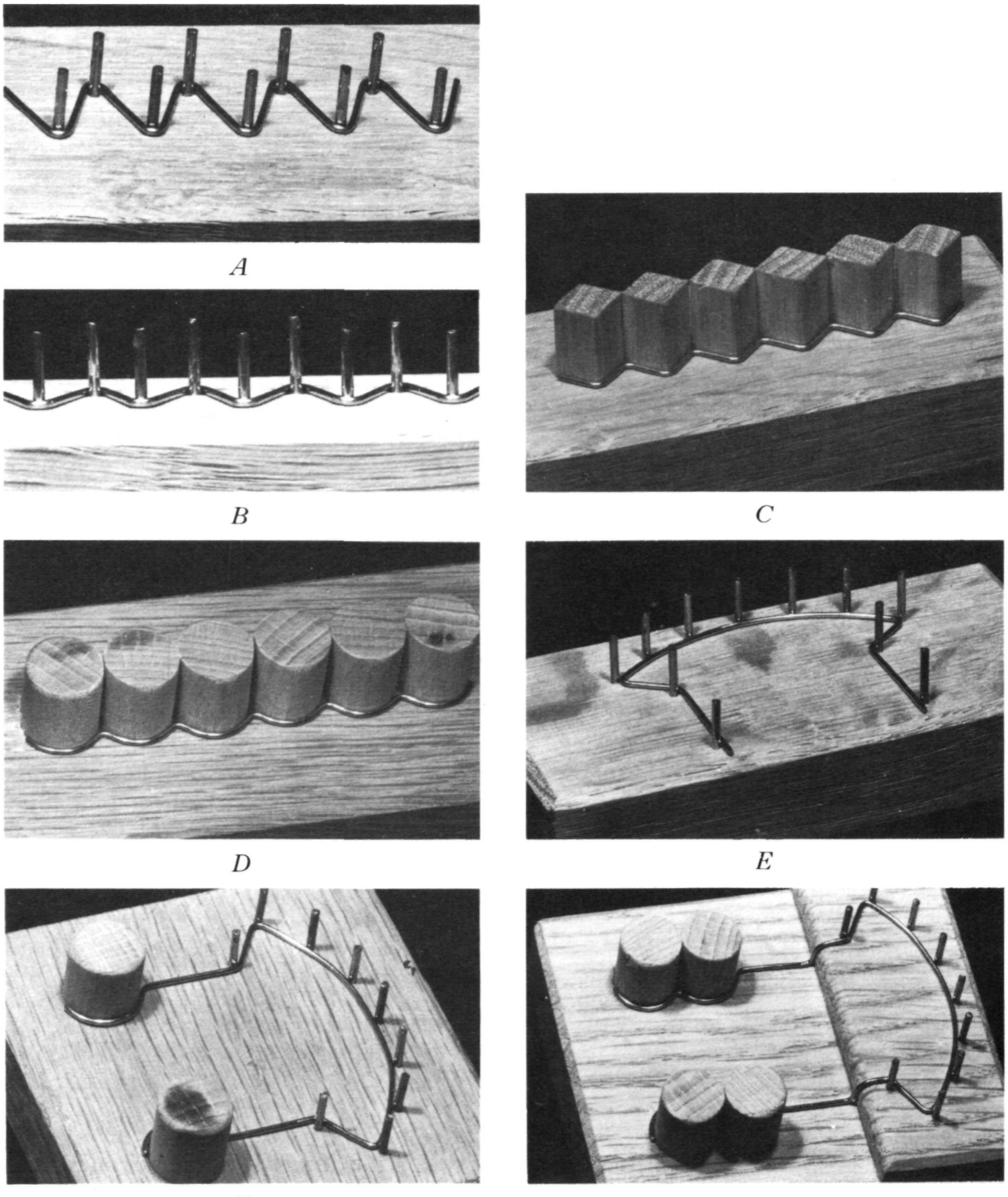


Fig. 9.13. *A*, Exercise No. 1. The pins are hard steel wire 1 mm thick set $\frac{1}{2}$ in. apart; the rows of pins are also $\frac{1}{2}$ in. apart. *B*, This illustration shows that the wire must be flat at all points on the wood block. *C*, Exercise No. 2. The posts are square and $\frac{1}{2}$ in. in diagonal. The corners against which the wire is fitted are *very slightly* rounded, it being impossible to make a perfectly sharp angle in 1·0 mm wire. *D*, Exercise No. 3. The posts are $\frac{1}{2}$ in. in diameter and $\frac{1}{2}$ in. high. *E*, Exercise No. 4. Simple lingual arch prototype. *F*, Exercise No. 5. Lingual arch prototype. The posts are $\frac{1}{2}$ in. in diameter, *G*, Exercise No. 6. Difficult lingual arch prototype. The step in the block makes the arch three-dimensional. The step is $\frac{1}{4}$ in. deep. The posts are $\frac{1}{2}$ in. in diameter.

9. When constructing bows or arches to fit *outside* a model, make the arch too wide and gradually contract it to fit. When constructing bows or arches to fit *inside* a model, make the arch too narrow and gradually expand it to fit. In both cases the principle is the same. The wire must be made *too loose* and gradually worked down to a fit. If the wire is too tight it is never possible to see exactly where it is binding and where to make the necessary correction.

Wire bending can be practised on a set of geometrical models which are designed to illustrate basic principles *(Fig.* 9.13). These models are made of hardwood blocks into some of which steel pins are driven, others having square or round posts. Others have pins and posts fixed into them. The placing and arrangement of these pins and posts are done according to a definite plan and pattern and not just in a haphazard way.

The first exercise consists of bending wire so as to fit exactly around two rows of pins in a zig-zag manner. This requires accurate placing of sharp turns in the wire and the method of adjusting the position of a sharp turn in a heavy wire as already explained is essential to the successful performance of this exercise.

The second exercise, consisting of six square pegs, makes use of the principle of working wire into corners or angles between objects as already shown. The third exercise is made with round pegs instead of square pegs, but the principle is the same.

The last three exercises are lingual arch prototypes. They exhibit nothing further in wire-bending principle apart from the art of making a lingual arch or bow passive.

All these exercises are performed with 1.0 mm stainless steel wire using Adams universal pliers and when completed should pass the following tests:

1. The wires must fit around exactly or touch all pins and fit around all posts.
2. The wires must lie fiat on the wood blocks.
3. The wire must be passive and should fall off the block when it is inverted and gently shaken (Nos. 1, 4, 5, 6).
4. The wires should not be so loose that they rattle when the blocks are shaken (Nos. 1, 4, 5, 6).

When carrying out these exercises an important point is to check the fit of the wire *after every bend* and to correct mistakes as they arise. Inaccuracies must not be allowed to accumulate; this is most important, as it is futile to try to correct a discrepancy due to a recent bend by going back beyond this point and interfering with the early part of the exercise which is correct.

This series of exercises is useful not only for the student who has to learn the wire-bending method from the beginning, but also for the enthusiast who wishes to check his methods and skill and strengthen and speed up his technique. The exercises are not devised primarily in order to tease the performer but to illustrate principles in wire-forming and to give the opportunity for practice. The exercise blocks are critical of every performance because, being geometrical and accurate, there can be no two opinions as to whether an exercise has been accurately performed or not. The most casual glance and inversion of the block will tell all that has to be known. The performer, therefore, has a constant and accurate standard to aim at and one that can be achieved with a little patience and practice.

APPLIED WIRE-BENDING TECHNIQUE

Adams universal pliers will be found useful in a great variety of situations such as, for instance, the bending of heavy wires *(Fig.* 9.14).

Adams spring-forming pliers are satisfactory for the formation of loops in wire of varying thicknesses up to 1.0 mm. Care should be taken when bending the heavier wires to use the strongest part of the beaks near to the hinge of the pliers. The finer wires, 0.4 mm and smaller, can be bent at any point on the beaks.

Sometimes the entire bending and adaptation of a spring can be effected using the

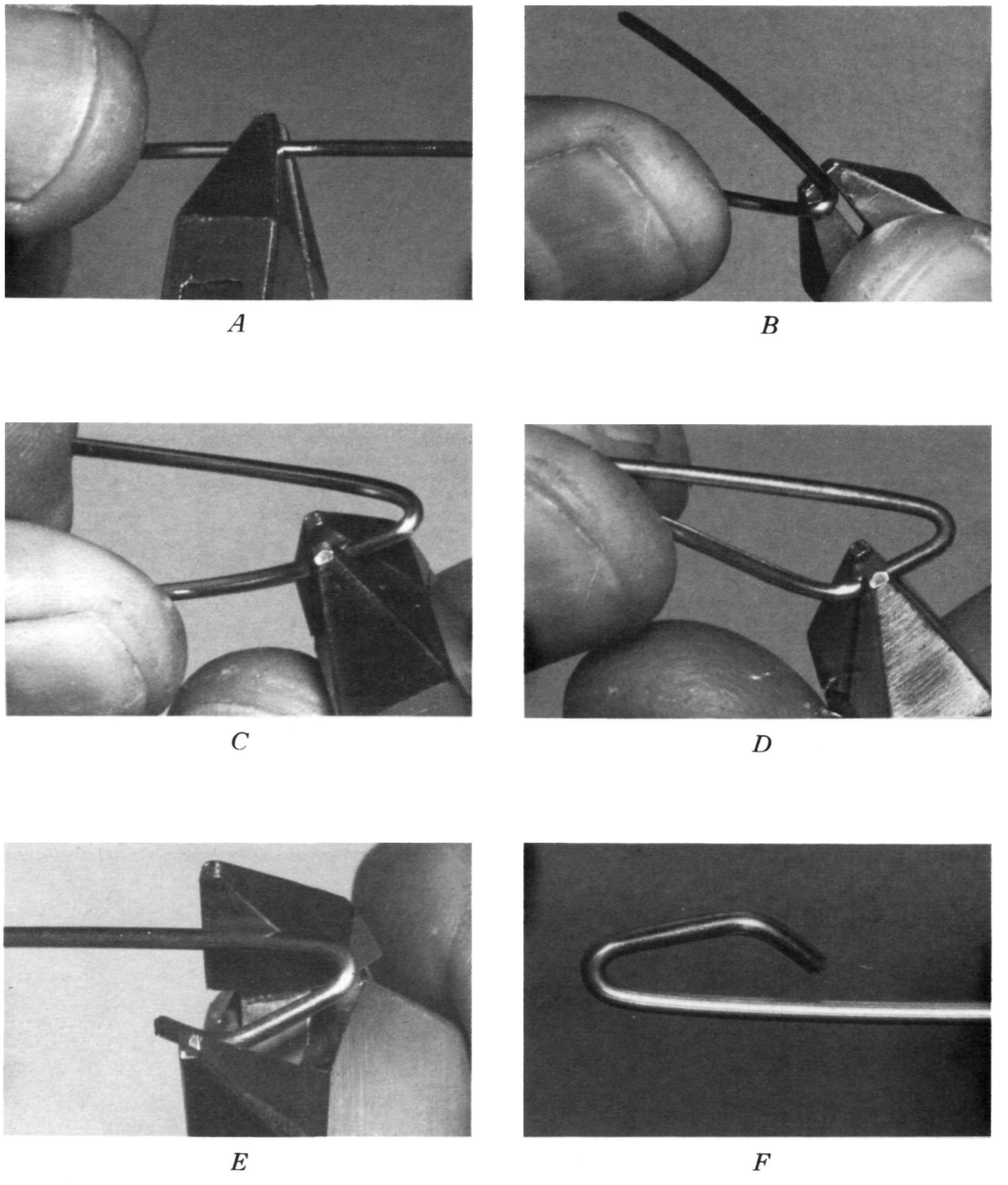


Fig. 9.14. Bending heavy wire with universal pliers; construction of an extra-oral attachment hook for cervical or occipital traction. *A,B,* 1.25 mm wire is used and a sharp bend is made, applying pressure with the left thumb. *C, D,* The short end of wire is then grasped and turned in towards the main arm. The 'short end' must not be so short that it cannot be used for bending. *E,* The end is cut off and the loop is closed as much as required, using Adams universal pliers. *F,* The completed hook. The cut end of the wire is smoothed with a disc or fine stone.

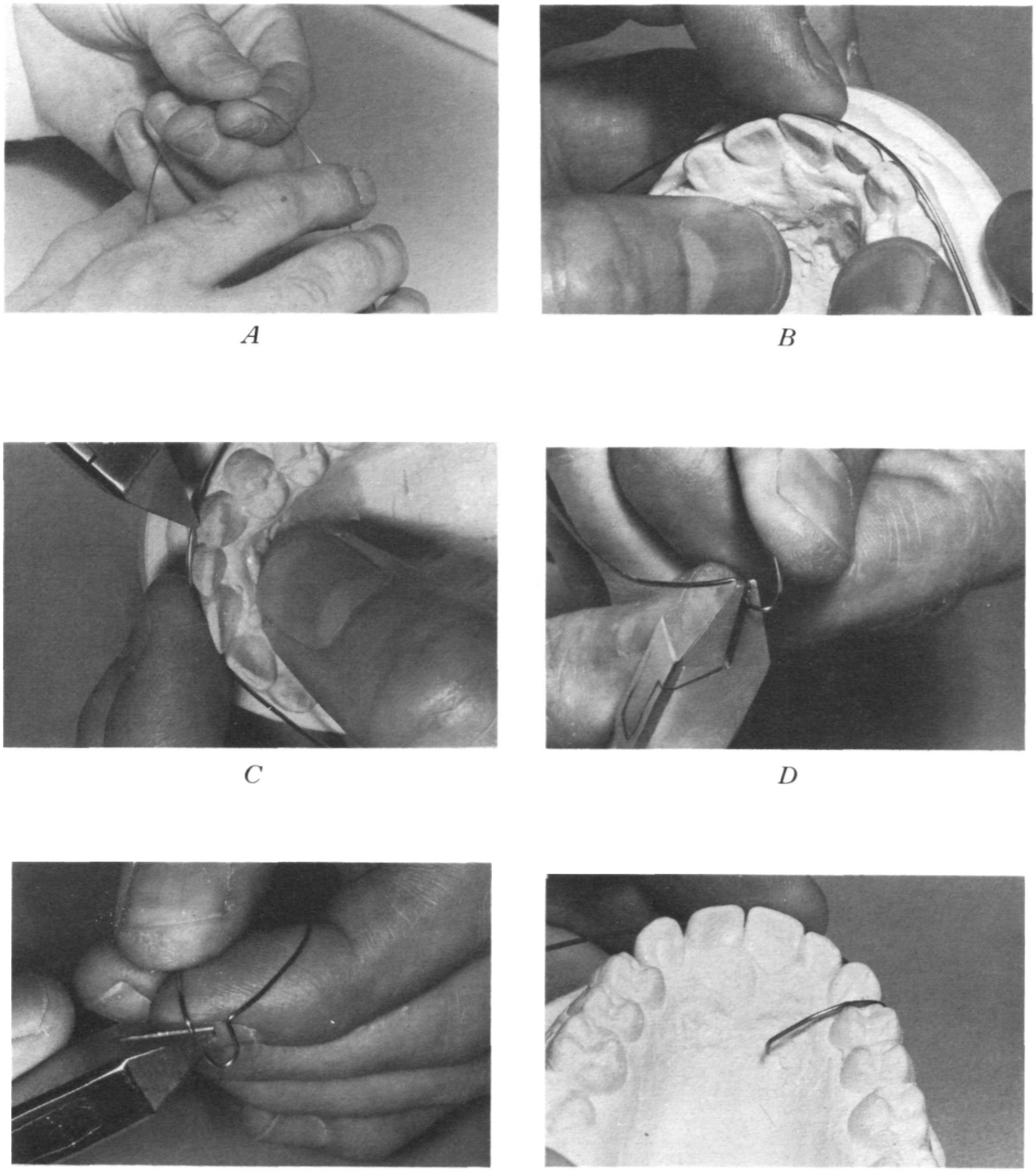


Fig. 9.15. Bending medium wire with universal pliers. The construction of a labial bow of 0·7 mm wire. *A,* The wire is curved with the fingers. *B,* The wire is tried on the labial surfaces of upper anterior teeth. C, The wire is caught at the centre of the canine tooth. *D,* Using the universal pliers, a U-loop is formed. *E,* The tag of the U-loop is brought into the palate across the embrasure between the canine and first premolar. *F,* The tag is formed as shown.

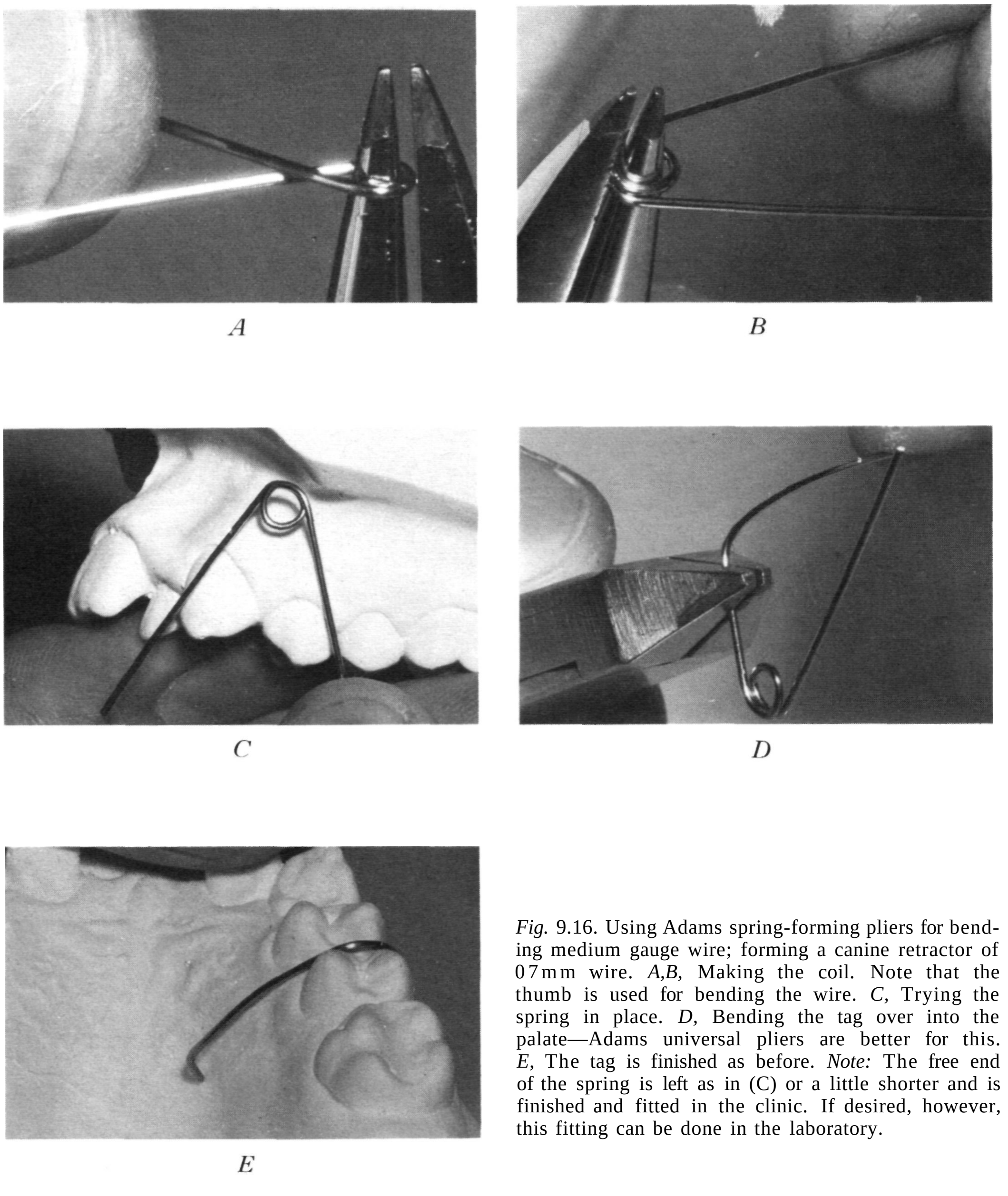


Fig. 9.16. Using Adams spring-forming pliers for bending medium gauge wire; forming a canine retractor of 0 7 mm wire. *A,B,* Making the coil. Note that the thumb is used for bending the wire. *C,* Trying the spring in place. *D,* Bending the tag over into the palate—Adams universal pliers are better for this. *E,* The tag is finished as before. *Note:* The free end of the spring is left as in (C) or a little shorter and is finished and fitted in the clinic. If desired, however, this fitting can be done in the laboratory.

spring-forming pliers, but in many instances a firmer and easier grip may be obtained with the Adams universal pliers for formation, finishing and adjusting of bows and springs *(Figs.* 9.15, 9.16, 9.17).

CLASP CONSTRUCTION

The Adams clasp should be made of 0.7 mm hard stainless steel wire for all teeth except canines for which 0.6 mm is preferred.

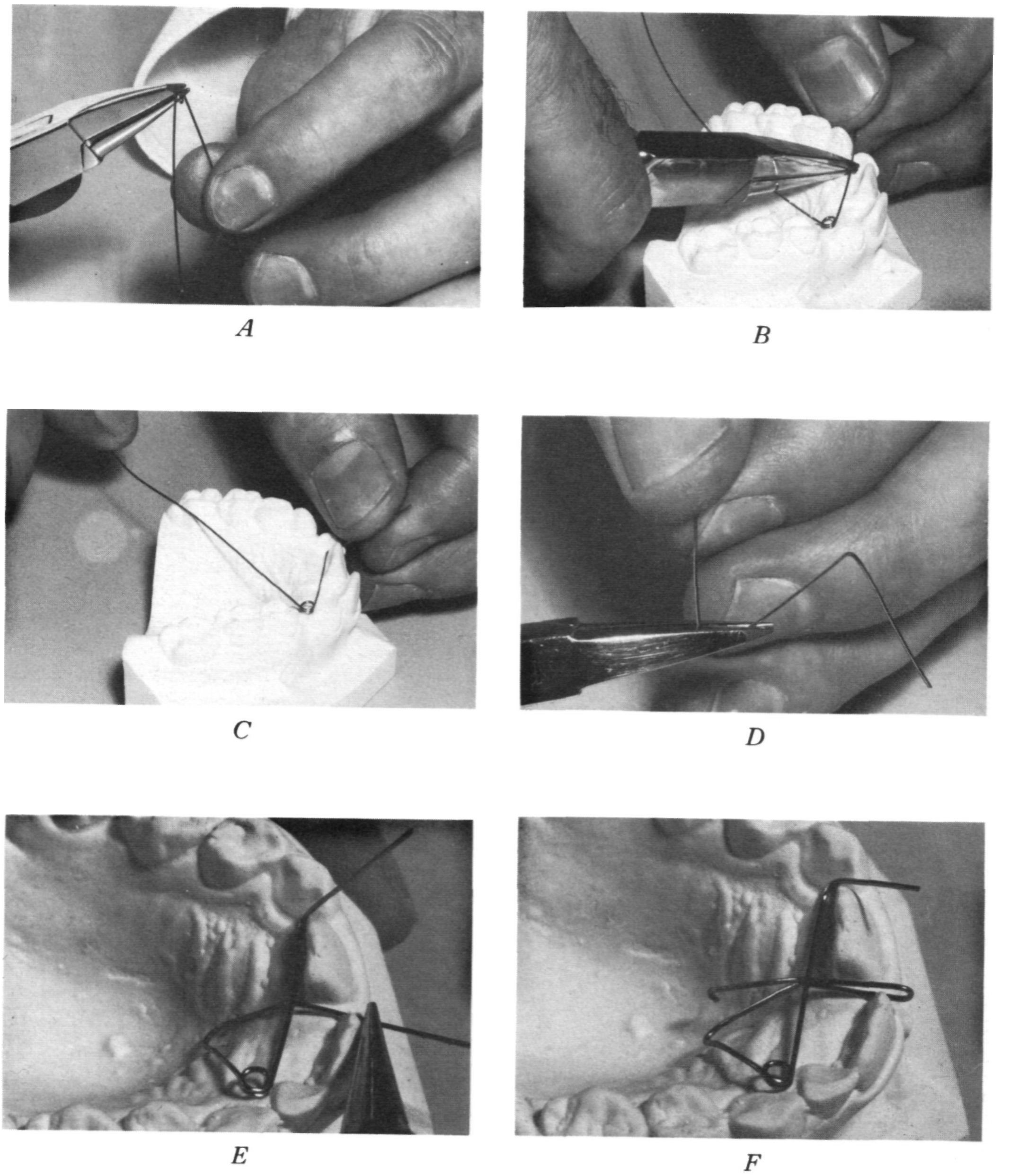
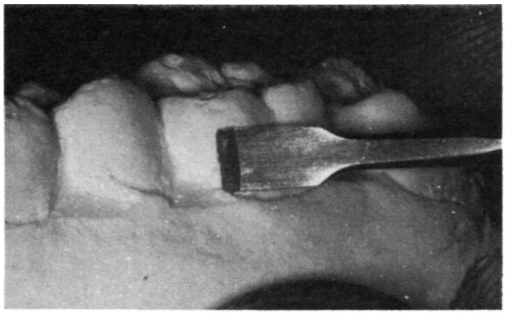


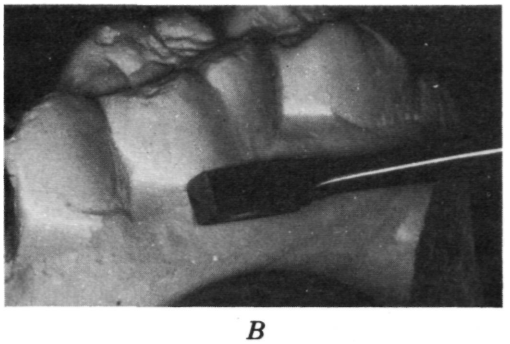
Fig. 9.17. Manipulating fine wire with spring-forming pliers. Making a finger spring of 0.5 mm wire to procline an upper incisor tooth. *A,* A single coil is placed in the wire. *B,* The spring is tried in place and the free end marked by grasping in the pliers. C, The free end is turned round the tooth to be moved. *D,* The tag end is turned down into the palate at the coil and brought back again across the spring to form the guide. *E,* The guide is marked for length by grasping with the pliers and turned back into the palate, completing the tag. *F,* The completed spring. *Note:* The guide is carried well forwards and passes between the central incisors, there being a space between these teeth.

Adams universal pliers simplify the construction of the clasp. The construction of the clasp for a first molar is done as follows:

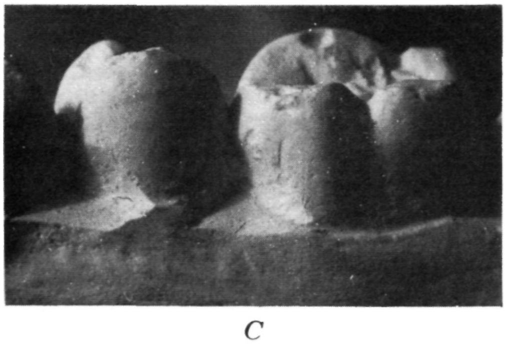
1. The plaster cast is examined. If the first molar is partly erupted, it will be necessary to trim the plaster representing the gum tissue using a wide, straight enamel chisel, so that the undercut mesially and distally on the tooth will be accessible for fitting the clasp *(Fig.* 9.18). When the finished appliance is placed in the mouth, the arrowheads of the clasp will then press back the interdental papillae slightly and make contact with the undercuts on the tooth. It is necessary to anticipate what will be the subgingival shape of the tooth and to reproduce that shape when trimming the cast so that the clasp fits accurately.



A



B

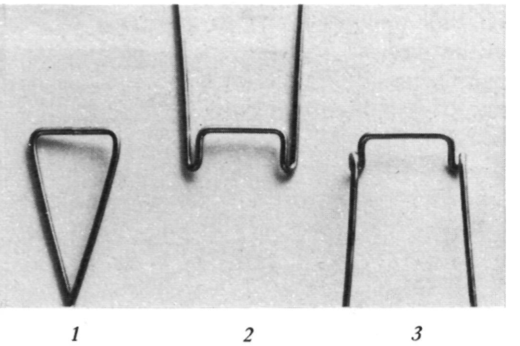


C

Fig. 9.18. Trimming the plaster tooth for fitting the Adams clasp. *A,* A broad enamel chisel is laid against the tooth and the plaster cut vertically. *B,* The enamel chisel is laid horizontally and plaster removed to show the undercut of the tooth. C, The appearance of the tooth after the trimming is complete.

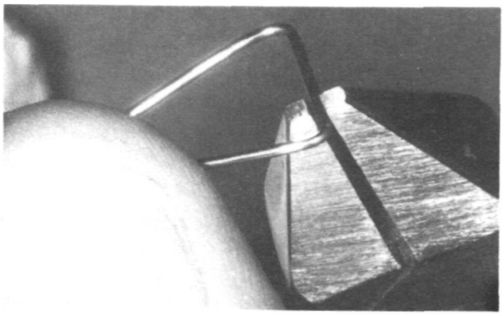
If the tooth is fully erupted and there is gum recession beyond the anatomical neck of the tooth, which occurs sometimes in adults, very large and deep undercuts, mesially and distally, will be found. It is then important to select as much of the undercut as may seem necessary for the purposes of the clasp and not to fit the clasp to the maximum available undercut. The maximum available undercut on the teeth, when there is gum recession, is too deep and a clasp that is made to fit into such a deep undercut will not spring over the most bulbous part of the tooth. It is necessary to make the clasp touch the tooth only far enough below the level of the contact points to ensure adequate retention

2. The three main stages in bending the wire are shown in *Fig.* 9.19. The formation of the arrowheads is also shown in *Fig.* 9.20. Stage 1 should present no difficulty *(Fig.* 9.20, *A).* It should be noted that the arrowheads may be made quite long; shortness in itself is no advantage. The wire is first bent

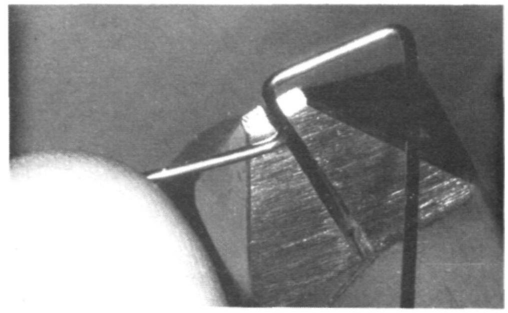


1 *2* *3*

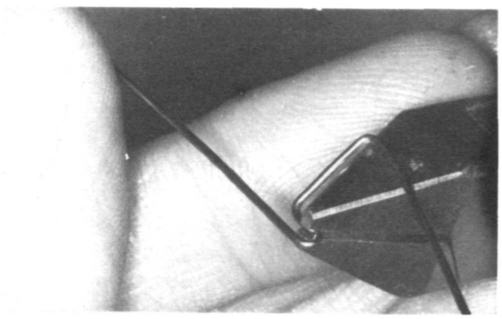
Fig. 9.19. Stages in bending the clasp.



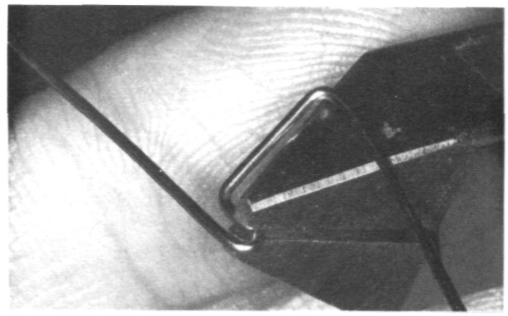
A



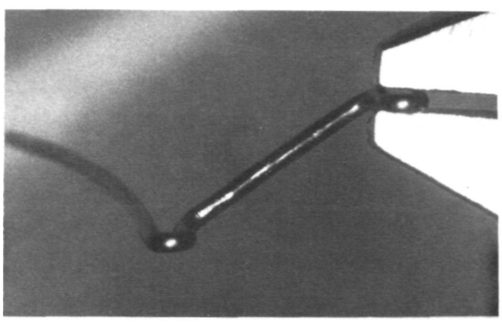
B



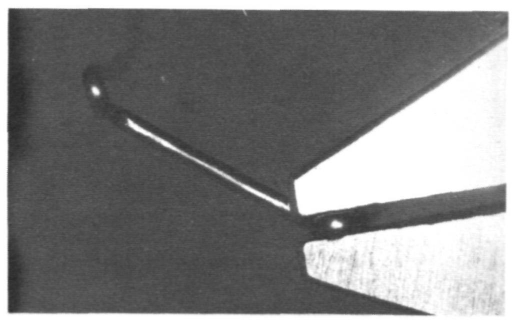
C



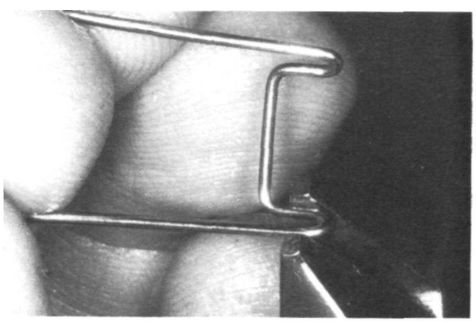
D



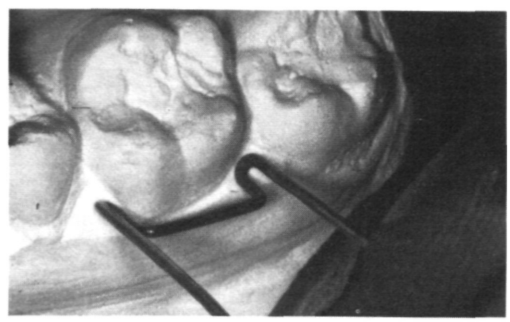
E



F



G



H

at a right angle *(Fig.* 9.20, *B).* The bridge of the clasp is then laid down against the beak of the pliers and the wire held firmly at the tip of the beaks. The tag is then bent through another right angle using firm pressure with the thumb of the left hand on the wire near the bend *(Fig.* 9.20, C, *D).* The wire is not bent around the ends of the pliers but outside the beaks. The second arrowhead is formed in the same way.

3. After the arrowheads are formed, it will usually be found that they both slope in the same direction when viewed end-on and one arrowhead will have to be adjusted *(Fig.* 9.20, *E,F),* so that both will conform to the slope of the gum margin of the tooth mesially and distally. The arrowheads are then squeezed a little to correct width (Fig. 9.20, *G).* While this is being done, a firm outward pressure is exerted on the tag to ensure that the sides of the arrowhead remain parallel.

4. The clasp is then tried on the tooth to see that the tips of the arrowheads are the correct distance apart *(Fig.* 9.20, *H).* There is some latitude in the distance between the points of the arrowheads which will satisfactorily fit any given molar tooth, but if the arrowheads are too far apart, there will be a tendency for them to disappear between the teeth altogether and the bridge between the arrowheads may be found to lie against the buccal surface of the tooth. Too wide a clasp will cause a tendency for the arrowheads to impinge on the adjoining teeth. This will prevent the clasp from acting properly on the tooth which is being clasped.

5. If the width of the clasp is satisfactory, the tags are turned over and brought across the contact points and onto the lingual side of the dental arch for embedding in the baseplate. This bend must be made sharply and accurately and must not be allowed to project beyond the bridge of the clasp. The bend is made by grasping the arrowhead from inside the clasp *(Fig.* 9.21, *A, B)* and holding half of the arrowhead's length at the very tip of the pliers. The wire is then bent outside the tip of the pliers and not around the tip of the beak. The clasp is then again tried on the tooth for alignment of the tag, inclination of the arrowhead and position of the bridge (Fig. 9.21, C). When this stage is satisfactory, the tag is finished off as shown and the second tag is then bent and finished *(Fig.* 9.21, *D).*

The tags need not be formed in a complicated manner. If the end of the tag is turned down at right angles for a distance of about 1.0-1.5 mm, the clasp becomes firmly supported and accurately held in position during construction of the baseplate. There should be a slight space between the tags and the surface of the cast to make sure that the tags are well encased in the baseplate material. Tags should be of harmonious length. Excessively long tags weaken the baseplate and use space which may be needed for the embedding of other wires. Tags should not be made very short either unless lack of space in the baseplate leaves no alternative. The features of the clasp are shown in *Fig.* 9.22.

Adjusting the Adams Clasp

When a removable appliance is first placed in the mouth, the arrowheads of the clasps should just make contact with the teeth but should not grip to any noticeable degree.

The accuracy of the baseplate and the positioning of springs and archwires are checked at this stage. If all is well, the finger springs are cut off and turned into loops and the points of application to teeth adjusted but without activating the springs. The fit

Fig. 9.20. Bending the arrowhead clasp. *A,* Stage 1. Two bends made at a little more than 90°. *B,* The formation of the arrowhead. The wire is first bent at right angles. *C, D,* The clasp is tilted downwards against the pliers and the arrowhead formed by bending outside the tip of the beak. The second arrowhead is formed in the same way. *E, F,* The arrowheads are aligned to follow the contours of the gum. G, The arrowheads are squeezed slightly to make the correct width. *H,* The clasp is tried on the tooth.

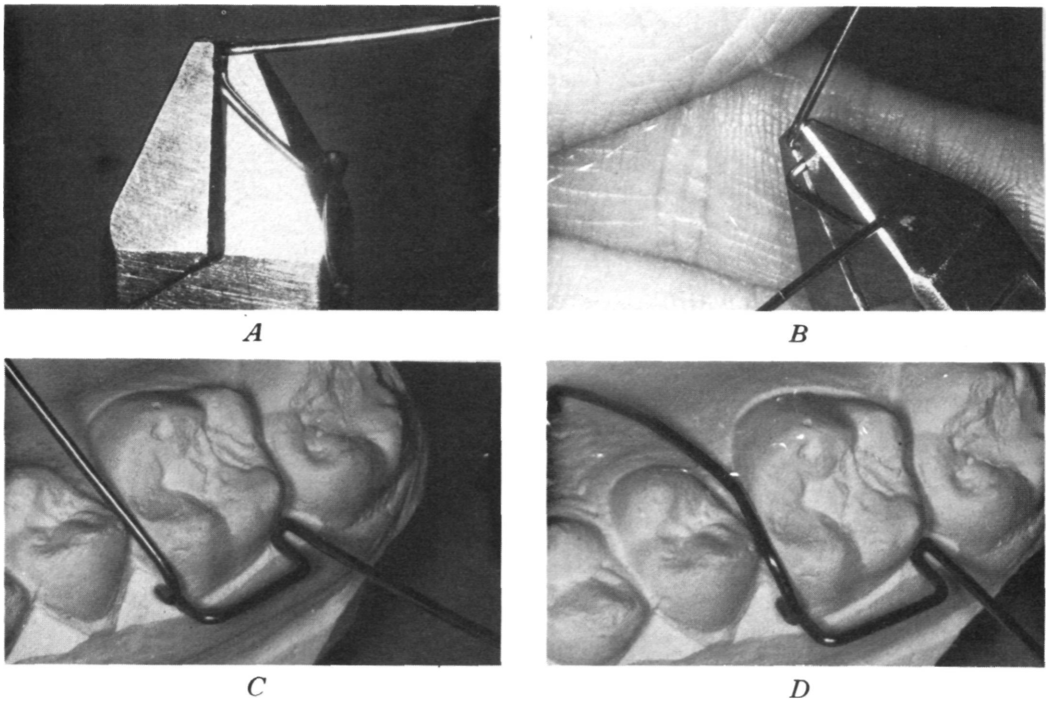


Fig. 9.21. Forming the tags. *A,* The arrowhead is grasped from inside the clasp and the tag bent up at 90°. *B,* The tag is then bent outwards and a further 45° over but not around the tip of the beaks. *C,* The clasp is tried on the tooth. *D,* The tag is completed. The second tag is completed in the same way.

and positions of heavy archwires are checked and any fine apron springs required are attached, formed and adjusted for position on the teeth.

The clasps should then be adjusted to grip the teeth sufficiently by bending the tags a little, just buccally to the point where they cross the contact points of the teeth. This adjustment may be most easily made with Adams universal pliers. To make the adjustment, the tag is gripped firmly and bent slightly. Both tags should be adjusted *(Fig.* 9.23). Clasps should not be tightened too much.

Clasping deciduous molars is of great use in constructing appliances for patients who have mixed deciduous and permanent dentitions, and 0.7 mm wire should be used. The crowns of the deciduous teeth are short in height and great care is necessary to ensure that the tags do not lie above the teeth and become bitten on by the opposing teeth as this is uncomfortable for the patient *(Fig.* 24, *B).* When clasping premolars beware of making the clasp too wide and the arrowheads too short. The necks of premolars are narrow and it is easy to overlook the need to make the distance between the arrowheads small to correspond with the width of the tooth where the arrowheads fit.

Clasps on Other Teeth

When making the clasp for canine teeth, 0.6 mm wire should be used *(Fig.* 9.24, *A).*

Traction Hooks

Traction hooks for intermaxillary traction can be incorporated by bending the hooks

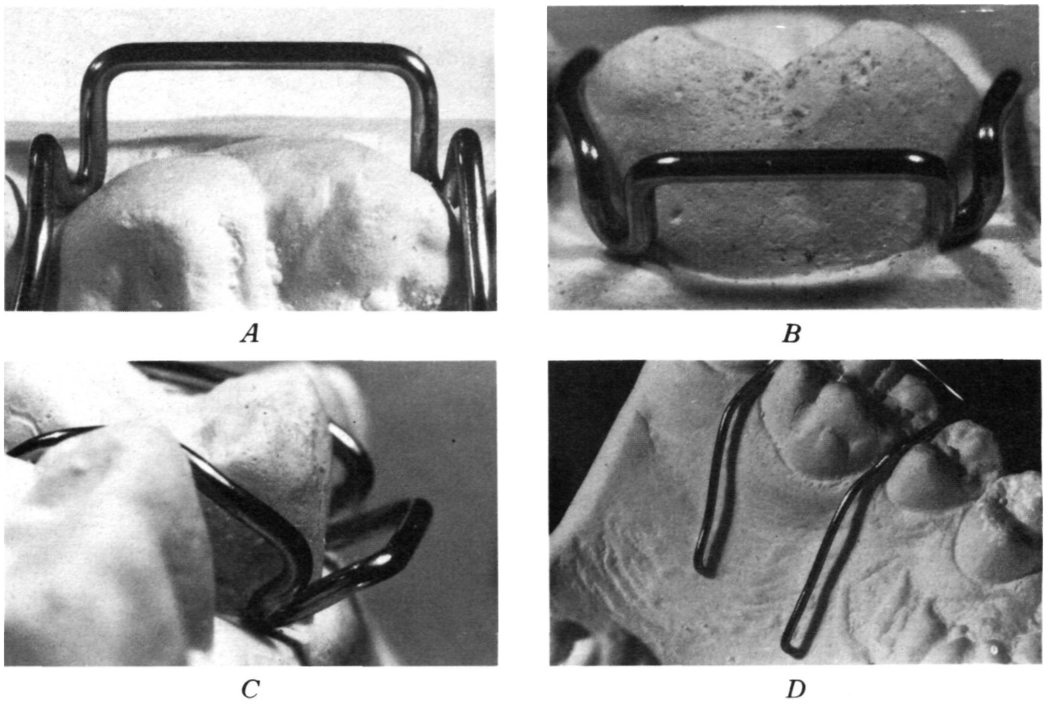


Fig. 9.22. The essential features of the Adams clasp. *A,* The bridge is straight. The arrowheads are parallel and the sides of the arrowheads are parallel. The bridge stands away from the tooth; the arrowheads do not touch the adjoining teeth. *B,* The arrowheads slope to match the contour of the gum. *C,* The bridge stands clear from the tooth and halfway between the tooth and the gum surface. The tags arch over the contact points. *D,* The tags are quite simply formed by turning down at right angles to the palate. A uniform space is left under the tags to encase them in the baseplate material.

into the clasps or by welding or soldering hooks onto the bridges of the clasps. The possibilities are shown in *Fig.* 9.24, *C,D.*

Accessory Arrowhead Clasps

Where extra retention is required for an appliance and it is not possible to clasp a second tooth in the same buccal segment, it is possible to use an accessory clasp which fits onto the tooth beside the tooth which has been clasped as the main retention. The free tag is welded to the bridge of the primary clasp *(Fig.* 9.24, *E).*

Over-erupted Teeth

When clasping over-erupted teeth, it is important only to use as much of the large available undercut that is present on such teeth. If the full depth of the available undercut is used, the clasp will not spring into this undercut when the appliance is placed in position and the appliance will not be held firmly in position *(Fig.* 9.24, *F).*

Rotated Teeth

Teeth which are rotated may be clasped without difficulty. The clasps are made in the usual way and the bridge is aligned with the buccal segment as a whole and not with the buccal surface of the tooth. The clasp is then fitted much more easily and functions more satisfactorily than if rotated to match the tooth *(Fig.* 9.24, *G, H).*

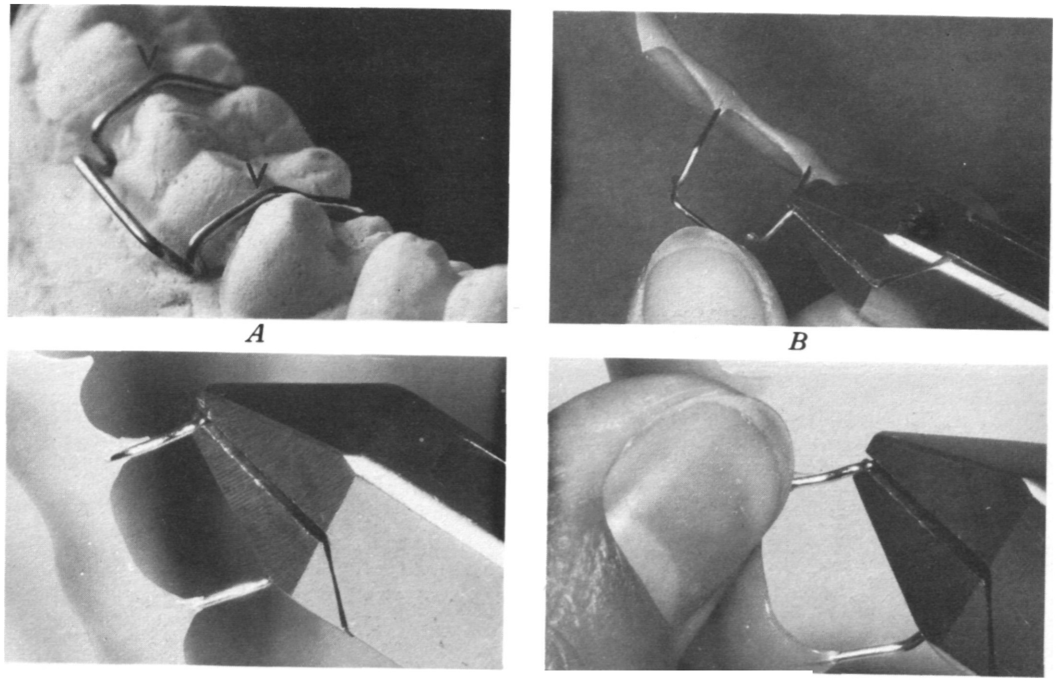
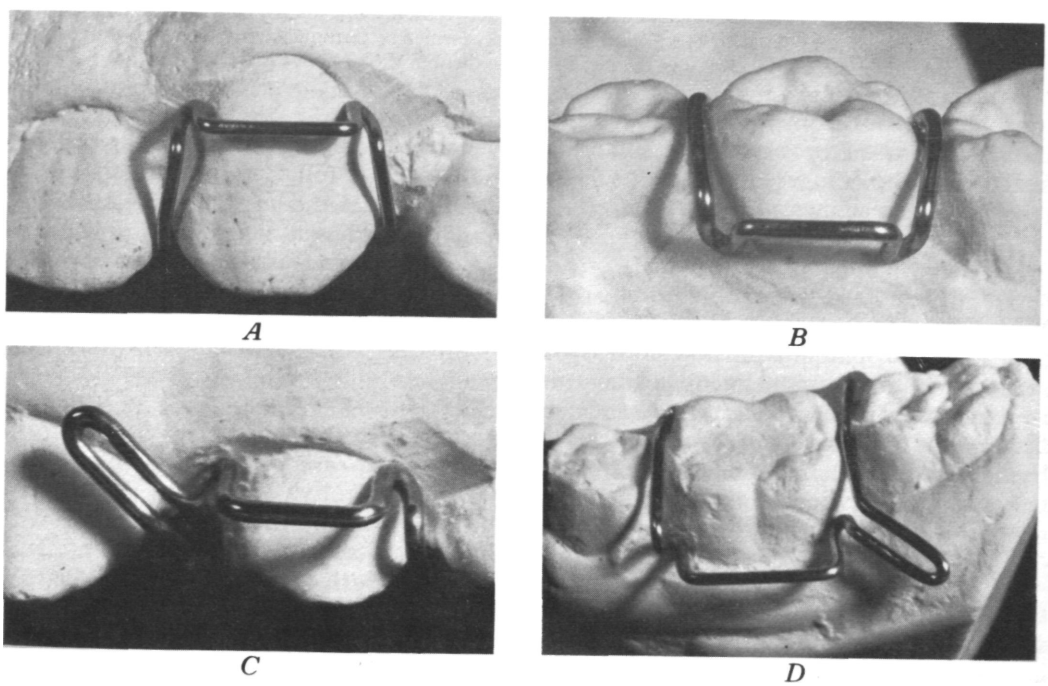
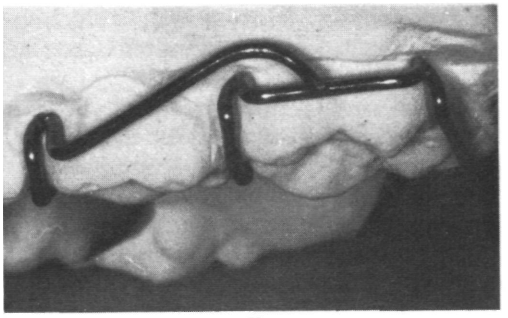
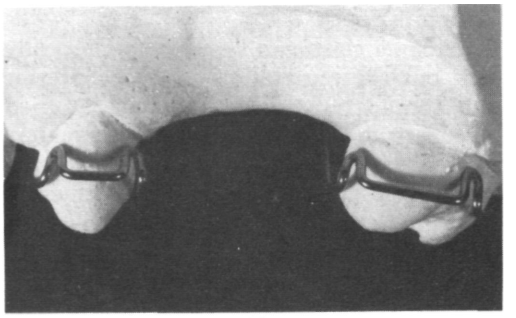


Fig. 9.23. Adjusting the arrowhead clasp. *A,* The bends are made just beyond the point where the tag bends down towards the arrowhead. *B,* The position at which the tag is held for adjusting the clasp *C,* The same. *D,* The same.

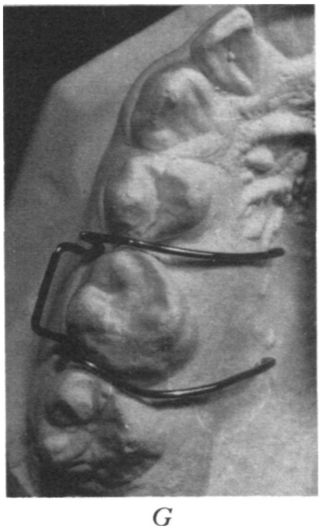




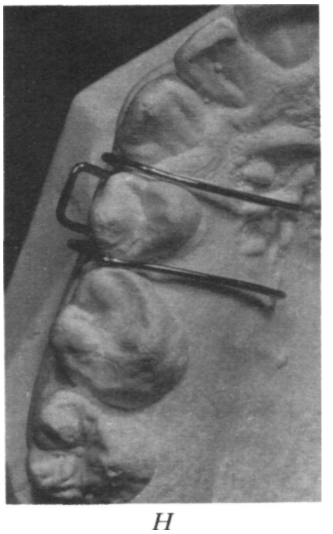
E



F

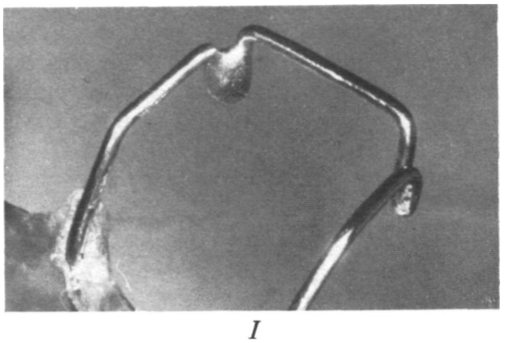


G



H

Fig. 9.24. *A,* The Adams clasp on the upper permanent canine. The wire is 0-6 mm for this purpose. *B,* The clasp on a lower second deciduous molar (wire 0-7 mm). Sometimes these teeth are very short in the crown and the clasp has to be very fiat. *C,D,* Traction hooks on upper premolar and lower molar. In the lower molar, it is possible simply to weld a hook of 0 7 mm soft stainless steel wire onto the bridge if required. *E,* The accessory arrowhead clasp. This is most conveniently welded to the bridge of the main clasp which is a far better arrangement than the practice of bridging two teeth by the same clasp. If either tooth moves slightly, the clasp ceases to work properly. *F,* Clasping teeth in which there is gum recession. The full depth of the undercut must never be used otherwise the clasp will be totally ineffective. *G, H,* Clasps on rotated teeth. These are made in the usual way and the bridge of the clasp should be in line with the buccal segment and not with the buccal surface of the tooth. /, A soldered repair of the arrowhead of a clasp.



I

Anterior Teeth

The Adams clasp can be used to clasp any tooth but the temptation to clasp anterior teeth should be resisted. A well designed and constructed appliance can be adequately retained in position by a few clasps on posterior teeth. In cases of extreme difficulty the need perhaps to use fixed appliances must be kept in mind. The clasping of two adjoining teeth with a single large clasp spanning both is not good practice. The clasp is intended to clasp a single tooth and does this with great efficiency. This efficiency is best developed when a single tooth is clasped.

Buccal Tubes

Tubes may be soldered to the bridges of Adams clasps in order to make it possible to attach extra-oral traction headgear or to use free-sliding buccal archwires with extra-oral or intermaxillary traction. The soldering process is described under Soldering (pp. 191, 192).

Some General Considerations

The clasp as described here will be found satisfactory for all removable appliance applications. It is compact, efficient and simple to construct. Fractures of the clasp are rare and are attributable to poor construction with overworking of the wire, placing tags so that unnecessary biting forces fall on them and carelessness on the part of the patient. Investigation has shown that with appliances made in commercial laboratories a fracture rate of just under 3 per cent was found over a large number of clasps (Adams, 1983).

Fracture of the arrowhead at the tip can be made good by soldering. The baseplate should be protected with a damp napkin (*Fig.* 9.24, /).

WELDING FOR ORTHODONTIC APPLIANCE CONSTRUCTION

The merits of stainless steel as an orthodontic material were recognized many years ago and before long welded stainless steel appliances became firmly established (Charlier, 1928; De Coster, 1931a, b, 1932).

Spot welding is a convenient method for uniting pieces of metal of the same kind. The method is clean and quick and produces joints which are strong and reliable; most metals may be spot welded.

The process consists of raising the temperature of the pieces of metal to be joined until the metal becomes plastic but not molten at the site of the joint and immediately applying pressure so that the metal parts are squeezed together in their plastic state and become one. This is comparable to the working of wrought iron by red heat and the hammer on an anvil. Red heat renders the iron plastic; hammering, which is a method of applying powerful pressure, forces the elements of the joint indissolubly into one another's structure.

The resistance welder uses electric current to produce heat in the metal parts which are to be welded. In spot welding the pieces of metal to be united are held together in the required position and placed between two copper alloy electrodes which press the parts together. In industrial welders the pressure may be provided by hydraulic, pneumatic or mechanical means. In small bench machines spring pressure is usually employed. When current is passed from one electrode to the other through the metal, heat is generated in and between the metal parts which is sufficient to make them plastic. The pressure of the electrodes then forces the metal parts together, so creating the weld.

The Welding Circuit

That part of the circuit which is actually used to heat the metal for welding is operated at low voltage, 2-10 V, and makes use of a high current. Current is usually provided by the mains alternating current electrical supply using a transformer to step down the voltage. The transformer is of large capacity so that a heavy current may be passed through the secondary winding; this is important as the heating effect of a current varies as the square of its amperage (I^2) and an adequate current density must be available to perform a resistance weld.

It is possible to use a heavy-duty storage battery to produce welds (Bell, 1932) but welding equipment based on such a supply usually has to be home-made and the mains-operated welder is to be preferred on grounds of freedom from maintenance problems, reliability and consistency.

The circuit of a mains-operated welder is shown in *Fig.* 9.25. The transformer is

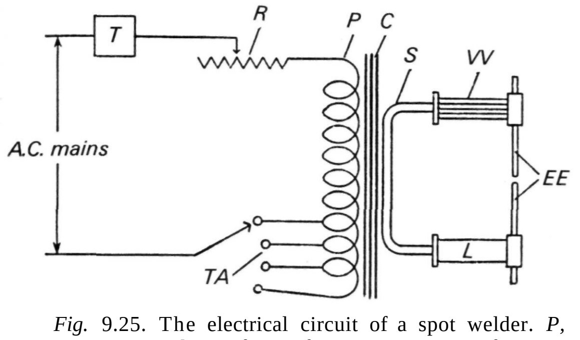


Fig. 9.25. The electrical circuit of a spot welder. *P*, Primary winding of transformer; C, Core of transformer; *S*, Secondary winding of transformer; *T*, Timing switch. This may be simple mechanical, automatic mechanical, electrically operated mechanical, or electronic. *TA*, Tappings on primary winding; *R*, Variable resistance; *VV*, Flexible vanes which carry current to upper electrode and also permit vertical movement of the upper electrode. Alternatively, a hinging movement of the upper electrode holder may be arranged or this electrode holder may move on a vertical slide. L, Lower electrode holder; this is rigid. *EE*, Electrodes.

substantial and the secondary winding is of thick copper wire and has very few turns; only a single turn or loop of copper may be used. The leads from the secondary winding and the electrode holders are similarly heavy in section. The electrodes complete the secondary side of the electrical circuit. These are usually of a copper alloy which is harder than pure copper while having almost the same electrical conductivity.

The primary side of the circuit consists of the primary winding, which is designed to conduct the mains voltage supply of the district in which the equipment is used, and a timing mechanism, which controls the length of time for which current is permitted to flow. Tappings are usually provided in the primary winding, which make it possible to vary the output of the transformer by varying the voltage in the secondary side of the circuit. In some welders a variable resistance is also provided in series with the primary winding of the transformer to give additional control.

When a weld is made, the workpieces are placed together between the electrodes which exert a controlled pressure on them. The arrangement of electrode—metal part—metal part—electrode makes up a circuit of varying resistance from point to point *(Fig.* 9.26). The electrodes, being of copper alloy,

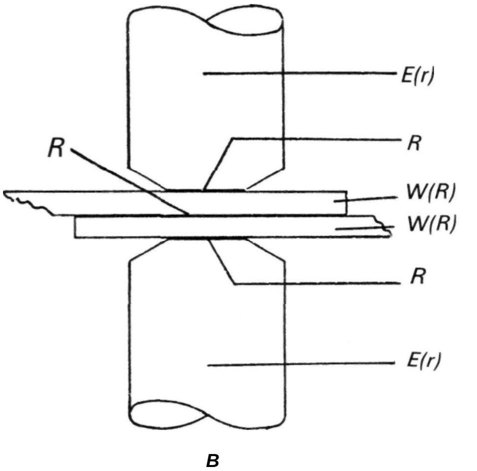


Fig. 9.26. Variation in electrical resistance between the electrodes. Between *A*, in the upper electrode, and *B*, in the lower electrode, electrical resistance varies greatly. In the electrodes themselves *E*, *E*, resistance is small, *r*. In the workpieces *W*, *W*, resistance is usually greater, *R*. Between the electrodes and the workpieces resistance is greater still *R*, *R*. Between the workpieces resistance is greatest, *R*. Heat produced is directly proportional to the resistance of the part of the circuit through which the current is flowing. The current is the same in every part of the circuit.

have a very low resistance. The workpieces have a higher resistance than the copper electrodes. The sites of contact between the electrodes and the workpieces have again a higher resistance and the resistance at the site of contact between the workpieces themselves is higher still.

When current is passed through this circuit heat is generated in proportion to the electrical resistance of the various parts.* This means that in the electrodes little heat is developed, while between the workpieces sufficient heat is developed to make the metal plastic and permit a weld to take place *(see Fig.* 9.27). Heat is also developed between the electrodes and the workpieces,

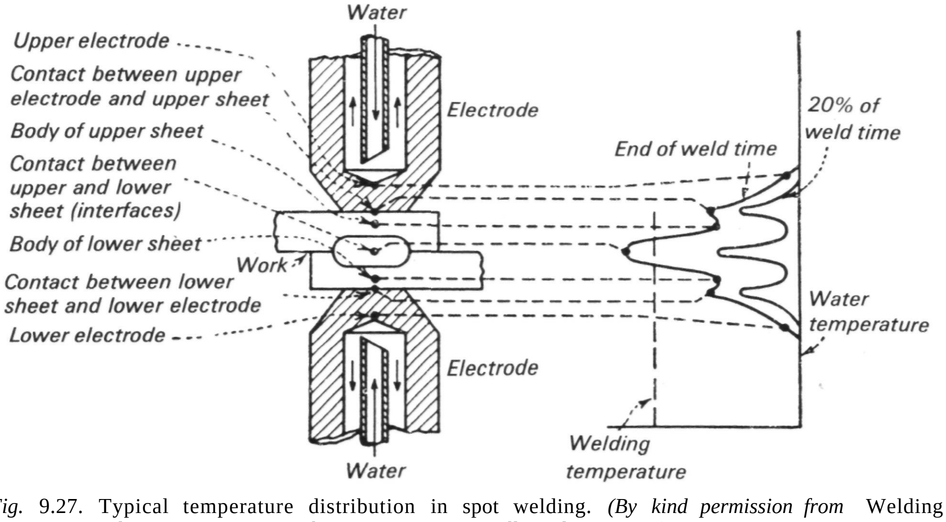


Fig. 9.27. Typical temperature distribution in spot welding. *(By kind permission from* Welding Engineering *by E. Rossi. Copyright,* 1954, *McGraw-Hill Book Co., Inc.)*

but this does not produce fusion of the electrodes to the workpieces because copper has a high thermal conductivity, and heat produced at this site is rapidly conducted away. Industrial welders are usually provided with water-cooled electrodes as the machines are designed to make welds at a high rate of repetition.

Orthodontic Welder Design

Spot welding is carried out without the aid of flux or any other protecting material so that as the temperature of the workpieces is raised, oxidization and breakdown of the composition of materials which are alloys can occur, which will produce weakness in the weld. These effects can be avoided by various means. It is feasible, for instance, in industrial circumstances to perform spot welds in an inert atmosphere of nitrogen which eliminates oxidization.

It has been found more practical, however, for orthodontic and other purposes making use of fine-gauge wires and sheets of metal, to reduce oxidization and breakdown of metal structure by keeping the time taken to perform welds as short as possible. The shorter the time during which the workpieces are kept at welding temperature, the less oxidization and disturbance of metal structure can take place. The heat required for spot welding is generated at the interface

*When current passes through a circuit heat is generated according to the relationship $H = KI^2RT$, where H — heat in joules; I = current in amperes; R = resistance in ohms; T — time of application of the current in seconds; K is a constant.

of the workpieces. The penetration of softening of the metal should be between one-third to four-fifths of the thickness of the workpieces (Rossi, 1954). The longer the time allowed for a weld, the greater the opportunity for heat developed at the interface to spread into the surrounding metal and the greater the possibility of the full workpiece thickness rising to a temperature at which loss of temper and softening can occur. Shortening the time allowed for a spot weld limits the heating of the workpieces to the interface and prevents softening of the full thickness of the metal which would destroy its properties as a spring material. Welding machines for orthodontic and similar materials are designed to deliver heavy currents for accurately predetermined, very short times.

Pioneer work on the design of a welder for orthodontic purposes was done by Friel and McKeag (Friel, 1933; Friel and McKeag, 1939), and resulted in the conversion of a small industrial machine into a satisfactory orthodontic welder with a semi-automatic mechanical timing switch.

Welders for orthodontic purposes of various kinds are available today and most are portable. *Fig.* 9.28 shows a typical and fairly simple welder of this kind. Others are available with more or less sophisticated facilities to make for ease in welding. The principal desirable features are speed of welding and power to make the welding of the heavier wires possible. Today with the availability of prefabricated parts for most orthodontic appliances there is some decline of interest in equipment such as welders.

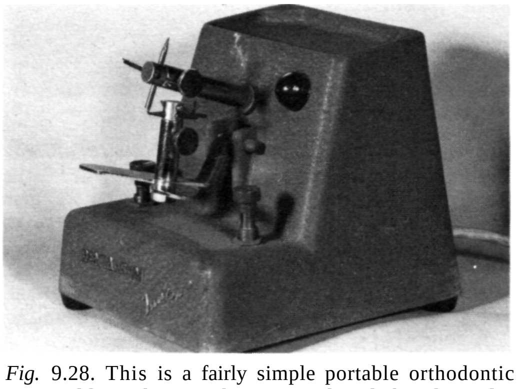


Fig. 9.28. This is a fairly simple portable orthodontic spot welder. The switch is manual and the electrodes are of the turret type giving a choice of pairs for different purposes.

The features of an orthodontic welder include turret electrodes which make various shapes of electrodes quickly available, a feature which holds the electrodes together so that both hands are free; this may be done by spring-loading the electrodes into the closed position when they are opened to admit the workpieces and then allowed to close, or the electrodes may be brought together by a foot pedal.

The timing switch may be automatic and controlled electronically or by capacitor discharge. There may be a circuit for soldering electrically or for heat treating archwires.

There are a few welders which have been adapted from the electronic industrial scene and which provide superb performance up to considerable power and with great consistency but suffer from the disadvantage, to some workers, of requiring to be built into benches or being fairly heavy and also being more expensive. For the worker who uses welding frequently and relies on it, such machines are ideal.

Electrode design

Electrode design is an important feature in orthodontic welders. Usually a variety of fine, specially shaped electrode tips are required for the welding of wires, latches and attachments in fixed appliance construction. Furthermore, certain construction methods demand the welding of appliances which are on plaster models, so making access difficult, which sometimes leads to the production of long and spindly electrodes to facilitate reaching into awkward corners.

Both these special requirements of fineness of electrode tips and length and slenderness for ease of access conflict with the basic welding principles that electrodes should be short and bulky so that they will conduct electricity to the weld, and heat away from it, with the greatest efficiency. As in most things, compromise is necessary and experience shows that an occasional liberty may be taken in electrode shaping when necessary.

Most orthodontic welders are provided with a variety of upper and lower electrodes set on rotating turrets so that any pair of upper and lower may be selected at will. A well-designed set of turret electrodes will combine the optimum in ease of access to awkward corners in a plaster model bearing a fixed appliance and conformity with the desirability of shortness and thickness in the electrodes. When filing the tips of electrodes to fit into angles and corners of special attachments, reduction of the bulk of the electrode tip unneccessarily should be avoided.

Welding for Appliance Construction

The material usually employed for appliance construction is 18/8 stainless steel alloy. This metal can be spot welded quite easily; the main difficulties that occur arise in connection either with the welding of pieces of dissimilar bulk or with the welding of wires. Flat materials do not present any great problem provided welds are not overheated.

Electrodes for welding tapes should have flat smooth ends and should have adequate bulk to permit free flow of current and to conduct heat away from the weld. Sharply pointed electrodes should be avoided as liable to produce burning and pitting.

Hard stainless steel wires as used for orthodontic appliances should be welded at right angles to one another using grooved electrodes. Joints made in this way are stronger than those made with wires laid parallel.

If wires are laid parallel to one another and flat electrodes used to make the weld, the stiffness of the wire on either side of the weld prevents the forging together of the heated metal and the surfaces in contact do not collapse and form a 'weld nugget'* *{Fig. 9.29, A,B,C).*

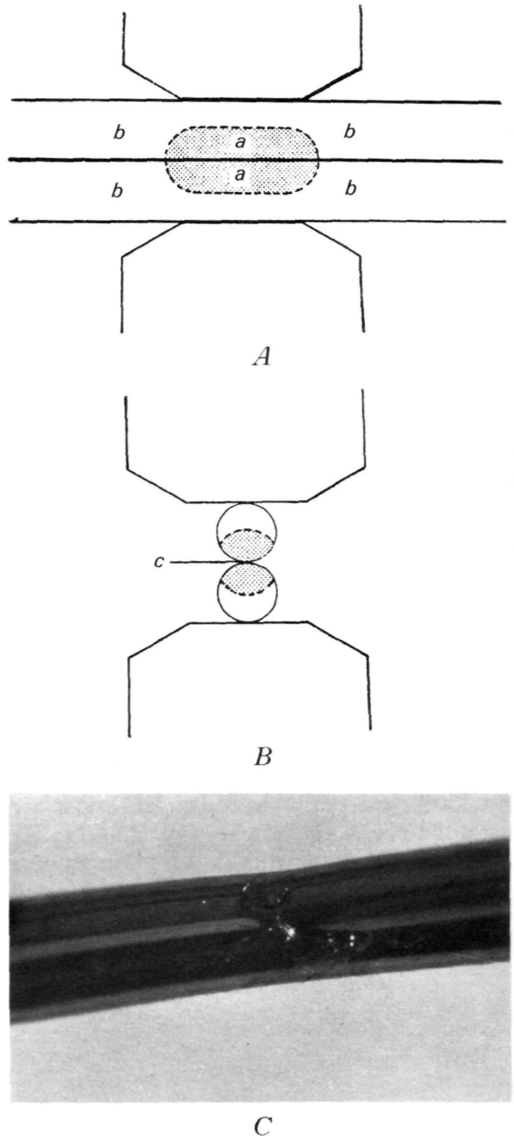
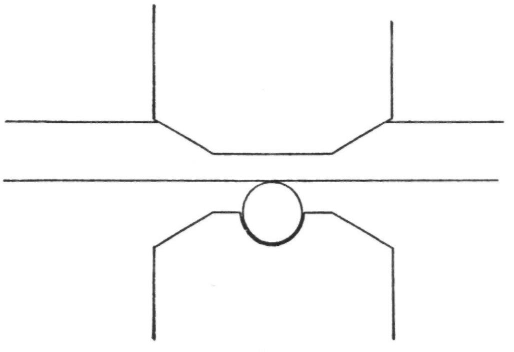
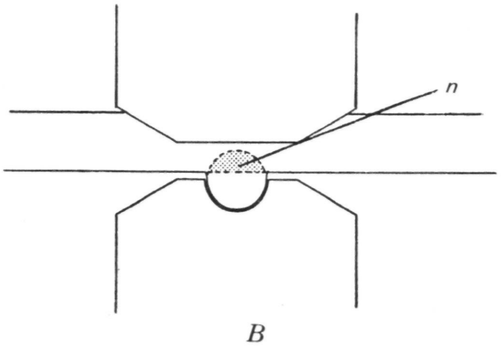


Fig. 9.29. The welding of wires. *A,* If the wires are laid parallel and flat electrodes are used, heating occurs in the area *a, a.* Softening should not penetrate more than four-fifths of the thickness of the wires. Support at *b, b, b, b* of unsoftened wire prevents fusion of softened areas into a weld nugget. *B,* Cross-section of the resulting weld shows how very little fusion of metal can take place in such circumstances. Area of Contact, *C.* A poor weld is made if the wires are parallel.

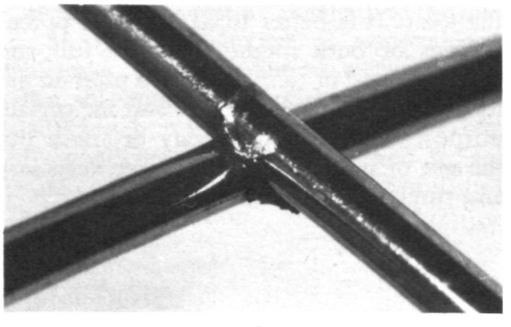
* *Nugget:* The metal joining the parts in spot, seam or projection welds (Rossi, 1954).



A



B



C

Fig. 9.30. Welding wires at right angles using grooved electrodes. *A,* Before welding. *B,* After welding. Note how the groove protects the outer surface of the wire and how all heating and fusion take place at the point of contact of the wires which sink into one another forming a weld nugget (n). *C,* The contour of the wires is protected and the weld is made between the contact surfaces of the wires.

If the electrodes are grooved and the wires are laid at right angles *(Fig.* 9.30, *A, B,* C), when the weld is made the two wires can be forged together without any distortion of their outer contours. This is because the hollow of the electrode spreads the current over a large surface area so reducing the heating effect at the surface of the wire. The current is concentrated at the contact points of the wires and here the maximum heating effect occurs. The outer contours of the wires have not been damaged or the metal softened at this situation; this contributes greatly to the strength of the joint and retains the essential properties of the wires. A joint of this kind represents the strongest single weld between two wires. If further strength is sought it is possible to weld wires at two points by turning one of them in a small half-circle and in this way a joint of double strength can be made.

Much of the difficulty of welding spring wires appears to arise from the fact that they are hard; soft stainless steel orthodontic wires can be spot welded very easily and strongly with grooved electrodes.

Heat Balance

Problems arise in welding light parts to heavy parts in that the heavy parts require more heat to raise them to welding temperature than light parts and there is a tendency to overheat the light part in the effort to get the heavy part up to the necessary degree of heat.

The problem is solved by the fact that heat is developed at the point of contact of the two workpieces, exactly at the site of the joint, and if the weld is made quickly enough it is completed before the heat is conducted away into the bulk of the heavy part. When welding a light part to a heavy part the bulk of the heavy part is not raised to welding temperature, only a skin at the surface making contact with the light part becomes plastic.

Light tapes can be welded to heavy wires using flat electrodes. When welding light wires to heavy wires precautions should be taken against overheating the finer wire. This means using a grooved electrode to weld the fine wire and, if this is done, fine

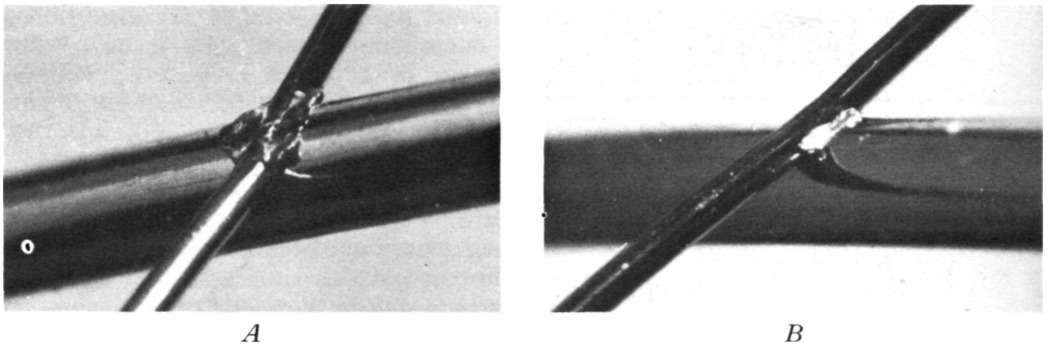


Fig. 9.31. *A*, 0.3 mm wire welded to 1.0mm arch, using flat electrodes. The fine spring wire has been overwelded and crushed. A degree of welding power that does not injure the outer surface of the fine wire is also insufficient to produce an adequate weld at all. *B*, The upper electrode has been grooved and now a secure weld can be made without distorting the fine wire.

spring wires may be successfully attached to heavy archwires *(Fig.* 9.31). When making such a weld it is not necessary to do more than make a fine V-groove in the tip of the upper electrode with the edge of a fine jeweller's file to accommodate the fine wire. Sufficient adaptation of the electrode to the curve of the wire is achieved in this way. When grooving an electrode to fit heavier wires it is desirable to make the groove with a fine fissure bur. For the most perfect results the electrode should be made to fit each size of wire accurately. This would mean having a large selection of electrodes with a different size of groove in each. It is found that it is not essential to have such a series of grooved electrodes to fit all the heavier wires. If an electrode is grooved to fit a 1.0 mm wire, it will be found that this groove will work very satisfactorily with wires of 0.9, 0.8, 0.7 mm and even 0.6 mm. Although the hollow of the electrode does not fit all these wires perfectly, the fact that the electrode is grooved at all protects the wires in the way that has been already discussed. For the finer wires (0.5 mm and smaller) a finer groove should be made in the electrode with a fine file as mentioned above.

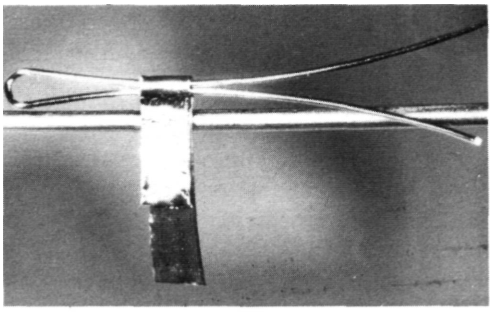
Another method for overcoming the problem of attaching a fine wire to a heavy arch is to make an attachment with a strap or loop of tape, so avoiding actually welding the fine wire. The tape can be welded to the archwire making a strong joint *(Fig.* 9.32).

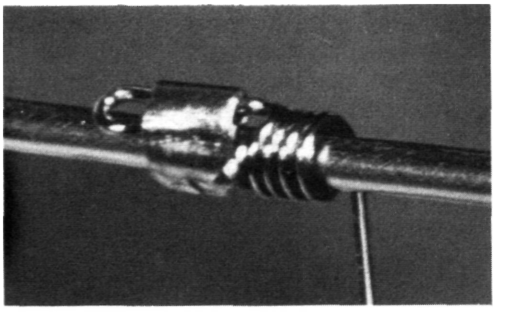
The practice of reinforcing welded joints with solder is to be deprecated. A properly welded joint does not need any reinforcement. Once the parts have been welded, it is impossible to solder them properly as small extrusions of metal which are tarnished prevent the flow of solder into the interstices of the joint. It is better to develop the potentialities of both methods to the full and either to weld or to solder. Each method has its own sphere of usefulness and for certain purposes either method may be used, but the use of both together is never necessary and rarely produces the best result.

SOLDERING OF STAINLESS STEEL FOR REMOVABLE APPLIANCE CONSTRUCTION

The use of soldered joints* in stainless steel for orthodontic appliances brings with it certain technical difficulties. First, no union takes place between solder and steel and as a

* Suitable materials for soldering stainless steel wire are 'Easy-flo' silver brazing alloy 0025 in. wireform and 'Easy-flo' flux powder (Johnson, Matthey & Co. Ltd, Hatton Garden, London).





A *B*

Fig. 9.32. The welded tape loop for attaching fine spring wires. *A*, A loop of tape 2.5 mm x 0.15 mm is pulled up tightly on the fine (0.3 mm) spring wire. The tape loop is welded to the heavy archwire. The tape loop is cut off and welded to the arch again close up to but not through the fine spring wire. The wire loop is then pulled up by the short end into the tape loop until jamming occurs and the short tail of wire turned tightly back. *B*, The short tail is cut off and smoothed, the tape welds and cut ends are smoothed, and the spring is wound. Note how the pull of winding the spring is against the loop of the tape and not against the weld. This attachment is suitable for any fine apron spring. Even when coils are not wanted, one or two turns of the spring wire are taken around the arch.

result the solder, under the conditions of stress and strain found in the mouth and the action of the oral secretions, is liable to come away from the steel, leading to joint failure. Secondly, the heating of stainless steel to the temperature required for soldering anneals the steel and makes it useless for spring purposes at the annealed part. Heat treatment does not restore elasticity to the metal.

In the construction of removable appliances, soldering almost always refers to the soldering of wires, and here the two difficulties referred to can be overcome by good design of the joint and by accurate control of heat distribution during the soldering operation.

Joint Design

Wherever possible, wires should be joined by turning one wire around the other and soldering the joint. This may seem a clumsy method, but the joint so formed is much more reliable than one formed by simply crossing the wires and soldering. The extra bulk formed by turning one wire around the other can be allowed for, and in some instances can be used to advantage as, for instance, in the stop hook for intermaxillary and extra-oral traction. It will be noted, too, that in the construction of the extra-oral attachment for cervical traction to a removable upper appliance, a 125 mm wire was bound to a 1.00mm wire with 0.3mm soft stainless steel wire and the whole joint then soldered. *(See also* Chapter 7, *Fig.* 7.7.) This method is useful in certain cases. Where a simple crossed or lapped joint is unavoidable, this may be made, of course, and good results are obtainable if the other principles of joint construction are attended to.

It is important, when soldering wires, to encase the joint completely in solder. The solder on the outer aspects of the joint will be thin; but however thin, the solder must be present all round the joint. The mechanical continuity of the solder has much to do with the permanence of the joint. For this reason soldered joints should not be polished; polishing removes the outer layer of solder and exposes the wire. This makes a break in the continuity of the solder which, in the mouth, generally leads to failure of the joint. Flux should be removed from soldered joints when the joint has barely cooled, by picking it away with a probe; the solder will be found to have a bright, smooth surface which is perfectly clean and hygienic. It is not usually feasible or necessary to remove flux on soldered joints on appliances by boiling it off with alum solution.

Heat Control

The most convenient method of melting solder for stainless steel soldering is by means of the miniature butane blowlamp (*Fig.* 9.33). The jet in the blowlamp should be small enough to make it possible to produce a fine needle flame 1 cm long when required.

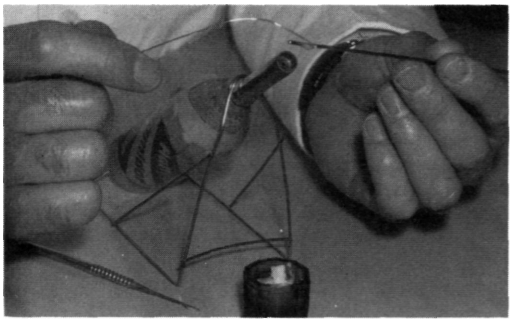


Fig. 9.33. A typical small portable blow-lamp using butane gas. It is usually necessary to make a cradle to hold the blow-lamp so that the flame points in a suitable direction.

Only enough heat should be used to melt the solder and the use of a fierce flame should be avoided. A soft, quiet blue flame will melt solder quite adequately and give the operator time to observe the flow of the solder and manipulate the wires. Even slight overheating of a joint produces burning of the wire and the solder, a weak joint, and a rough pitted surface on the solder.

The final soldering operation should be performed if possible in one heating. Remelting a joint to add more solder or make adjustments increases the risk of burning the solder and the wire.

The localization of heat to the site of soldering is important when it is wished to avoid annealing a large section of wire, and where wires embedded in baseplates are being soldered. Heat may be localized by covering the adjoining wires with wet napkins or cotton-wool or by using a small flame. Another method of heat control is to melt solder on a separate piece of wire and to touch the wires to be soldered against the molten bead of solder. The molten solder will then flow on to the joint. This method provides both heat control and control of the amount of solder to be applied to a joint.

The annealing of stainless steel wire during soldering operations is related to two distinct uses of the wire. First, wires which are used as rigid arches, for example free sliding buccal arches, do not suffer from annealing because the wire is still strong enough when softened to resist the pressures of the forces applied to it. The same applies to wires, usually 0.7 mm soft, used for hooks. Such wires are strong enough even when soft to withstand the pressure of inter-maxillary traction. Secondly, finer wires used for springs, when annealed, become quite useless for their purpose. It is necessary when attaching such wires by soldering to use only enough heat to melt the solder, so annealing as little of the spring wire as possible, and to wind the annealed part of any such spring around the arch before beginning to use the wire as a spring. If it is possible to use the turns of such a spring wire around the arch as the coils of the spring, so much the better. The annealed part of the wire will then be well out of the way and unlikely to break down.

Other Points in Soldering

If solder is first of all flowed around one or both of the wires to be soldered and the wires held in position, a gentle heat just enough to melt the solder will produce a perfect joint.

Flux must be applied liberally at all stages of stainless steel soldering. The flux/water mixture has a tendency to boil and leave areas of metal uncovered. This may be avoided by drying on a thick layer of flux by gentle heat before heating to soldering temperature and by cleaning just the area to be soldered with a fine cuttlefish disc or a fine smooth file. A wire so prepared will take a smooth and even layer of flux which remains evenly spread when molten. For small joints between wires it is not necessary to prepare the wire apart from wiping off surface dirt or grease. Stainless steel soldering takes place in a bath of molten flux which protects the metal and the solder from oxidization.

Soldering medium wires to thick wires

The medium thick wire is turned accurately around the thick wire, but not so tightly that it will not slide along the thick wire. A bead of solder is melted on to the thick wire at the site of the joint. The thinner wire is fluxed and brought near to the solder bead, which is again melted, and the loop in the thin wire is moved into the molten solder and heating continued for a second or so until the joint is uniformly covered with solder. The wires are withdrawn from the flame and held until the solder hardens.

If required, such wires as these or wires of equal thickness may be united without looping one about the other. It is necessary to make sure that the wires are completely encased in solder (*Fig.* 9.34). Do not polish the joint.*

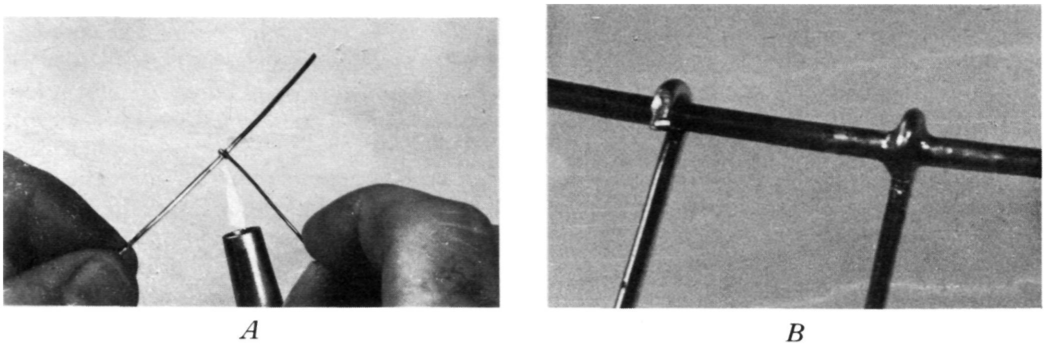
*This method of soldering was described by H. G. Watkin in the *Transactions of the British Society for the Study of Orthodontics* in the discussion of the paper by Cutler (1932).

Soldering fine wires to thick wires

The fine wire is given slightly more than a half turn at the extreme end and clipped on to the thick wire at the site of the joint and both wires fluxed all round (*Fig.* 9.35). A piece of 1.25 mm wire is filed flat across the end and a small spot of solder is melted on to the tip. This piece of wire is heated with a small, fine, fairly fierce flame just proximal to the bead of solder, which melts. The wires to be joined are held against the molten solder, which transfers itself to them without overheating the fine wire. The wires are withdrawn from the flame and when cool the flux is chipped off and the fine wire wound at least once completely around the thick arch, after which it may be used as a spring with or without further coils. By this technique it is possible to solder a 0.3 mm wire to a 1.0 mm wire without softening the 0.3 mm wire.

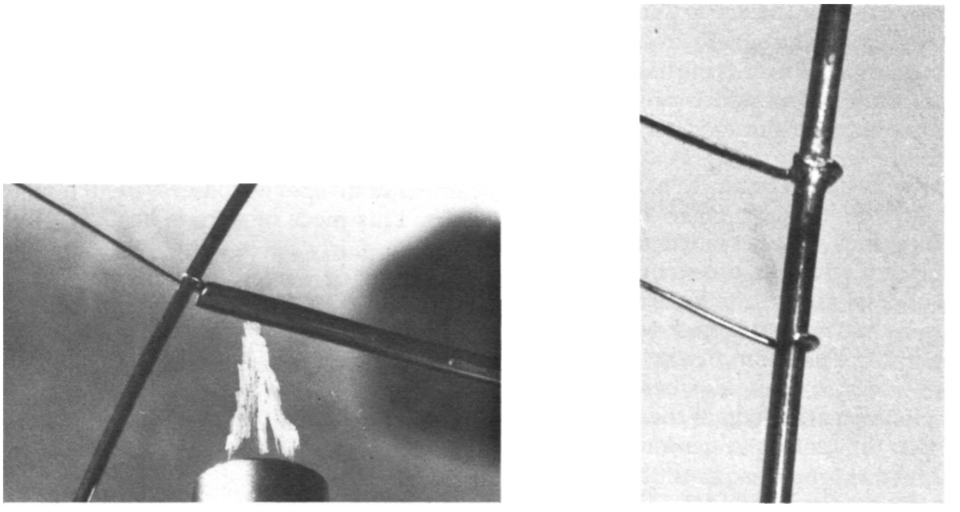
The soldering of tubes to Adams clasps is strictly comparable to the joining of wires by soldering.

A long length of tubing should be used, and the required section cut off after soldering. If it is desired to use up short lengths of tubing, these may be aligned and held in position by placing them on a longer length of finer tubing or straight wire.



A *B*

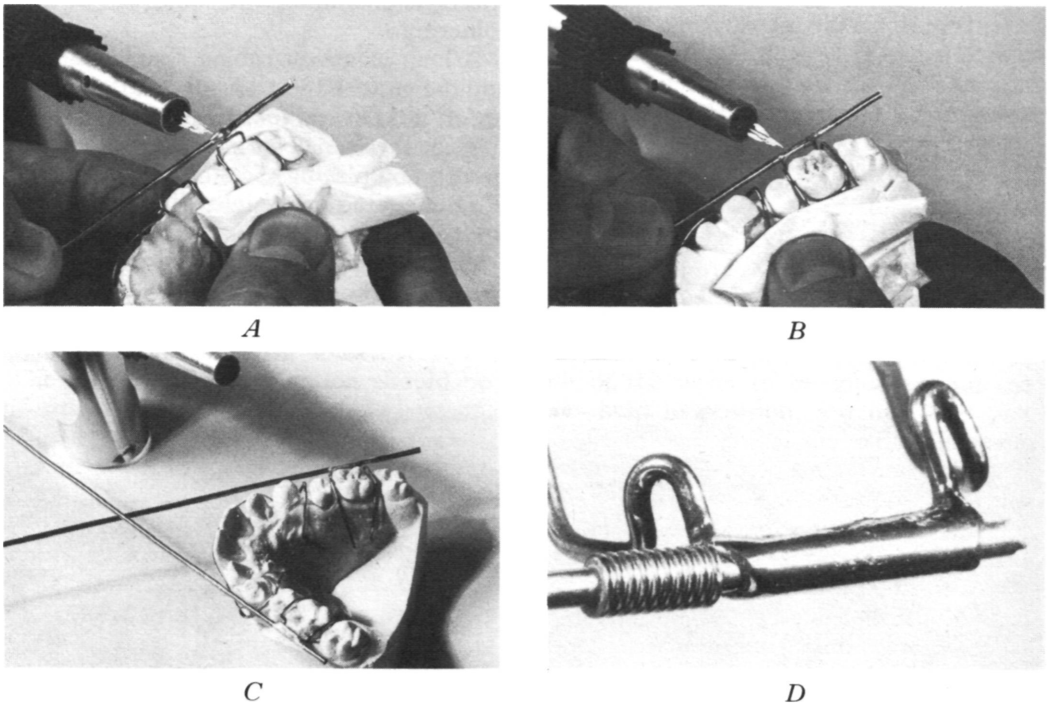
Fig. 9.34. Soldering a thinner wire to a thicker one. *A,* The thinner wire is wound round the thicker wire first of all. *B,* The joint before and after soldering.



A

B

Fig. 9.35. Soldering a very thin wire to a thick wire. *A,* A soldering iron of thick copper wire is used. *B,* A joint before and after soldering.



A

B

C

D

Fig. 9.36. Soldering tubes. *A,* The tubing is coated with an adequate amount of solder. *B,* The flame is applied to the tube and the clasp is moved up against the molten solder which flows around it. *C,* Both tubes have been soldered; the first tube is used as a guide for the second. *D,* The completed tube showing an archwire with a friction-fit stop.

The area of tube to be soldered is coated with a thick blob of solder *(Fig.* 9.36, *A),* and the tube tried on the appliance for alignment. The model on which the appliance was processed is preserved and used to assist in the alignment of the tubes.

The bridge of the clasp is then fluxed and, using a very fine needle-pointed flame, the solder on the tube is heated, when it will flow on to and around the wire of the clasp *(Fig.* 9.36, *B).* It is most important that heat should be applied only to the solder on the tube by means of a fine, short, needle-pointed flame. If the wire of the clasp is heated, the tags will lose their hardness and the clasp will not then remain tight when adjusted. The baseplate is protected by a well-wetted napkin arranged to cover it completely opposite the clasp and the two adjoining teeth.

The tubing must be aligned to suit the curve of the arch in the buccal segments, and also in the horizontal plane to suit the level at which the bow being used must lie anteriorly. When one tube has been soldered, the alignment of the second in the horizontal plane is greatly facilitated, as the two lengths of tubing will cross anteriorly *(Fig.* 9.36, C), and it is only necessary to consider the alignment of this tube in a buccolingual direction. The tube is then cut to length with a carborundum disc and the ends smoothed *(Fig.* 9.36, *D).* The soldering is not polished.

The soldering of tubes to premolar clasps is done in exactly the same way. A little less solder is required and it is not spread as far along the tube.

The author finds it most convenient when soldering tubes to have the flame coming towards him, as, holding the model and tubing in this way, it is easier to judge the alignment of the tube. There is a risk of burning the fingers or clothing accidentally, however, and others may prefer to have the flame pointing in the opposite direction.

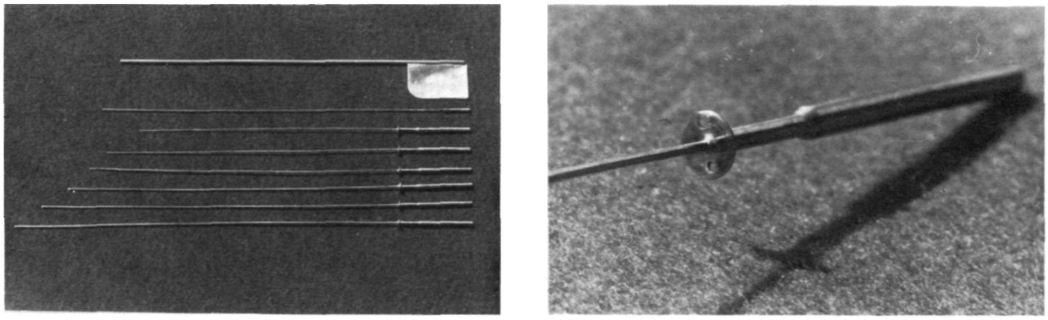
For the sake of clarity in the illustrations flux has been omitted in all the soldering operations. Flux must, of course, be applied liberally as mentioned earlier.

The practice of welding the parts together before soldering does not always confer the advantage of a doubly strong joint and may in fact lead to trouble in the long run. Welding parts together inevitably leads to some oxidizing of the metal and the formation of small gaps and crevices between the parts which are difficult to clean out and flux properly and into which solder will not readily flow. Both these factors are inimical to the creation of a properly soldered joint, and if the first attempt at soldering is not successful subsequent reheating may only make matters worse.

AN ORTHODONTIC COIL SPRING WINDER

Coil springs find a great variety of uses both in fixed and removable orthodontic appliance technique. The winder that is illustrated in this section has been in use for many years at the Eastman Dental Hospital, London, where it was introduced by Mr J. S. Beresford. The inspiration for this device came originally from a winder, identical in principle but rather different in design, described by Porter (1941, 1943). The present author has made a few small modifications to the Eastman pattern that make for greater ease in construction and speed in operation, but does not claim any originality for the device as a whole.

The winder consists essentially of a series of mandrels made of stainless steel wire from 0.5 mm to 1.0 mm thick, on which the coils are wound. This range of diameters will cover all normal orthodontic coil spring requirements. These mandrels run in a stainless steel tube, 1.0 mm internal diameter, and the spring wire is fed in at right angles through a fine 0.5mm internal tube *(Fig.* 9.37). The spring wire is attached to the mandrel temporarily by means of a perforated disc fixed to the mandrel through a hole in which the spring wire is passed.



A B

Fig, 9.37. *A,* Winding jig, lining tube and six winding mandrels sizes 1.0, 0.9, 0.8, 0.7, 0.6 and 0.5 mm thick. The mandrels are graduated in length from thickest to thinnest, so that selection of the required size is facilitated. *B,* A mandrel showing the shank, made from a bur or straight handpiece mandrel with a disc 5-6 mm diameter perforated in two places. One of these holes is used to retain the spring wire during winding of the spring.

Construction of the Mandrels

The mandrels are constructed from hard stainless steel wire, well straightened and soldered on to a straight bur shank through the medium of a short length of tubing. The bur is first ground down at the end to a diameter of 1.0 mm forming a short stub 3 0 mm long with a definite shoulder at the junction with the bur shank *(Fig.* 9.38, *A, B).* This stub is most easily formed by holding the bur in a straight handpiece and, while running the bur rapidly, holding it against a fine new carborundum wheel which is running on a lathe. If this wheel is reasonably new a definite sharp step can be formed where the stub projects from the bur shank.

A length of 1.0 mm tubing is next fitted over the stub and soldered on. This tube is then cut off, leaving about 1 0 cm attached to the bur shank. The piece of wire from which the mandrel is to be made is straightened and pushed into the open end of the tubing. A piece of steel molar band material 5-6 mm square and at least 0.15 mm thick is perforated centrally with a hole of the same size as the mandrel wire and is slipped on to the wire and pushed right up against the tubing. Tube, wire and band material are then soldered together using a minimum of solder and heat *(Fig.* 9.38, *C).*

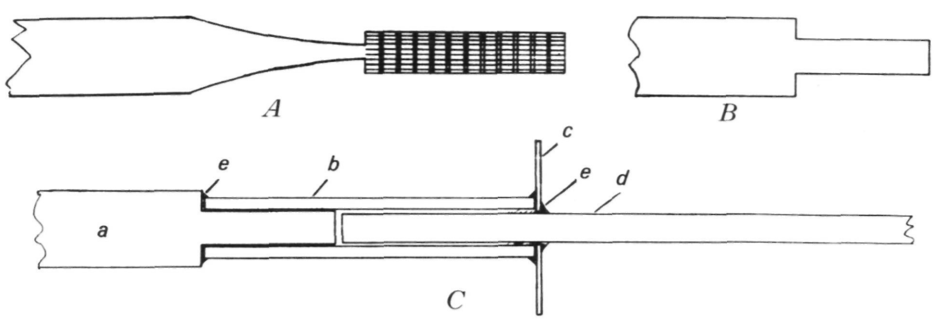


Fig. 9.38. Construction of winding mandrel from straight handpiece bur shank. *A,* Bur, any kind can be used. *B,* Bur ground down forming stub 3-5 mm long and 1 0 mm thick. *C,* 1 0 mm tubing soldered over stub. A long piece is used to facilitate soldering and tubing is then cut off leaving 1 0 cm attached to bur *(a, b).* The winding wire *(d)* is then fitted in and a plate of stainless steel tape *(c)* is fitted over the wire and the whole soldered together (c).

It will be found that the finer mandrel wires are a rather slack fit in the tubing and may be a little eccentric when soldered in, but this does not affect the efficiency of the winder. When making the 0.5 mm mandrel it is helpful to put a piece of 0.5 mm tubing inside the 1.0 mm tubing. This will centre the mandrel accurately.

The square plate of stainless steel is next turned into a circle by rotating the mandrel in a handpiece and holding the edge of the plate lightly against a rotating carborundum wheel. Two small holes are finally drilled in the disc with a spear point drill and the whole assembly smoothed off and polished.

It is helpful to make the set of mandrels of different lengths, the thickest being the longest, each successively thinner mandrel being shorter by 1.0 cm. A useful selection of mandrels is 1.0 mm reducing by 01 mm to 0.5 mm thick, which is about the thinnest that it is practicable to use. This will give a set of six mandrels which may be selected by their lengths. The longest mandrel does not need to be longer than 25 cm (10 in.) overall, making it possible to wind a spring of about 20 cm (8 in.) in length if necessary.

An alternative method of constructing mandrels is to start with a straight handpiece mandrel as used for sandpaper discs, discarding the central screw at the head *(Fig. 9.39, A)*. The flange at the end is ground off *(Fig. 9.39, B)*, and the winding wire fitted into the central hole with the square of tape in position and the mandrel, wire and tape soldered together as before *(Fig. 9.39, C)*. The complete mandrel is then finished off by rounding the square of tape into a circle, perforating and smoothing off.

The Winding Jig

The winding jig consists of a piece of 1.0 mm internal stainless steel tube, 17.5-20cm (7-8 in.) long, soldered to the long edge of a piece of 24 gauge stainless steel plate approximately 3 x 2 cm in size. Along the adjoining edge of the plate is soldered a finer shorter length of tubing 0.5 mm internal diameter *(Fig. 9.40)*. It is a great help if these pieces of tubing can be

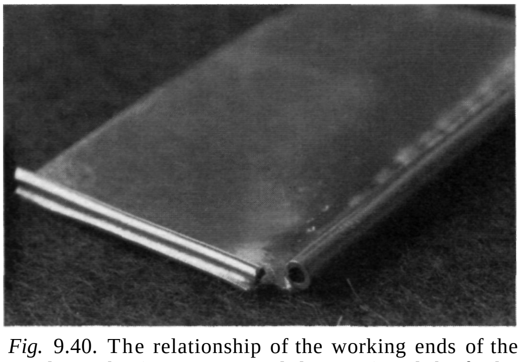


Fig. 9.40. The relationship of the working ends of the winding tube (10 mm internal diameter) and the feeder tube (0.5 mm internal diameter).

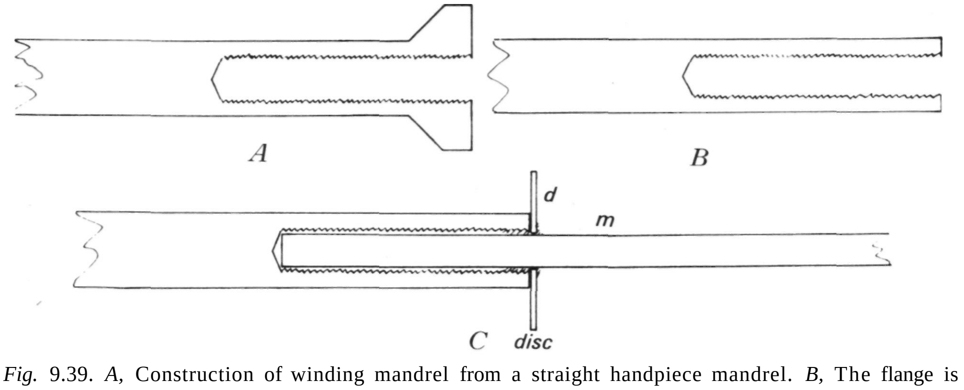
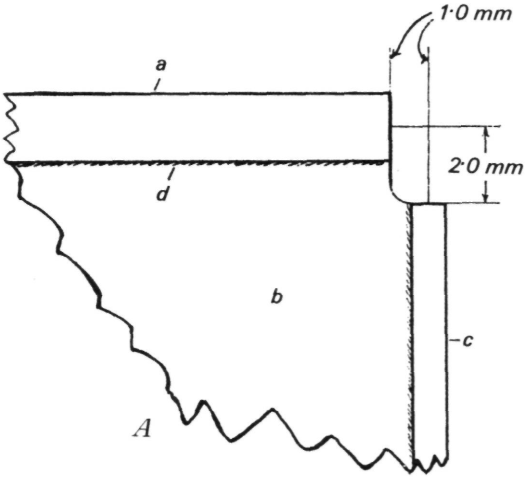


Fig. 9.39. *A,* Construction of winding mandrel from a straight handpiece mandrel. *B,* The flange is ground off. *C,* The plate of stainless steel *(d)* and winding wire (w) are fitted as in *Fig.* 9.38 and soldered together.



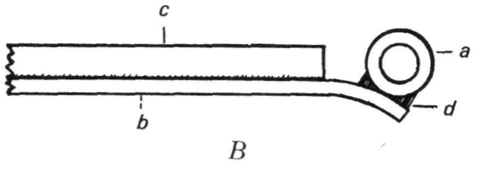


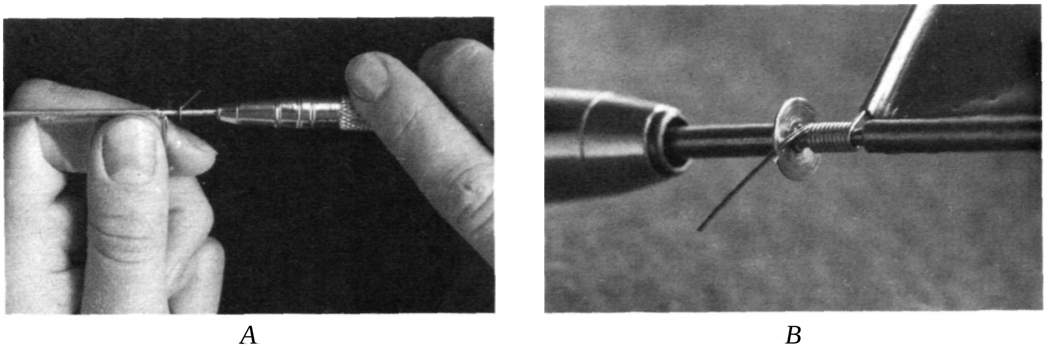
Fig. 9.41. *A,* Plan of the arrangement of the ends of the winder and feeder tubes. The dimensions shown should be carefully observed to secure the best results. *B,* View of the winding tube, end on. Note that the edge of the plate is bent down so that the centre line of the feeder tube is level with the centre of the winding tube. It is then possible to wind springs in either direction with equal tension, *a,* Main or winding tube; *b,* Steel base-plate material; *c,* Feeder tube; *d,* Solder.

lightly tacked to the plate by welding before they are soldered. The alignment of these tubes and the relation of their ends should be carefully noted *(Fig.* 9.41).

Use of the winder

The spring wire is fed through the fine tube until about 1.5 cm project past the large tube. The mandrel is inserted past the fine wire into the large tube and pushed in until the disc is approaching the projecting end of the spring wire. The spring wire is bent over and led through one of the holes in the disc and the mandrel pushed right home. About 1 cm of spring wire should project through the hole in the disc. The mandrel is then put into a straight handpiece and the engine set in motion, when the coils will become wound on the mandrel *(Fig.* 9.42). It is necessary to control the rate at which the mandrel is withdrawn from the tube to prevent either an open coil being wound or the coil wire from riding over coils already formed and jamming the winder.*

* It is most important when making coil springs to use an engine that has accurate slow speeds and can be stopped instantly if the wire becomes tangled or looped around a finger.



A B

Fig. 9.42. *A,* The winder in use. The spring wire is controlled by the fingers of the left hand. The wire can be seen entering from below. A slow winding speed should be used until experience has been gained in controlling the entry of the wire and withdrawal of the mandrel from the jig. *B,* The winder in use. This spring is being wound in a right-handed manner. The mandrel may, however, be equally well rotated in the opposite direction.

The most generally useful way of winding coil springs is to wind them all closely, that is with all the coils touching each other. Such coils are then 'set' to give their optimum working range in compression by stretching the spring by its extreme ends an adequate amount. The spring will be found to stretch perfectly uniformly. The spring is then replaced on the mandrel and compressed completely. When released, the spring will be found to return to a certain point. The useful working range of the spring in compression lies between this point and total compression, because it is known that total compression will not deform the spring and that it will always return to the point from which it was compressed.

When winding springs on the 0.5 mm mandrel, the mandrel is often found to be unstable inside the 1.0 mm winding tube and difficulty may be experienced in obtaining a smooth coil spring. The difficulty may be overcome by lining the 1.0 mm tube with a length of 0.5mm internal tubing. The lining tube must be prevented from rotating and moving longitudinally inside the larger tube. This liner is stabilized by means of a cuff or clip of band material, welded or soldered to the outer or far end of the liner, which clips over the outside of the outer end of the main winding tube. When winding coils on the 0.5 mm mandrel, therefore, the lining tube is slipped into the main winding tube and the clip or cuff steadies the fine tube in the larger one. At the inner or working end the lining tube must be quite flush with the outer tube and must not project.

Removing the Spring from the Winder

During the course of winding, the spring is bound tightly around the mandrel, which cannot be withdrawn from the spring while there is any wire still in the feed tube. The mandrel, spring and jig can be separated in two ways:

1. If the supply of spring wire runs out and the last of the wire is wound on to the mandrel, the tension of the spring is released and the whole spring unwinds slightly and relaxes its grip on the mandrel. The mandrel can then be withdrawn from the jig and the spring pulled off the mandrel.

2. If it is desired to withdraw the spring from the winder before the wire has run out, or in order to leave a coil spring with a tail of wire attached, first release the tension in the spring which is gripping the mandrel. This is done by releasing the grip of the handpiece on the shank of the mandrel. The spring and mandrel then unwind slightly and the grip of the spring on the mandrel is released. The mandrel is then pulled out and the spring is removed from the jig by drawing the unused portion of the spring wire, attached to the coil spring, through the feeder tube.

Points to remember

Coil springs can be wound with this simple apparatus in wire from 0.45 mm thick downwards on mandrels from 1.0 mm thick downwards. It will naturally be found that it is not feasible to wind a thick wire on a thin mandrel; a point will be reached where the mandrel will not stand the strain or the engine used for driving the device will become overloaded. Up to this point, however, there is a very large range of coil springs that can be made using different combinations of thicknesses of wire and thicknesses of mandrel.

In practice, coil springs are generally made of wires 0.15 mm or 0.2 mm thick. Thicker wires give springs which are too powerful and have too short a range of action. For twin-wire arch coil springs, 0.15 mm wire wound on a mandrel 0.5 mm thick gives a very suitable spring. For springs of larger diameter, that is 0.8 mm, 0.9 mm or 1.0 mm, wire of 0.2 mm thickness may in certain circumstances be used.

The thicker wires, 0.3 mm, 0.35 mm and 0.4 mm, are suitable for Trevor Johnson friction-fit stops which are wound on a mandrel one size, or 0.1 mm, smaller than the arch on which they are to be used. For these stops it is better to use a large number of coils of a fairly fine wire than a small number of coils of a thicker wire, i.e. six turns of 0.3 mm wire rather than two or three turns of 0.4 mm wire. The former stop will be as firm as but more resilient and less likely to loosen in use than the latter. On the other hand, if the friction-fit attachment is to be used also as a traction hook by forming a free end into a hook, a firm wire must be used for the purpose of the hook and therefore a 0.4 mm wire requires to be used for the whole attachment.

The winder can also be used for both right-hand and left-hand coils, a point that must be taken into consideration when the end of the wire is to be used for spring or hook purposes. A winder of this type once made up will last for years, the only replacement being possibly the occasional reconstruction of one of the finer mandrels should breakage occur.

The Fitting and Adjustment of Friction-fit Stops

Friction-fit stops on heavy archwires, 1.0 mm or 0.9 mm in thickness, are a great convenience as they may be moved to any position on the archwire as required. The stops should consist of about six turns of 0.35 mm hard wire wound on a mandrel 01mm smaller than the archwire being used.

To place a stop on the archwire, the end of the arch is slightly tapered and pressed into the stop. To get the archwire through the stop the arch is gripped close to the stop with Adams universal pliers. The stop is placed on a block of wood and the pliers pressed firmly at the end near the archwire with the left thumb. The grip of the pliers on the archwire must not be allowed to slip and the end of the archwire will pass through the stop and into the wood (*Fig.* 9.43).

To move the stop along the archwire, the archwire is gripped in Adams pliers in the *left* hand, as shown in *Fig.* 9.44. The stop to be moved should only be a few millimetres from the pliers. The end of the archwire projecting through the stop is lightly held with pliers such as Howe pliers held in the *right* hand.

Using the left thumb, the stop is pressed along the archwire, holding firmly with the left hand and lightly with the right.

By this method the stop can be moved easily and the amount of movement predetermined by the point at which the archwire is held with the Adams pliers.

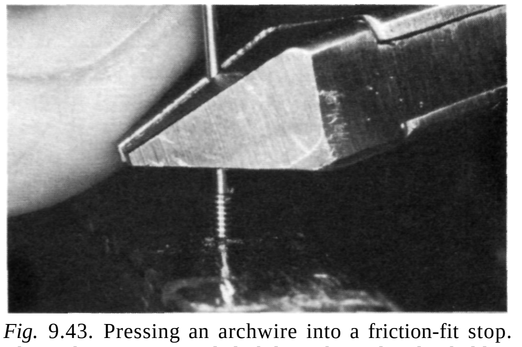


Fig. 9.43. Pressing an archwire into a friction-fit stop. The archwire is tapered slightly at the end and is held in Adams universal pliers near to the end using the right hand. The end of the archwire is placed in the stop which is rested on a piece of soft wood. Using the left thumb on the pliers beaks, the archwire is pressed into and through the stop.

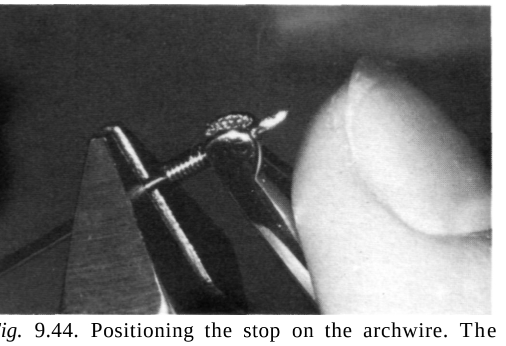


Fig. 9.44. Positioning the stop on the archwire. The archwire is gripped in Adams universal pliers using the left hand. The stop is a short way from the pliers. This distance can be predetermined making accurate movements of a stop very easy. Note tapered end of 1.0 mm archwire. Howe pliers are placed over the projecting end of the archwire which is held *lightly* using the right hand. Almost any other fine-nosed pliers may be used as well as Howe's. The *left* thumb is placed on top of the Howe pliers and presses the stop along the archwire until it comes in contact with the Adams pliers.

PREPARATION OF THE ORTHODONTIC STUDY MODEL*

Study models have always been and will remain one of the most informative records of the arrangement of the teeth and of the occlusion available to the orthodontist; no other method of recording can embody the three-dimensional effect that is required. It is important, therefore, always to employ a model preparation routine that will ensure that accurate, well-made and finished study casts can be prepared without drudgery and the expenditure of an undue amount of time.

When preparing models of the teeth for study, record and measurement purposes, it is usual to make them with a bulk of plaster in addition to the teeth, palate and alveolar processes so that bases can be formed. The bases make a background against which the arrangement of the teeth is judged. The bases of the casts should be shaped so as to avoid any outline or angulation that will suggest abnormalities of alignment or position of the teeth that do not in fact exist. If the posterior surfaces of the models are cut in the same vertical plane this serves to register the occlusal relationship of the dental arches and makes the models easier to handle and store

It was at ohe time recommended that the base of the upper model should be carved so that its top surface corresponded with the Frankfurt plane (Simon, 1926). This resulted in the production of a rather tall and bulky set of study models, and as X-ray cephalometry has made it possible to relate the arrangement of the teeth and the occlusion to the face and head as a whole, it is no longer necessary to prepare study models which incorporate facial landmarks in the plaster bases.

There is one anatomical landmark which does appear in all study models and which is invariably used in making visual assessments of the arrangement of the teeth in the upper arch. This is the median palatine raphe and its associated palatal rugae. The middle line of the palate has always been used in estimating the symmetry of the upper arch and the amount of drift of permanent teeth that has taken place following the early loss of deciduous teeth. If the bases of study casts are cut so as to be symmetrical about the median palatine raphe of the upper model, the eye is greatly aided in judging the symmetry or lack of symmetry of the dental arches when looking at record models.

The relationship between the occlusal plane and the model base must also be considered. It is not necessary to register the relationship of the occlusal plane, as this can be measured on cephalometric X-ray films. Rather than attempt to embody some guess as to the inclination of the occlusal plane in a set of study casts, the purely arbitrary decision should be taken to make the occlusal plane parallel to the top surface of the upper model. For this purpose the occlusal plane is defined by the incisal edges of the incisor teeth and the occlusal surfaces of the last pair of molars in the upper dental arch.

Equipment

1. One electric plaster-trimming machine with a medium-grit, carborundum wheel, grit No. 60, is suitable for a general-purpose machine. The platform of the machine must be perfectly flat and at right angles to the surface of the grinding wheel. The sides of the platform must be straight and parallel and also at right angles to the wheel. If large numbers of study casts are to be prepared for exhibition or photographing, it is a great convenience to have a second machine with a very fine wheel, grit No. 120. With this machine the cut surfaces can be polished so that no hand finishing or sandpapering is required on the cut surfaces. A very accurate, fine finish is produced in this way. One machine with a medium-grit wheel is all that is required for routine clinical purposes (*Fig.* 9.45).

*The method of study model preparation described owes much to the method suggested by G. Northcroft, shown in *The Science and Practice of Dental Surgery*. London, Oxford University Press, 1931.

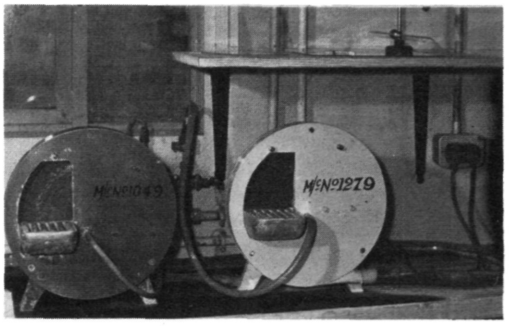


Fig. 9.45. **Two standard model-trimming machines.** Medium grit on right; No. 120 grit on left. On the shelf above are surface gauge and symmetroscope.

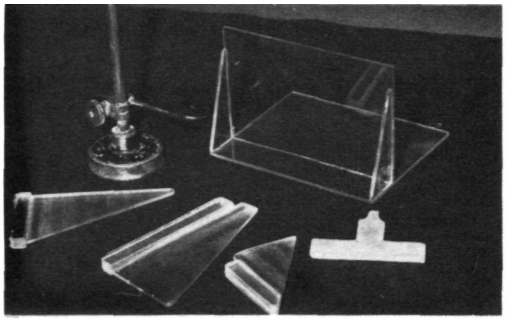


Fig. 9.46. The surface gauge, symmetroscope, set squares and the rubber T-piece.

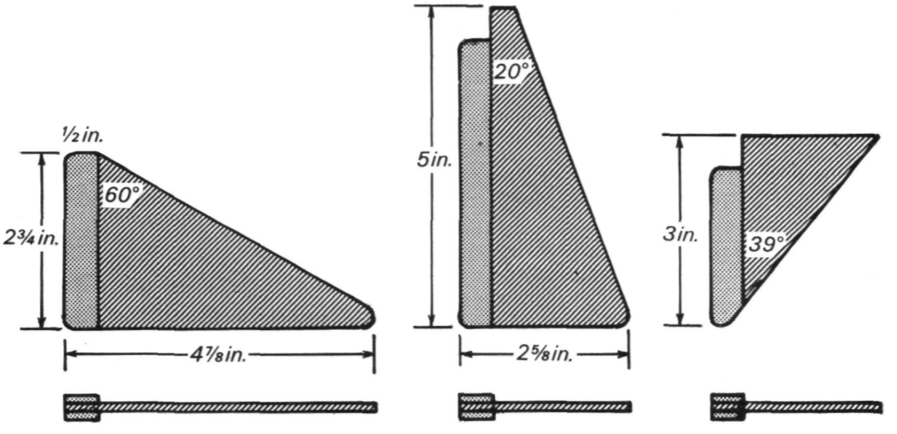


Fig. 9.47. The set squares for trimming study models. These are made, to the shapes and sizes shown, of 1/8 in. perspex material cemented with chloroform.

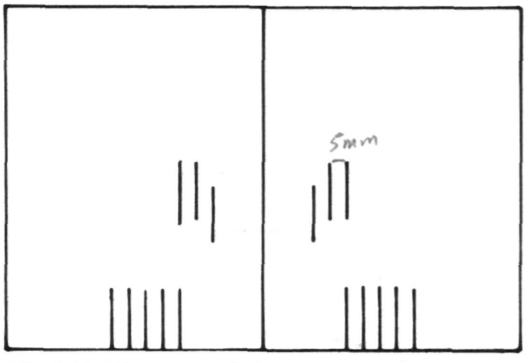


Fig. 9.48. The screen of the symmetroscope measures 6 × 4 in. The markings are 5 mm apart and are distributed symmetrically about the vertical centre line.

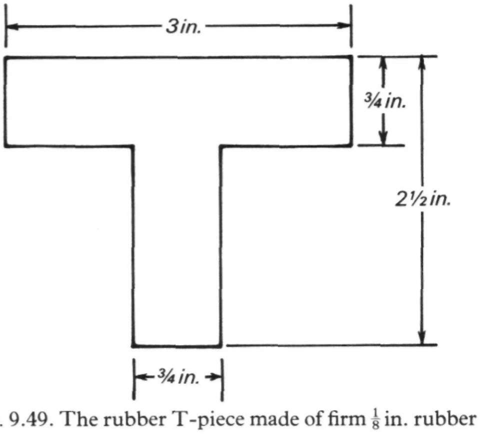


Fig. 9.49. The rubber T-piece made of firm $\frac{1}{8}$ in. rubber sheet.

2. One simple engineer's surface gauge.

3. One rubber T-piece, a symmetroscope and three jigs for guiding the models to the correct angles, a piece of plate glass 10 in. square *(Figs.* 9.46-9.49).

The small pieces of equipment can be made in the laboratory. The rubber T-piece is made of firm rubber sheet 1/8-1/4 in. thick and to the size and shape shown in *Fig.* 9.49. The set squares and symmetroscope are made of perspex sheet 1/8 in. thick to the sizes and shapes shown in *Figs.* 9.47 and 9.48. On the viewing sheet of the symmetroscope the centre line and two set of width lines are drawn with a fine needle and the lines filled in with indian ink *(Fig.* 9.48). The perspex can be sawn and filed to shape. If a heavy carpenter's plane and shooting board are used the truing up of the set squares is made easier. To put the set squares together, the pieces are clipped with clothes-pegs and chloroform run into the joints by capillary attraction. The symmetroscope is similarly fixed together, and when the joints have dried they may be reinforced with a cement of perspex dissolved in chloroform.

Stages in the Preparation of Study Models

1. The impression and wax bite

The models should be cast in accurate impressions. Today the alginate mixtures provide most of the requirements of a good impression material. The impressions should extend to the limits of the buccal sulci and into the lingual sulcus in the molar region of the lower arch. The upper impression should cover the hard palate but should not extend on to the soft palate. Impressions which only take in the tooth crowns and a few millimetres of the adjoining gingival tissue are unsuitable for orthodontic record purposes. A wax bite should always be taken. This should consist of only a bar of moderately softened wax across the premolar region *(see Fig.* 9.53). When the teeth are fully closed, the molars will be in contact and the record models can easily be brought similarly into contact when registered in the wax bite. If a large area of wax covers the teeth it is difficult to bring the record models fully together. The wax should not be permitted to encroach on the incisors as the plaster reproductions of these teeth are easily broken off if the record casts are pressed into a wax bite. In some cases there are very few teeth in the buccal segments. In such cases, the wax bite-bar must be thick enough to fill the gaps in the buccal occlusion. When, later on, the record models are occluded and trimmed, there must be adequate support between the models in the premolar region so that no pressure is thrown on the incisors.

2. Casting the model

The models may be cast in plain dental plaster, in stone plaster, in plain-plaster-stone-plaster mixtures, or the teeth may be cast in stone plaster and the bases in plain plaster. The method of casting is a matter of personal preference. Teeth cast in stone plaster are stronger than teeth cast in white plaster, but even stone plaster teeth will break if the study model is roughly handled. If plain plaster models are stored and treated with care they are completely satisfactory.

The models should be cast with sufficient plaster in the base to allow for trimming to shape. The use of rubber boxes greatly facilitates the casting of adequate bases with economy of plaster *(Fig.* 9.50).

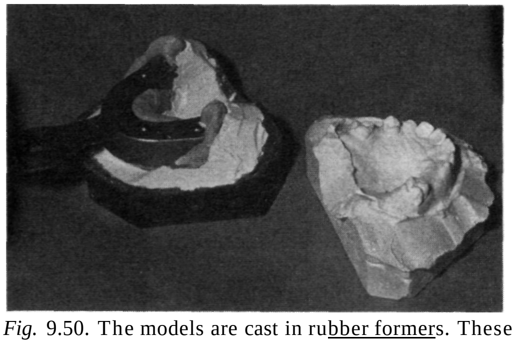


Fig. 9.50. The models are cast in rubber formers. These provide a rough approximation to the shape of the base and give an adequate bulk of material for trimming.

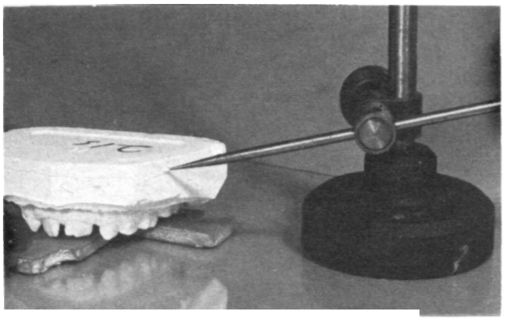


Fig. 9.51. Scribing the upper model

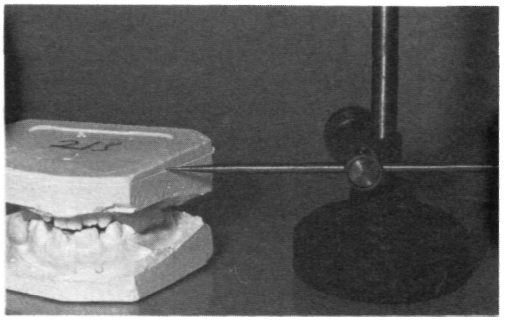


Fig. 9.53. Scribing the base of the lower model. Note the size and position of the wax bite.

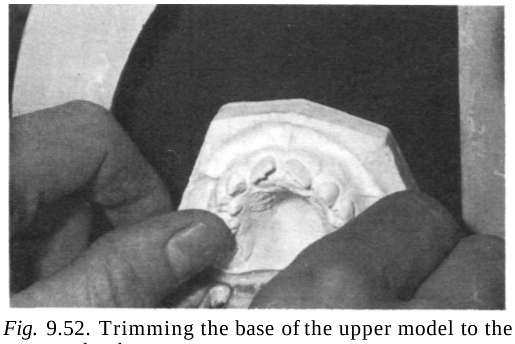


Fig. 9.52. Trimming the base of the upper model to the correct depth.

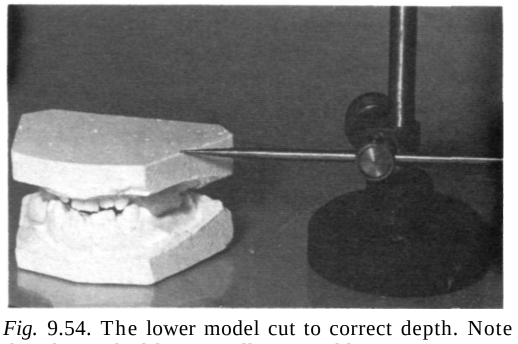


Fig. 9.54. The lower model cut to correct depth. Note that the scribed line is still just visible.

3. Trimming the bases

a. The upper model is set on the rubber T-piece on the plate glass and with the surface gauge a horizontal line is scribed right around the base of the model *(Fig.* 9.51).

b. The base of the model is trimmed to the scribed line *(Fig.* 9.52).

c. The models are placed in occlusion with the wax bite in position and placed on the glass plate, lower model uppermost. The base of the lower model is scribed all around parallel to the base of the upper and the lower is trimmed to the scribed line *(Figs.* 9.53, 9.54). The heights of the models must be determined by trial and standardized. A total height for deciduous teeth of 4 cm and of 5 cm for permanent teeth is suitable.

d. The heel or back surface of the upper model is trimmed back sufficiently and made at right angles to the median palatine raphe *(Figs.* 9.55-9.57).

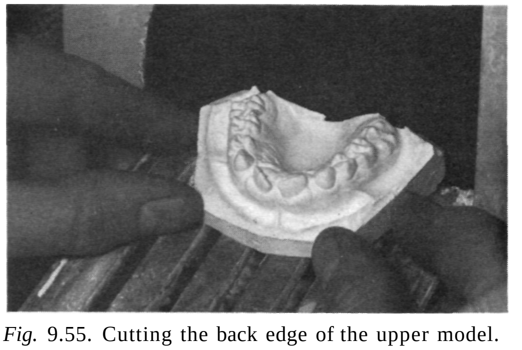


Fig. 9.55. Cutting the back edge of the upper model.

e. The front of the model is trimmed so that the point is in line with the median palatine raphe *(Figs.* 9.58-9.61).

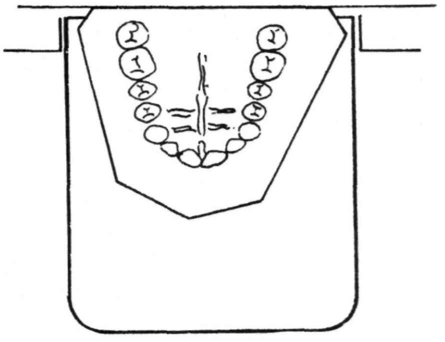


Fig. 9.56. The back edge is trimmed at right angles to the middle line.

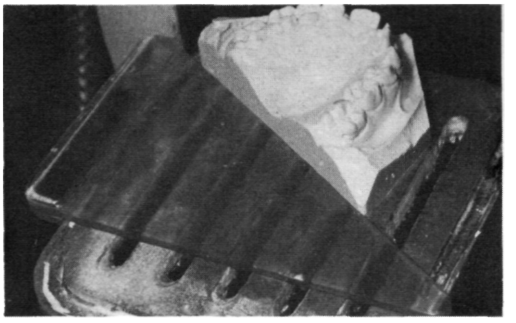


Fig. 9.58. Trimming the front of the upper model. Right side.

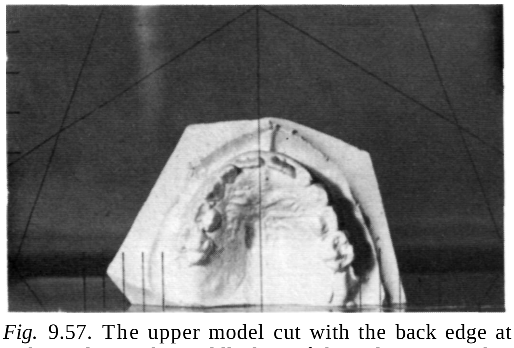


Fig. 9.57. The upper model cut with the back edge at right angles to the middle line of the palate. Note that the centre line of the dental arch does not correspond with the middle line of the palate; 2 is missing.

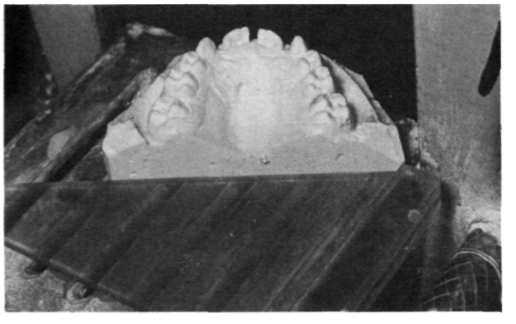


Fig. 9.59. Trimming the front of the upper model: Left side.

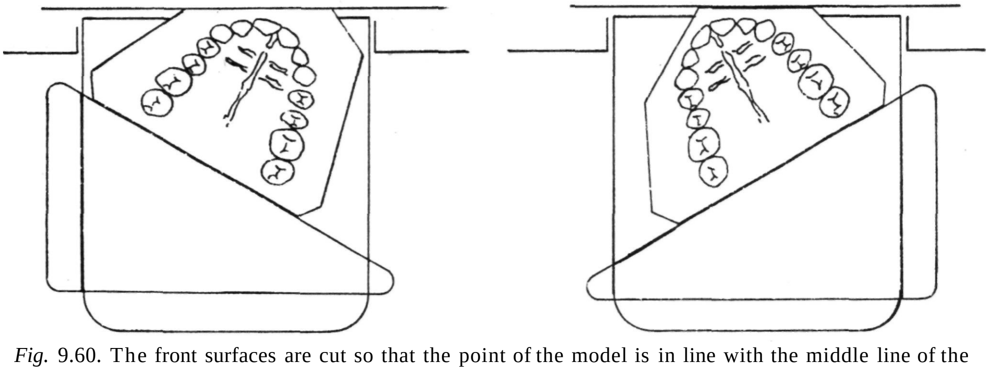


Fig. 9.60. The front surfaces are cut so that the point of the model is in line with the middle line of the palate.

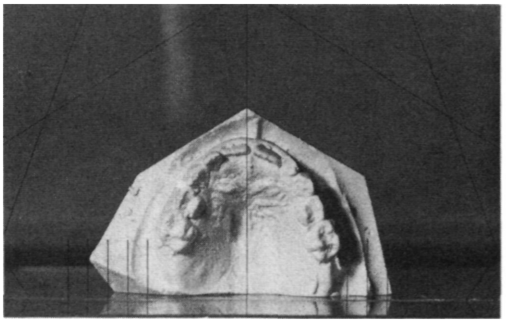


Fig. 9.61. The point at the front of the model is in line with the centre line of the palate.

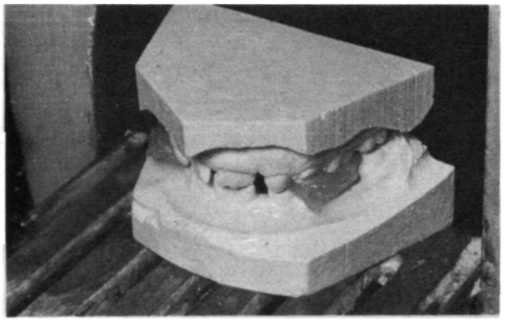


Fig. 9.64. The upper model is used as a guide in trimming the back edge of the lower model.

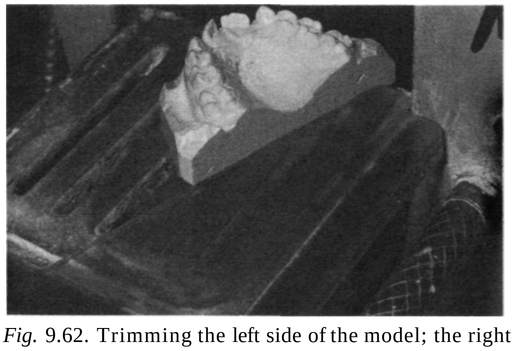


Fig. 9.62. Trimming the left side of the model; the right side is similarly trimmed.

/. The sides of the model are trimmed equidistantly from the middle line, making the model of a suitable width (*Figs.* 9.62, 9.63).

g. The models are placed in occlusion with the wax bite in position and, using the upper model as a guide, the heel or back surface and the sides of the lower model are trimmed to match the upper (*Figs.* 9.64, 9.65).

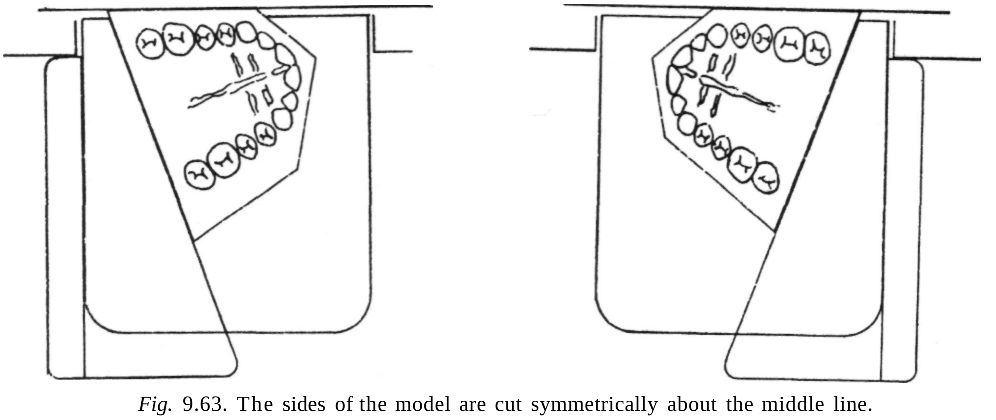


Fig. 9.63. The sides of the model are cut symmetrically about the middle line.

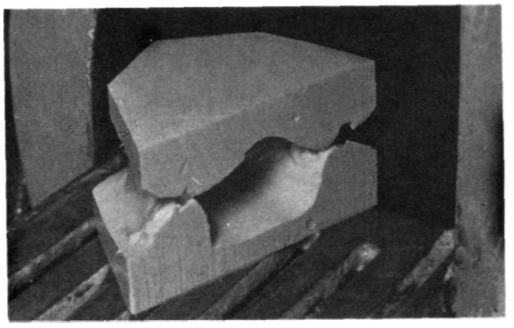


Fig. 9.65. The upper model is used as a guide in trimming the sides of the lower model.

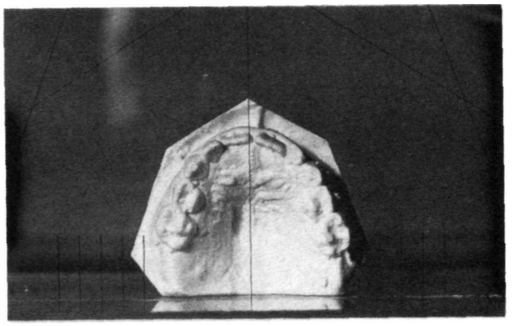


Fig. 9.68. The upper model base is completely symmetrical.

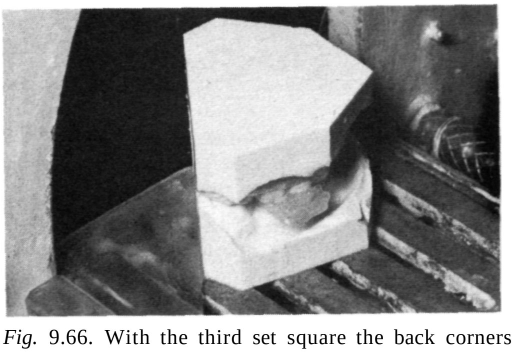


Fig. 9.66. With the third set square the back corners of the upper and lower models are trimmed simultaneously.

It is useful to use the second set square when trimming the sides of both models together.

h. The distal corners of the models are then trimmed using the third set square (*Figs.* 9.66, 9.67) and the final symmetry of the upper model is checked *(Fig.* 9.68).

i. The front of the lower model is trimmed to a curve to approximate the curve of the lower labial segment *(Fig.* 9.69).

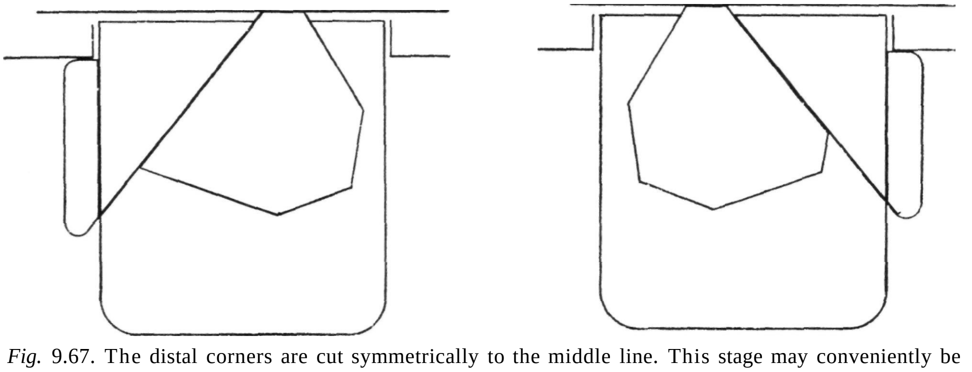


Fig. 9.67. The distal corners are cut symmetrically to the middle line. This stage may conveniently be done with both models in occlusion so that upper and lower are cut simultaneously.

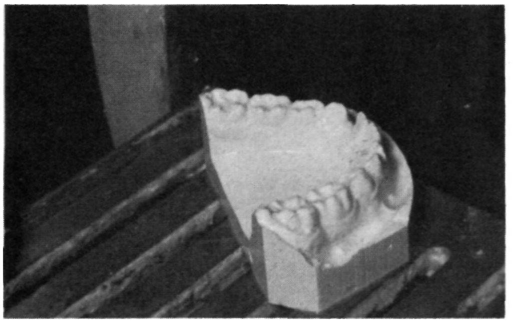


Fig. 9.69. The front of the lower model is trimmed to a smooth curve.

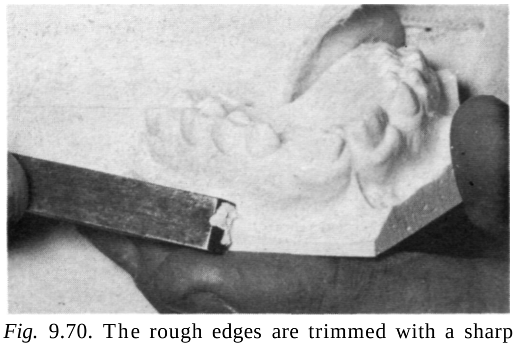


Fig. 9.70. The rough edges are trimmed with a sharp vulcanite cutter.

Fig. 9.71. The curved cut edges are smoothed with wet and dry sandpaper.

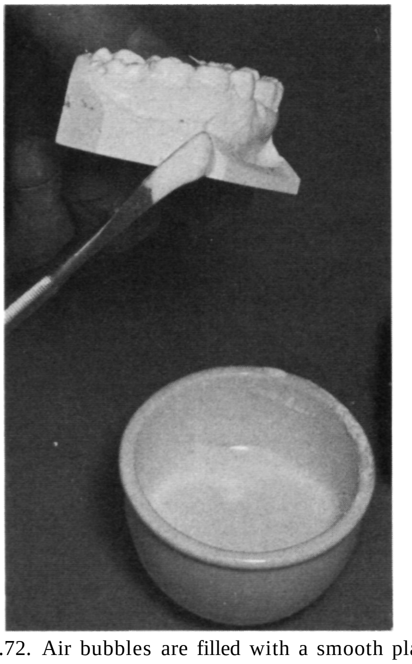


Fig. 9.72. Air bubbles are filled with a smooth plaster mixture.

/. The cut edges of the plaster are trimmed to smooth curves with a sharp hand chisel *(Fig.* 9.70).

k. For an exhibition or photographic finish the ground surfaces are polished on a No. 120 grit carborundum wheel. (If models are to be so treated only occasionally, the same effect can be produced by rubbing the models, in occlusion, on a very fine carborundum whetstone under a running tap.) The chiselled curves are smoothed with a scrap of well-wetted wet and dry sandpaper *(Fig.* 9.71). Any defects in the cut and polished surfaces due to air bubbles are filled with a creamy paste of plaster wiped on with a spatula and smoothed with the moist finger tip *(Fig.* 9.72).

Models are shown to the best advantage in photographs by reproducing left, central and right views in occlusion and the occlusal view of both models *(Fig.* 9.73).

Care of Record Models

Record models should be dried out in a warm atmosphere or in a drying cabinet. The patient's name and number and the

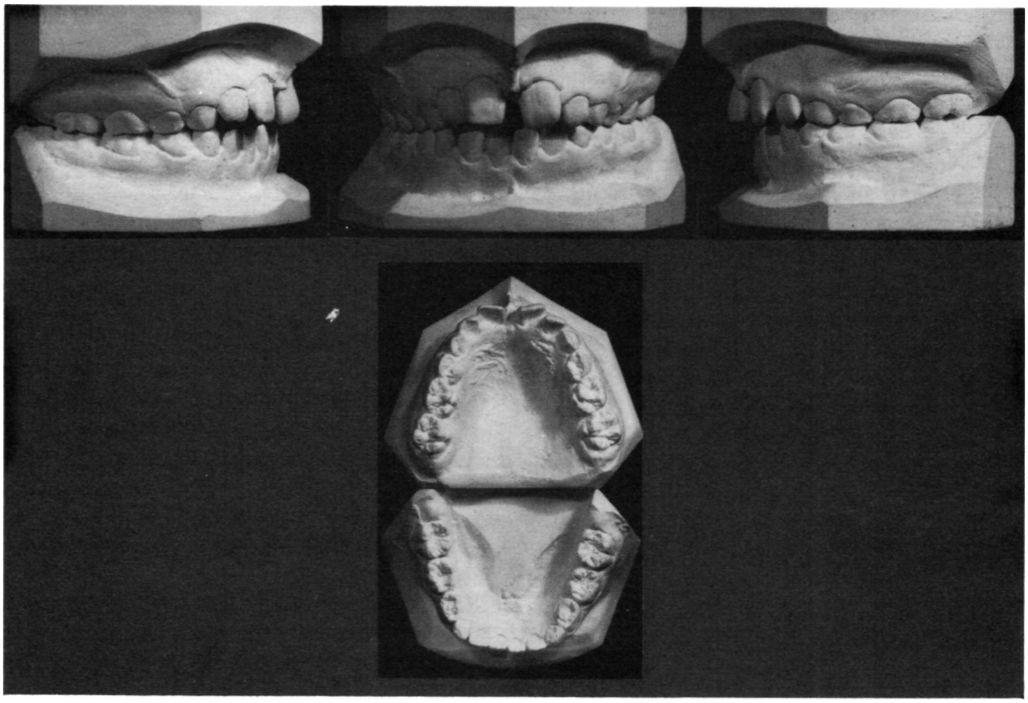


Fig. 9.73. Photographs showing the models to best advantage.

Fig. 9.74. Models are best stored in long boxes 3 x 3 x 11 in. Sheet plastic foam is put between the occlusal surfaces.

date on which the impressions were taken are most easily put on with a soft lead pencil. These details are best put on the top of the upper model and bottom of the lower. If put on the front and sides, such data may be difficult to eliminate from photographic reproductions. Record casts should be kept in boxes holding 5-6 sets of models, each pair held together by a light elastic band. A square of thin plastic foam should be placed between the occlusal surfaces of the teeth (*Fig.* 9.74). The wax bite should *not* be left between the teeth. In time the wax may stick to the plaster and pull pieces off the occlusal surfaces of the teeth when the models are separated. As the back surfaces or heels are cut exactly in the same vertical plane, the correct occlusion is best found by putting the models, back surfaces down, on a smooth flat surface and sliding them together. In most cases the wax bite has served its purpose and may be thrown away. In some cases where there are few teeth in the buccal segments and a thick wax bite has been taken, the wax should be stored with the models as it will be of help in finding the occlusal relationship at a later date.

Appendix: Materials for Removable Appliance Construction

STAINLESS STEEL

Steel wires were formerly used for the construction of orthodontic appliances, although the problem of corrosion placed limitations on their usefulness under the conditions met with in the mouth. In early dental literature piano wire was recommended where strength and elasticity were required, and the problem of corrosion was overcome by tinning the wire before use (Packham, 1932). The discovery of stainless steel and its eventual production in wire and ribbon form in Germany and Great Britain (Cutler, 1932) were followed by the development and refinement of methods for working, jointing and exploiting the physical properties of the new material for orthodontic appliance construction (Friel, 1933).

Stainless steel is the material that is most widely used for the metallic parts of orthodontic appliance construction at the present time. The particular variety employed is known as 18/8 stainless steel alloy, containing 18 per cent chromium and 8 per cent nickel as major constituents.

Properties of Stainless Steel Wire

The wires of the larger gauges, 0.6 mm and upwards, are of a medium hardness which combines a useful elasticity for spring purposes with a degree of malleability that makes it possible to bend the wire with any desired degree of sharpness. It is important to remember that stainless steel wire must be worked and used in the state in which it is purchased. It is not feasible to alter the properties of the metal by heat treatment. A second important point is that stainless steel wire of medium hardness may be bent sharply and, if the bend is incorrectly placed, straightened out; but it may not be bent again at the same spot otherwise it will break, if not at the time, then before very long under conditions of use in the mouth. In other words, the material fatigues if *sharp* bends are overworked. The wire is, however, enormously strong if the mistake of overworking it is avoided. This means that when bending stainless steel wire a technique should be used which ensures the maximum accuracy in placing the bends and which will permit of adjustment of bends, after they have been made, without overworking the wire.

Soft stainless steel wires are available where spring and elasticity are not required or are undesirable. For instance, 0.7 mm soft wire can be used for intermaxillary traction hooks. Although this wire is very soft and can be bent with spring-forming pliers, it is heavy enough to resist the pull of intermaxillary elastics *(Fig.* 7.5*A)*. Fine soft wire, 0 3 mm thick, may be used to bind together heavier wires before soldering or for ligatures in fixed appliance work.

Gauges of Wire

Stainless steel wires of circular section are used in gauges of 1.5 mm down to 0.15 mm. The heavier gauges, 1.25 and 1.5 mm, are used in a few situations. The thicker wires, 1.5, 1.25, 1.0, 0.9 and 0.8 mm, are used for bows and arches. The middle range, 07 and 0.6 mm, are used for clasps and self-supporting springs. The thinner wires, 0.5, 0.4, 0.35 and 0.3 mm, are used for finger springs and springs wound on supports or heavy arches. The very fine wires, 0.25, 0.2 and 0.15 mm, are used for coil springs, usually working on a heavier arch or support of some kind.

Orthodontists have become familiar with the use of stainless steel alloys for appliance construction, accepting the material as supplied by the manufacturer without specifying the manner of preparation, composition or precise physical properties of the finished product, although Cutler (1932) described simple tests for evaluating the elasticity of wires and their resistance to breakage.

Stainless steel wires for orthodontic use are produced in three grades: very soft or fully annealed, hard, and a specially hard grade. The extra-hard grade may be called 'high tensile', 'spring hard', 'super hard', or some similar term to indicate a specially hard wire.

For the usual hard grades of orthodontic stainless steel wire tensile strength varies from 100 to 150 tons per sq. in. depending on the thickness of the wire, the higher values relating to the finer grades of wire. The wires originally produced in Britain and used for orthodontic appliance construction were designated 'hard' or 'hard drawn'. Today, with the availability of wires from a number of manufacturers and the introduction of specially hard wires for fixed appliance arches, it is necessary to specify the properties of the wires that should be used in removable orthodontic construction. The use of an incorrect grade of wire may render the construction of appliances unnecessarily difficult if the wires are too hard, or prevent an appliance from working properly if the wires are too soft.

The British Specification 3507:1962 specifies the properties of stainless steel wires and tapes for orthodontic use in regard to composition, size, tensile strength, resistance to failure on bending and finish. If the properties of wires intended for orthodontic use are known in terms of the British Specification, no difficulty should be experienced in procuring suitable materials for any given purpose.

Tensile strength and resistance to failure on bending are the most practical means of defining the working properties of orthodontic wires. Tensile strength may be stated in kg per mm^2, lb per $in.^2$ (U.S.A.) or tons per $in.^2$ The statement of tensile strength in tons per $in.^2$ gives a set of figures which is neat, concise and easy to remember (*Table* A.1).

Table A.1. Conversion table for tensile strength*

Description	Tensile strength		
	$lb/in.^2$ (U.S.A.)	$tons/in.^2$	kg/mm^2
Hard or hard drawn	224 000–246 400	100–110	157–173
	246 400–268 800	110–120	173–189
	268 800–291 200	120–130	189–205
	291 200–313 600	130–140	205–220
	313 600–336 000	140–150	220–236
High, tensile, spring hard, super hard	358 400 or more	160 or more	252 or more

* Extracts from British Standard 3507 :1962, 'Specification for Orthodontic Wire and Tape and Dental Ligature Wire made of Stainless Steel' are reproduced by permission of the British Standards Institution, 2 Park Street, London, W1, from whom copies of the complete standard may be purchased.

Wires having the tensile strengths shown in *Table* A.2 provide the most suitable properties for the construction of removable orthodontic appliances.

HEAT TREATMENT OF STAINLESS STEEL WIRES

The possibility of heat-treating stainless steel for orthodontic applications has been known since 1949 (Backofen and Gales, 1952). These authors and Funk (1951) have shown experimentally that 18/8 hard drawn stainless steel wires may be heat-treated

Table A.2. Tensile strength of stainless steel wires for orthodontic appliance construction*

Diameter (mm)	*Tensile strength* (tons/in.^{2})	*Application*
1·5 1·25	100–110	Bows and arches
1·0 0·9 0·8	110–120	Bows and arches
0·7 0·6 0·5	120–130	Clasps; Finger springs, Self-supporting springs
0·4 0·35 0·3	130–140	Springs supported on heavy arches
0·25 0·2 0·15	140–150	Twin-wire arch; Coil springs
0·4 0·45 0·5 0·55	160 or more	Arches for multiband appliances

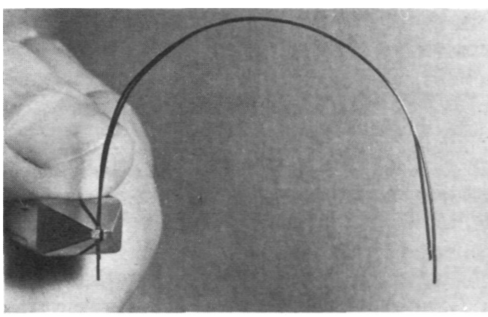
* Extracts from British Standard 3507 :1962, 'Specification for Orthodontic Wire and Tape and Dental Ligature Wire made of Stainless Steel' are reproduced by permission of the British Standards Institution, 2 Park Street, London, W1, from whom copies of the complete standard may be purchased.

after they have been formed into arches or loops. Heat treatment of wires before forming to the required shape does not enhance the physical properties. The effect of heat treating is shown in a simple way in *Fig.* A.l (Lager, 1963).

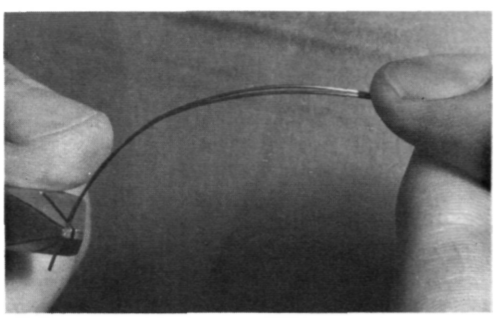
The Effects of Heat Treatment

Heat treatment does not enhance the physical properties of stainless steel wires to any appreciable extent, as these properties are mainly derived by work-hardening during the wire drawing or metal rolling processes.

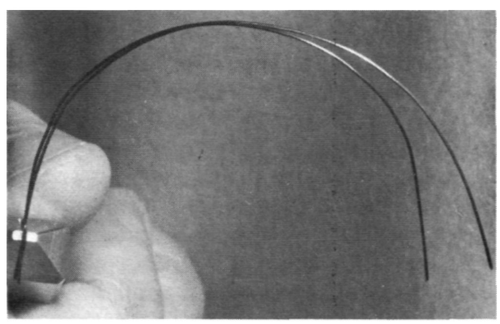
When such work-hardened wires are formed into arches or loops, however, further stresses occur at the points of bending, and it is these additional stresses that it is the purpose of heat treatment to remove. If this can be done without affecting the original physical properties of the material, arches and loops accept the new shape into which they have been bent, and resist deformation back towards their previous shape to a greater degree than they would if untreated.



A



B



C

Fig. A.1. *A,* Two plain arches of 0 5 mm hard wire have been formed. One has been heat-treated, the other has not. *B,* The archwires are held side by side in strong pliers and stroked once or twice with a straightening movement of the fingers and thumb. C, The heat-treated wire has resisted the straightening effect to a marked degree; the untreated wire has shown a tendency to return to its original shape before it was bent into arch form.

Such heat treatment is often referred to as 'stress-relief anneal'.

Applications of Stress-relieving Heat Treatment

The value of heat treatment for arch wires used in multiband orthodontic appliances will be obvious, and such treatment applied to wires of similar gauges used as finger springs and auxiliary springs for removable appliances will confer corresponding benefits. The relief of stress in any wire which has been bent, especially if the bend is sharp and exposed to forces which may later lead to fracture, would be of value in clinical practice.

In the construction of removable appliances, the hard stainless steel wires may be used without any after-treatment. This is not to say that if simple and effective methods of heat treatment were at hand, improvements in removable appliance construction could not be made.

The Heat Treatment Procedures for Orthodontic Wires

The obvious method for heat-treating wires is to place them in a temperature-controlled oven for a specified time. Backofen and Gales (1952) investigated the effect on stainless steel wires of heat treatment at 260 °C (500 °F) for 20 minutes and at 399 °C (750 °F) for 10 minutes, showing that the latter combination provides the better effect. These results do suggest, however, that a limitation on the use of the procedure is that it may not be convenient to heat-treat wires in an oven during the actual construction of an appliance because of the time involved.

An archwire may, however, be heat-treated almost instantly by passing an electric current through it. Provision for doing this is made on some orthodontic welders by means of two terminal blocks at which a potential of up to approximately 3-4 V is available. The voltage is controlled by means of transformer tappings and a multipoint switch. One of the archwires shown in *Fig.* A.l was treated by applying 2.5 V at the ends and carefully watching the colour of the wire. Within a matter of a few seconds the colour changed to a 'medium straw', at which moment the current was switched off and heat treatment was complete. For finer wires or arches having loops or coils, being therefore longer, a higher potential than 2.5 V would be required to overcome the electrical resistance and to cause the passage of a current adequate to generate the necessary heat.

The heat treatment of springs and clasps for removable appliance construction could be made a practical proposition by preforming these parts and 'soaking' them in a gas or electric oven for 10 minutes at 399 °C (750 °F). The effectiveness of the procedure in terms of improved resilience of the wires would need to be assessed largely in the light of clinical experience.

MILLIMETRES OR INCHES

The dimensions of orthodontic materials can be stated in thousandths of an inch or in millimetres. The standard wire gauge is rarely if ever used today in orthodontics. The choice of the British or the metric scale depends as a rule on custom and upbringing, but it is useful to understand the relationship between the two scales so that either may be used at will and measurements transposed from one scale to the other when required.

One metre is equal to 39-37 in., from which it follows that 1.0mm = 003937in. In *Table* A.3 the first column gives the sizes of wires commonly used in millimetres; the second column shows the sizes in inches correct to three decimal places.

If the approximation is accepted that for practical purposes 1.0mm = 0.040in. the conversion of millimetres to inches becomes even simpler and the calculations can be made mentally.

In the third column sizes of the wires are given as worked out from the approximation that 1.0 mm = 40 thousandths of an inch. The differences between these figures and

Table A.3. Wire and tape thickness in millimetres and equivalent thickness in inches

mm	*in.*	*thous of an inch*
1·5	0·059	60
1·25	0·049	50
1·0	0·039	40
0·9	0·035	36
0·8	0·032	32
0·7	0·028	28
0·65	0·026	26
0·6	0·024	24
0·55	0·022	22
0·5	0·020	20
0·45	0·018	18
0·4	0·016	16
0·35	0·014	14
0·3	0·012	12
0·25	0·010	10
0·2	0·008	8
0·15	0·006	6
0·1	0·004	4
0·05	0·002	2
0·025	0·001	1

the values correct to three decimal places are very slight and only occur in the heaviest gauges of wire.

Finally, it is useful to keep in mind when thinking of thicknesses of wire that for practical purposes:

1 mm = 40 thousandths of an inch.

1 thousandth of an inch = 0025 mm.

ACRYLIC RESINS

The acrylic resins, both heat-curing and self-curing, are used for the construction of baseplates and of the screens of functional appliances.

Heat-curing Acrylic Resins

Heat-curing resins give as a final product a dense, hard, colour-stable plate free from porosity and, if colourless polymer is used, a clear transparent material. The appliance must be preformed in wax and invested and the resin processed in the flask under heat and pressure.

A great deal of time and effort can be saved if the wax-up stage of the appliance and the process of investment are carefully done by following a few straightforward methods.

1. The wire parts of the appliance should be fixed to the dry dental cast with a minimum of pink wax, filling the spaces between the tags and the plaster.

2. The dental cast is then briefly dipped in water and surface wetness is allowed to dry. Pink wax flowed on to the cast will then adhere but can be trimmed and the excess picked cleanly off giving an accurate outline to the waxed-up appliance.

3. Wax is then applied to the cast as a single sheet sufficiently softened and pressed down to the upper model without thinning out the palate. In the lower arch, extra thickness is applied where necessary *(Fig. A.2, A, B).*

4. The wax is firmly pressed down around the teeth and trimmed to shape with a flat-ended plastic filling instrument. The wax is also trimmed around springs *(Fig. A.2, C).*

5. The edges of the wax around the teeth and springs are quickly flamed, pressed into accurate contact with the plaster and given a final trim, if necessary using a No. 12 probe around the coils of any springs *(Fig. A.2, D,E).*

6. When flasking the appliance, care should be taken to put plaster accurately around the springs and inside the coils. If an air bubble forms inside a coil, the resin which goes into it subsequently is not easy to remove without damaging the wire.

7. When processed, the appliance is deflasked and all plaster removed; it is only necessary to take away the flash using an acrylic bur and to polish the plate. If trimming to shape or thickness has to be done the appliance could not have been properly waxed up or invested or both. Dental burs should *never* be used to free spring coils or guides from the baseplate. If acrylic material has been allowed to encroach on such wires,

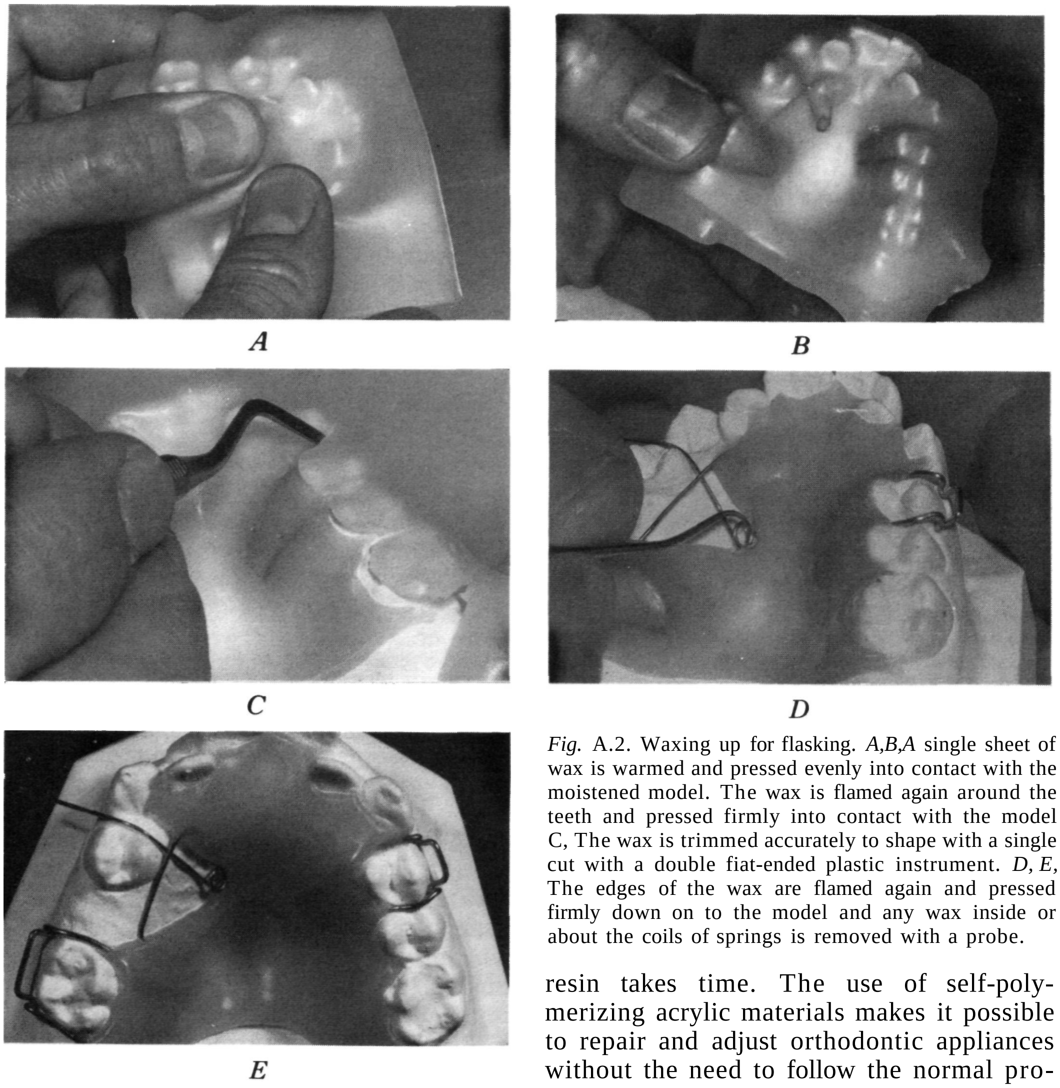


Fig. A.2. Waxing up for flasking. *A,B,A* single sheet of wax is warmed and pressed evenly into contact with the moistened model. The wax is flamed again around the teeth and pressed firmly into contact with the model C, The wax is trimmed accurately to shape with a single cut with a double fiat-ended plastic instrument. *D, E,* The edges of the wax are flamed again and pressed firmly down on to the model and any wax inside or about the coils of springs is removed with a probe.

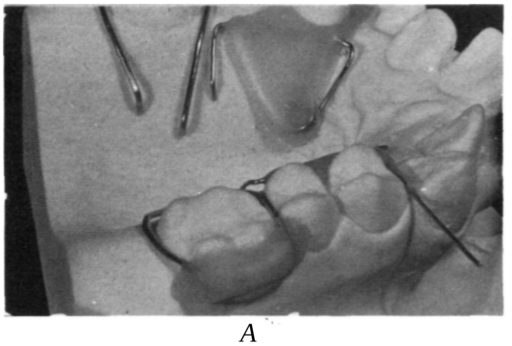
it should be carefully pared back with a sharp vulcanite chisel and the coil finally freed by placing a probe through the coil and rocking it just enough to free the wire from the embrace of the resin to allow the coil to act.

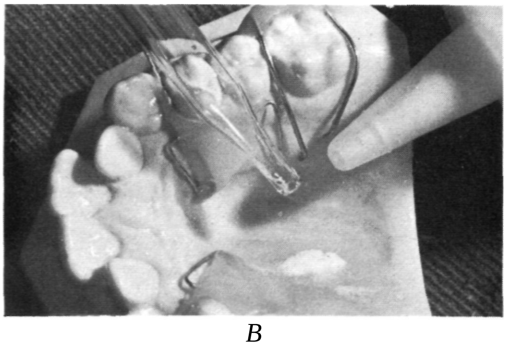
Self-curing Acrylic Materials

Even when the best methods of waxing, packing and finishing are used, the construction of appliances in heat-curing acrylic resin takes time. The use of self-polymerizing acrylic materials makes it possible to repair and adjust orthodontic appliances without the need to follow the normal procedure of waxing-up, flasking, packing and finishing in the laboratory. It is also possible, using this material, to construct complete appliances rapidly and conveniently (Hallett, 1952; Weber, 1960; Cousins, 1962).

Clasps, arches or springs are constructed in the usual way, and placed in position on the working model which has been previously coated with a film of the appropriate separating material. The clasps are secured in position with a little pink wax, attached on the buccal side, leaving clear the palatal or lingual area over which the baseplate must extend. Parts of springs which must not be bound up in the baseplate material are covered with pink wax, which will also help to hold them in place, and when the wax has set it is accurately trimmed to cover up only that part of the springs that must be left free in the finished appliance *(Fig.* A.3, *A).*

working model, setting can be accelerated by placing the completed appliance in warm water. The polymerizing of the material can be accelerated and porosity eliminated by applying warmth and pressure simultaneously in a hydraulic pressure flask. The appliance is removed from the model, trimmed to shape and polished in the usual way, care being taken to avoid overheating





A *B*

Fig. A.3. *A,* Clasps and springs are attached to the model with pink wax. For the springs, the pink wax serves to block out areas which do not need to be reproduced in acrylic material and also holds the wires in place. *B,* Liquid is dropped on with a dropper and the powder blown on from a soft polythene bottle. Note that the position of the model controls the flow of the acrylic mixture. One side of an appliance should be completed and have begun to set before the other is commenced. For the construction of the front part of the baseplate, the model is placed with the incisors downwards.

The self-curing acrylic material is then applied to the model. This may be done either by running or pressing on a thin mixture of the material, or the powder and liquid may be added separately, building up the thickness of the baseplate as may be required *(Fig. A.3,B).* In order to avoid the need for extensive carving of the baseplate after the acrylic material has hardened, care should be taken to see that excessive bulk does not accumulate in the vault of the palate in an upper model. This area is sometimes difficult to get at to trim and polish if the dental arch is narrow and the palatal vault relatively high. The movement of the soft material can be controlled by positioning the model and by constructing the baseplate in sections, thereby avoiding the difficulty of having material flowing from two directions into a central pool.

When the required area and thickness of the material have been applied to the on the lathe brush. It is sometimes claimed that appliances made in this way fit more accurately than appliances made with heat-curing acrylic, but it is very doubtful whether there is a significant difference in the fit of appliances made in one material or in the other.

The disadvantages associated with the use of self-curing acrylics are that the material may suffer from the drawbacks of difficulty in obtaining a high polish, a tendency to porosity and colour instability. These problems can be overcome to a great extent by processing the appliance by the hydraulic pressure flask technique. It is also sometimes found that the oral tissues are sensitive to these materials. Where speed is essential and large numbers of appliances are required regularly from a laboratory, the use of self-curing acrylic materials may be a valuable contribution to the treatment of patients.

Bibliography

Adams C. P. (1969) An investigation into indications for and the effects of the function regulator. *Trans. Europ. Orthod. Soc.* 293-312.

Adams C. P. (1983) Letter to the Editor. *Br. J. Orthodont.* 10, 167.

Andresen V. (1936) The Norwegian system of functional gnatho-orthopaedics. *Acta gnath. Kbh.* 1, No. 1.

Angle E. H. (1903-4) A masterpiece. (The sin of extraction for regulation purposes). *Commonwealth Dent. Rev.* I, 26.

Angle E. H. (1907) *Treatment of Malocclusion of the Teeth.* Philadelphia, The S.S. White Dental Manufacturing Company.

Angle E. H. (1910) Bone growing: a problem in orthodontic treatment. *Dent. Cosmos* LII, 261-267.

Backofen W. A. and Gales G. F. (1951) The low temperature heat treatment of stainless steel. *Angle Orthodont.* 21, 117-24.

Backofen W. A. and Gales G. F. (1952) Heat treating stainless steel for orthodontics. *Am. J. Orthod.* 38, 755-65.

Badcock J. H. (1911) The screw expansion plate. *Trans. Br. Soc. Orthod.* 3, 3—8.

Baker, H. A. (1904) Treatment of protruding and receding jaws by the use of inter-maxillary elastics. *Int. Dent. J.* 25, 344-56.

Bass N. M. (1975) Early treatment of skeletal II malocclusion involving preliminary incisor root torquing. *Trans. Europ. Orthod. Soc.* 191-200.

Begg P. R. (1965) *Begg Orthodontic Theory and Technique.* Philadelphia, W. B. Saunders. 3rd edition 1977, by Begg P. R. and Kesling P. C.

Bell R. D. (1932) Electric resistance spot welding. *Dent. Rec.* 52, 554-66.

Bjork A. (1963) Personal communication.

Charlier M. (1928) La technique des alliages inoxydables et celle de leur sourdure electrique. *Odontologie.* 67, 645-51.

Clark W. J. (1982) The twin block traction technique. *Europ. J. Orthod.* 4, 130-8.

Coffin W. H. (1881) A generalized treatment of irregularities. *Trans. Int. Congr. Med.* 7th Session. London, Aug., vol. Ill, 542-47.

De Coster L. (1931a) Une technique systematique d'appareillage orthodontique en acier inoxydable. *Province Dentaire.* 17, 201-22.

De Coster L. (1931b) The use of rustless steel in dentofacial orthopaedics. *Int. Orthod. Congr.* 2, 475-79; also in *Int. J. Orthod.* (1932) 18, 1191-5.

Cousins A. J. P. (1962) Removable appliance technique: the application of rapid cold-cure acrylic resin. *Dent. Practit.* 13, 29-32.

Crozat G. B. (1920) Possibilities and use of removable labiolingual spring appliances. *Int. J. Orthodontia.* 6, 1—7.

Cutler R. (1932) A new preparation of British stainless steel. *Trans. Br. Soc. Orthod.* pp. 10-15.

Duyzings J. A. C. (1954) *Orthodontische Apparatur,* Amsterdam, Dental-Depot A. M. Disselkoen, pp. 33, 35 and 37.

Eskert-Mobius A. (1953) Normale und pathologische Physiologie der Nasen und Mundatmung. *Dtsch. Zahn-, Mund- u. Kieferheilk.* 18, 346-78.

Eckert-Mobius A. (1962) Grenzprobleme der Zahn-mund- und Kieferheilkunde und der Hals-, Nasen- und Ohrenheilkunde aus rhinologischer Sicht. *Dtsch. Zahn-, Mund- u. Kieferheilk.* 37, 216-25.

Eckert-Mobius A. (1963) Grundsatzliches zur Atmung als rhinologisch-kieferorthopadisches Problem. *Acta Otolaryngol. (Stockh.)* Suppl. 183, 36-8.

Endicott C. L., Pedley V. G. and Grossmann W. (1947) Practical and theoretical observations on the Norwegian system. *Trans. Br. Soc. Orthod.* pp. 31-60.

Frankel R. (1964) Luftdruck, Atmung und die orofazialen Weichteile. *Dtsch. Zahn-, Mund- u. Kieferheilk.* 43, 367-74.

Frankel R. (1966) The theoretical concept underlying treatment with function correctors. *Trans. Europ. Orthod. Soc.* pp. 233-50.

Frankel R. (1966) *Funktionskieferothopadie und der Mundvorhof als apparative Basis.* Berlin, Verlag Volk und Gesundheit.

Friel E. S. (1933) The practical application of stainless steel in the construction of fixed orthodontic appliances. *Trans. Br. Soc. Orthod.* 23 pp.

Friel E. S. and McKeag H. T. A. (1939) The design and construction of fixed orthodontic appliances in stainless steel. *Dent. Rec.* 59, 359-90; also *Trans. Europ. Orthod. Soc.* (1938) 22, 53-84.

Funk A. C. (1951) Th heat treatment of stainless steel. *Angle Orthod.* 21, 129-38.

Grude R. (1938) The Norwegian system of orthodontic treatment. *Dent. Rec.* 58, 529-51.

Hallett G. E. M. (1952) Cold curing acrylic resin as an aid in orthodontics. *Br. Dent. J.* 92, 294-5.

Harvold E. P. (1974) *The Activator in Interceptive Orthodontics.* St. Louis, C. V. Mosby.

Harvold E. P. and Vargervik K. (1971) Morphogenetic response to activator treatment. *Am. J. Orthod.* 60, 478-9.

Haupl K., Grossmann W. J. and Clarkson P. (1952) *Textbook of Functional Jaw Orthopaedics.* London, Kimpton.

Hill C. V. (1954) Controlled tooth movement. Multiband round arch technique. *Dent. Practit.* 5, 2-13, 52-63.

Hopkin G. B. (1958) The rubber peg plate. *Trans. Br. Soc. Orthod.* pp. 86-87; also *Dent. Practit.* (1958) 9, 86-7.

Jackson V. H. (1904) *Orthodontia and Orthopedia of the Face.* Philadelphia, J. B. Lippincott.

Jackson V. H. (1906) Orthodontia. *Dent. Cosmos* 48, 278-84.

Johnson J. E. (1938) The twin-wire appliance. *Am. J. Orthod.* 24, 303-27.

Johnson J. E. (1941) The construction and manipulation of the twin-wire arch mechanism. *Am. J. Orthod.* 27, 289-307.

Johnson W. T. (1952) A friction fit attachment. *Trans. Br. Soc. Orthod.* 65-69; also *Dent. Rec.* (1953) 73, 326-30.

Korbitz A. (1914) *Kursus der systematischen Orthodontik,* 2nd ed. Leipzig, Verlag H. Licht.

Korkhaus G. (1960) Present orthodontic thought in Germany. Experiences with the Norwegian method of functional orthopaedics in the treatment of distocclusion. *Am. J. Orthod.* 46, 270-87.

Lager H. (1963) Personal communication.

Leech H. L. (1951) Appliances in the treatment of the collapsed lower arch. *Trans. Br. Soc. Orthod.* pp. 94-8.

McCallin S. G. (1954) Retraction of maxillary teeth with removable appliances using intermaxillary or extra-oral traction. *Dent. Rec.* 74, 36-41.

McCoy J. D. (1941) *Applied Orthodontics.* London, Kimpton.

McKeag H. T. A. (1921) Orthodontic education. *Trans. Br. Soc. Orthod.* 9-13.

McKeag H. T. A. (1928) Physical laws and the design of orthodontic appliances. *Trans. Br. Soc. Orthod.* pp. 69-87.

McKeag H. T. A. (1935) The teaching of appliance design in orthodontia. *Trans. Br. Soc. Orthod.* pp. 260-77.

Moss M. L. (1962) Cephalometric changes during functional appliance therapy. *Trans. Europ. Orthod. Soc.* pp. 327-41.

Nolteimier H. (1949) *Einfuhrung in die allgemeine Keifer- und Gesichtsorthopadie,* vols. I, II. Alfeld, Buchdruckerei P. Dobler.

Oliver O. A., Irish R. E. and Wood C. R. (1940) *Labiolingual Technique.* London, Kimpton.

Packham A. L. (1932) In Discussion on paper by Cutler R. (q.v.).

Parfitt G. J. and Friel F. S. (1946). Experimental welder design. *Trans. Br. Soc. Orthod.* 106-120; also *Dent. Rec.* (1947) 67, 250-9.

Porter L. J. (1941) Johnson twin arch technique. *Am. y. Orthod.* 27, 577-83.

Porter L. J. (1943) Johnson twin arch technique and special arch pulling vice. *Am. y. Orthod.* 29, 348-54.

Richardson A. and Adams C. P. (1963) An investigation into the short and long term effects of the anterior bite plane on the occlusal relationship and facial form. *Trans. Europ. Orthod. Soc.* 375-83.

Roberts G. H. (1956) A removable incisor retractor. *Dent. Practit.* 7, 220-1.

Robin P. (1902) Observations sur un nouvel appareil de redressement. *Rev. Stomat.*, Paris.

Rossi E. B. (1954) *Welding Engineering.* New York, McGraw-Hill.

Roux W. (1895) Funktionelle Anpassung. *Real-Encyclopaedie der gesamten Heilkunde,* Bd. 8. Vienna, Eulenberg.

Schwarz A. M. (1933) Tissue changes incidental to orthodontic tooth movement. *2nd Int. Orthod. Congr.* pp. 123-44. St Louis, Mosby.

Schwarz A. M. (1954) *Die Zahn-, Mund- und Kieferheilkunde.* Munich, Urban, pp. 450-7.

Schwarz A. M. (1956) *Lehrgand der Gebissnegelung,* Bd II. Munich, Urban.

Simon P. (1926) On the necessity of gnathostatic diagnosis in orthodontic practice. *Int. J. Orthod.* 12, 1102-13.

Softley J. W. (1953) Cephalometric changes in seven 'post-normal' cases treated by the Andresen method. *Dent. Rec.* 73, 485-94.

Strang R. H. W. (1950) *A Textbook of Orthodontia.* London, Kimpton.

Sved A. (1944) Changing the occlusal level and a new method of retention. *Am. J. Orthod. Oral Surg.* 30, 527-35.

Watkin H. G. (1933) Treated cases. *Trans. Br. Soc. Study Orthod.* 30 pp.

Watry F. M. (1947) A contribution to the history of physiotherapeutics in maxillofacial orthopedics. *Trans. Europ. Orthod. Soc.* 56—63.

Weber F. N. (1960) Personal communication.

White T. C, Gardiner J. H. and Leighton B. C. (1954) *Orthodontics for Dental Students.* London, Staples. 3rd edition, London, Macmillan, 1976.

Wild N. (1950) Design and behaviour of orthodontic springs. *Trans. Br. Soc. Orthodont.* 109-20.

Wilson H. E. (1953) Myofunctional appliances. *Dent. Practit.* 4, 70-8.

Index

The fifth edition of *The Design, Construction and Use of Removable Orthodontic Appliances* has been largely rewritten and offers an entirely new approach to the subject of orthodontic appliances.

Basic principles of all appliance types are discussed and compared to clarify and emphasise the place and role of removable appliances within the range of means that are available to the orthodontist for the management of dental irregularity and malocclusion.

A distinction is made between removable appliances or 'fixed plates' and functional appliances. Both systems are described in detail and their use in treatment is illustrated.

Technical methods required for removable appliance construction are given special consideration, together with a discussion of the materials and equipment involved, and a British specification of stainless steel wires is included.

The illustrations and diagrams are clear and give the maximum enlargement possible and the style is straightforward and uncluttered with jargon.

This book is excellent source material for the undergraduate and postgraduate student and a handy reference for practitioners and specialists in Orthodontics.

ISBN 0 7236 0713 3