THE PHYSICAL AND MECHANICAL ASPECTS OF ORTHODONTIC APPLIANCES

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Functional appliances

PHYSICS

Newton's Laws of Motion

These laws were first published in Latin, in 1687. The first law may be literally translated thus,

Every body continues in its state of rest or of uniform motion in a straight line, unless it is compelled to change that state by impressed force.

This means that if a body is at rest it will remain so unless some force acts on it, if in motion, the velocity of motion must continue uniform unless some force acts to increase it or diminish it.
Also the direction of motion must continue unchanged and therefore rectilinear unless some force causes it to be diverted.
This law therefore supplies us with a definition of force;

Force is that which produces or tends to produce, motion of change of motion.

Newton's second law of motion may be translated as follows:-

The change of motion (produced) is proportional to the impressed force producing it, and pursues the direction in which that force is impressed.

This law leads to a method of measuring forces.
If we change the velocity with which a mass is moving, we also change its momentum. Change in momentum will serve to measure force. It seems obvious that whatever change in momentum is produced by a force, twice the force will produce twice the change, etc. i.e. the change is directly proportional to the force.
For a given mass, m, change of momentum, mv, means change of velocity; the change of velocity per unit time is acceleration, a; the change in momentum per unit time is therefore ma. If we employ absolute units (poundals or dynes) this can be shown as;

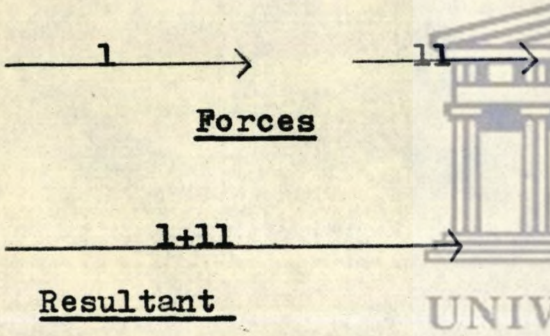
$$F = ma$$

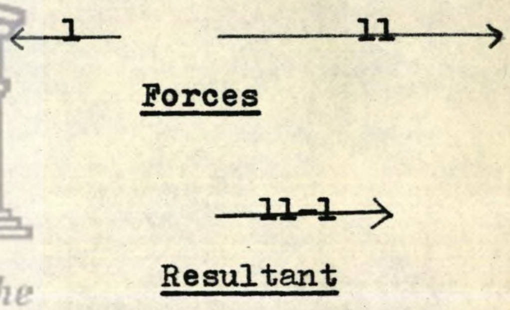
Newton's third law of motion states that 'to every action there is an equal and opposite reaction'. This law recognises the dual aspect of forces

If a tooth is pushed by a finger spring, the spring is also pushed by the tooth, and an equal counter force acts towards the spring until the biology of the system intervenes. This dual stress is called <u>pressure</u>.

Retracting incisors against posterior segments it is apparent that the reaction of the posterior segments must be equal and opposite to the incisors. In this case the two forces act away from each other, and to this dual stress we give the name <u>tension</u>.

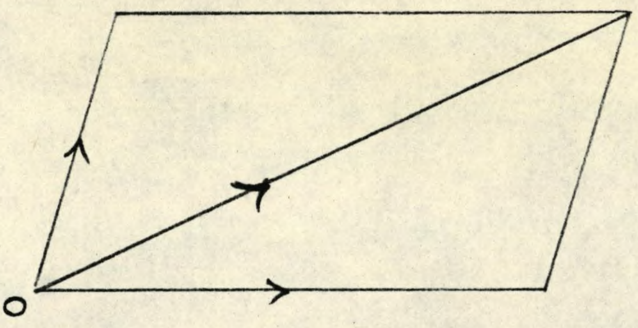
Composition and Resolution of Forces





When two forces act on a body we can often find a single force that will produce the same effect on the body as the two forces combined. This force is called the resultant, and the two forces are called its components. It should be fairly obvious that if the two forces act in the same straight line and in the same direction the resultant will be the sum of them, whereas if they act in opposite directions then the resultant will be equal to their difference and act in the direction of the greater.

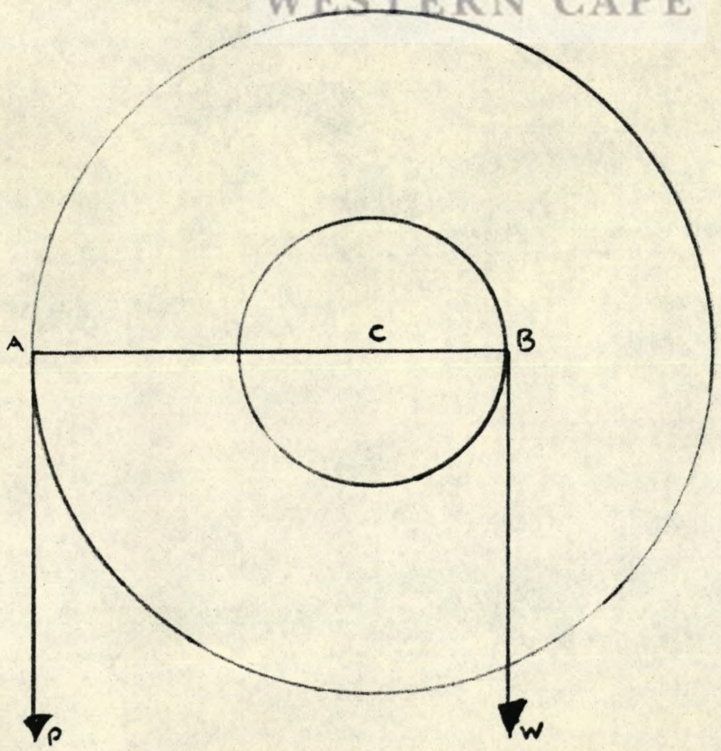
If however the two forces are inclined to each other and meet at a point O then the resultant may be found by means of the parallelogram of forces.



Half of this parallelogram forms a triangle which is composed of the two force representations and their antiresultant(that force which will completely counteract the two forces).This triangle thus represents any three concurrent forces that are in equilibrium,the converse is also true ; if three concurrent forces can be so repesented they are in equilibrium.This is the proposition known as the Triangle of Forces.

Moments

A lever rotates around its fulcrum.In this illustration it is a rigid rod represented by AB with fulcrum C.



The segments AC and BC are called the arms of the lever.

P and W are forces applied at A and B respectively.
The power of a force to produce rotation depends upon,

1.the magnitude of the force

2.the perpendicular distancebetween the line of action of the force and the point or line about which rotation takes place.

This power is called the moment of the force about the turning point .It is measured by the product of 1. and 2. above.
Thus in the above diagram the moment of P is P x CA and the moment of W is W x CB.They tend to produce rotation around C in opposite directions.

Couples

WHen two forces are parallel as are P and W in the above diagram the magnitude of the resultant is the algebraic sum of the forces,the direction of the resultant is parallel to that of the forces and passes through a point C.
When the two parallel forces are equal and unlike there algebraic sum is zero ,they therefore have no resultant to produce translation and can only produce rotation.Two such forces constitute a couple,The perpendicular intercepted between them is the arm of the couple.The product of one force and the arm is the moment of the couple about that point.
Derotation of teeth and uprighting procedures employ the concept of couples.

Biomechanics

When a force is applied to the crown of a tooth it is displaced within the confines of the periodontal space.This small displacement sets up areas of tension and compression within the periodontal ligament and provided that the force is applied for a sufficient period of time and is of a certain magnitude the bony socket remodels and the tooth moves. Depending on the type of force or system of forces applied to the tooth ,the tooth may be tipped,rotated or moved bodily.

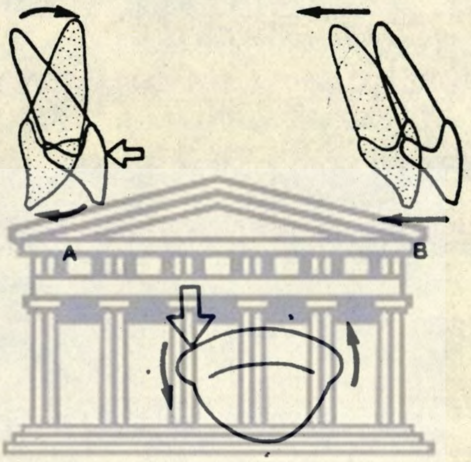


Fig. 10. Three kinds of tooth movement: *a*, Tipping. *b*, Bodily movement. *c*, Rotation about the long axis.

The rationale of orthodontic treatment is based on this area of knowledge.

Tooth Movements

When a force is applied to a smooth surface it can be resolved into two components,one of which is perpendicular to the surface and the other parallel to the surface.Now, if this surface is curved,as in a tooth,the force is resolved perpendicular to and parallel to the tangent at the point of contact.If the force is applied at an angle to the surface,tooth movement will be produced by the perpendicular component.Thus the tooth will not move in the direction of the applied force.

Tipping

A force applied at a single point on the crown of a tooth will produce a tipping motion about a fulcrum.Christiansen and Burstone (1969) showed that this centre of rotation is

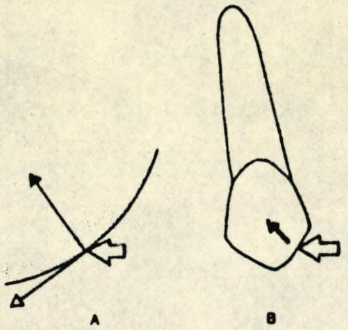


Fig. 11. *a*, When a force is applied to a curved surface, the direction of the resultant movement is at right angles to the tangent at the point of contact. *b*, A partially erupted tooth will be intruded if a spring is applied to the cuspal incline.

about 40% of the length of the root from the apex. From this it is obvious that the crown and apex of the tooth move in opposite directions.

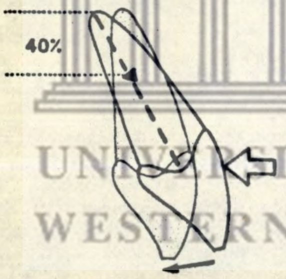
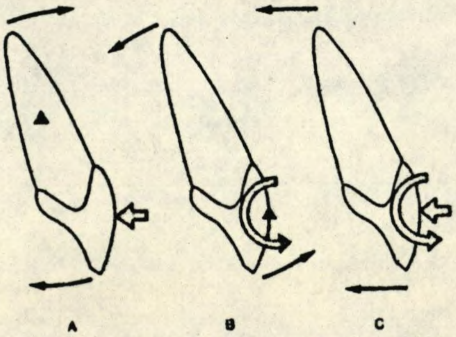


Fig. 12. When a tooth is tipped with a removable appliance, the fulcrum of rotation is approximately 40 per cent of the length of the root from the apex.

Bodily Movements

It is not possible to move a tooth bodily using a single force. The force system must consist of a couple which allows control of the fulcrum



. Bodily movement of teeth: *a*, A force applied at a single point on the crown results in tipping. *b*, A force couple applied to a crown will cause rotation of the tooth about a fulcrum. *c*, An appropriate combination of a force couple and a palatally directed force will give bodily tooth movement.

Bodily movement of teeth is not normally within the scope of removable appliances but is capable of being produced by fixed appliances.

Movements in the Plane of Occlusion

An example of this type of movement is the retraction of an upper canine.The tooth will move in the direction of the component of force at right angles to its surface.With removable appliances it is not uncommon to find that the spring is positioned too far posteriorly so that the resultant force does not lie in the required direction of tooth movement.In this case the tooth will be moved buccally and distally

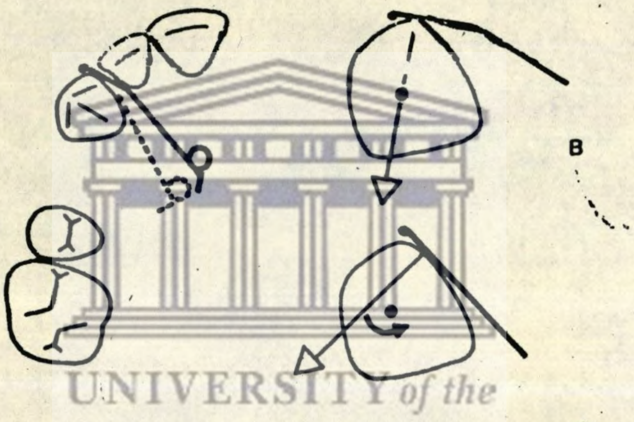


Fig. 15. Application of force to the crown of a tooth: *a*, If a palatal cantilever spring is positioned too far distally, the tooth will be moved buccally. Correct position is shown by the solid line. *b*, Correct application of a palatal finger spring to a canine. *c*, Incorrect application results in unwanted rotation of the canine.

Rotations

As for bodily movement rotations can only be produced by application of a couple.This is a movement that is much easier to perform with a fixed appliance than removable , however if the tooth has a broad mesio-distal dimension a couple can be applied by two separate forces in opposite directions at opposite ends of the mesio-distal width.Thus a central incisor may be derotated easier than a narrower tooth such as a lateral incisor.

METALLURGY

Plain Carbon Steels

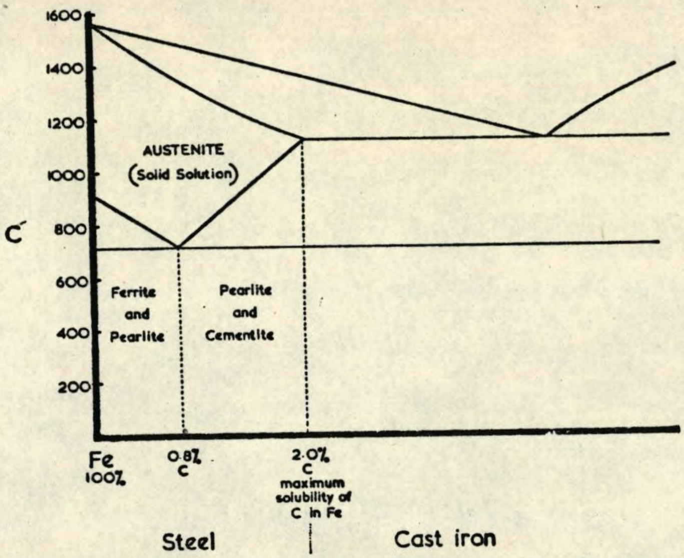


Figure 31. Simplified thermal diagram for alloys between iron and low percentages of carbon.

The above figure is an equilibrium diagram of alloys between iron and carbon.It shows that carbon is soluble in the high temperature form of iron up to a maximum of 2% forming an interstitial solid solution known as austenite.On cooling the solubility of carbon reduces with temperature until at 723°C the austenite contains 0.8% carbon.At this temperature the solid solution austenite breaks down to form a mixture of two compounds ,ferrite (contains virtually no carbon) and cementite (carbon rich).

If this austenite is cooled rapidly we may expect it to retain its solid solution grain structure,however it is impossible to cool a plain carbon steel to retain the austenitic structure. There may be insufficient time for the formation of the equilibrium phases ferrite and cementite and a form called martensite may result .This martensite is very hard but may be brittle. In the quenched condition the modulus of elasticity of a steel is very high and its hardness and strength are maximal.The steel must be softened slightly so that it will deform elastically and absorb the energy applied to it without fracture.The adjustment of hardness is called tempering and consists of heating the steel to a relatively low temperature holding it at this temperature for a period of time ,then cooling it rapidly.

Chromium Steels

When the chromium content of a steel exceeds 11% the alloy is commonly defined as stainless steel. These steels resist tarnish and corrosion primarily because of the passivating effect of the chromium, i.e. a very thin transparent but tough and impervious oxide layer forms on the surface of the alloy when it is subjected to an oxidizing atmosphere as mild as clean air.The oxide layer prevents tarnish and corrosion.If the oxide layer ,which may be Cr_2O_3 or $FeO.Cr_2O_3$,is ruptured by mechanical or chemical means,a loss against corrosion results.

There are essentially three types of stainless steel,ferritic austenitic and martensitic.

Table 38-1. *Composition (Percentages) of the Three Basic Types of Stainless Steel*

Type (space lattice)	Cr	Ni	C
Ferritic (bcc)	11.5–27	0	0.2 max.
Austenitic (fcc)	16–26	7–22	0.25 max.
Martensitic (bct)	11.5–17	0–2.5	0.15–1.20

Si, P, S, Mn, Ta, Ti, and Cb may also be present in small amounts. The balance is iron.

The austenitic stainless steel alloys are the most corrosion resistant of the stainless steels.

AISI 302 is the basic type,containing 18% chromium,8% nickel and 0.15% carbon.Type 304 has a similar composition, the chief difference being that the carbon content is limited to 0.08% .Both of these types may be designated 18-8 stainless steels and are the types most commonly used in orthodontics for bands and wires.

The 18-8 stainless steels may lose their corrosion resistance if they are heated to between 400°and 900°C,the exact temperature depends on the carbon content.(These temperatures are well within those used routinely by orthodontists)

The reason for a decrease in corrosion resistance is the precipitation of chromium carbide at the grain boundaries at the high temperatures.The small,rapidly diffusing carbon atoms migrate to the grain boundaries from all parts of the crystal to combine with the large,slowly diffusing chromium atoms at the periphery of the grain where the energy is highest.Because the portion of the grain adjacent to the grain boundary is the portion that is generally 'robbed' of chromium to form the carbide,an intergranular corrosion occurs which may lead to partial disintegration of the metal, which results in a general weakening of the structure.

If stainless steel is severely cold worked,the carbides precipitate along the slip planes.As a result,the distribution of the areas deficient in chromium is less localized so that the resistance to corrosion is greater than when only the grain boundaries are involved.Such a method is relied upon in orthodontics.

Any surface roughness may be a potential source of tarnish or corrosion,therefore orthodontic appliances should be polished ,not only for the patients' comfort ,but also so that it remains cleaner and freeer from corrosion during use.

A common cause of stainless steel corrosion is the incorporation of bits of carbon steel in its surface.Thus if a stainless steel wire is carelessly manipulated by carbon steel pliers ,it is possible that some of the steel from the pliers may embed in the stainless steel.Such a situation results in an electric couple which may cause considerable corrosion.

Slip and Dislocation

On permanent deformation,one layer of atoms moves over the surface of another thus taking up a new relationship with opposing atoms.This movement is called slip. The plane along which it occurs is called a slip plane.

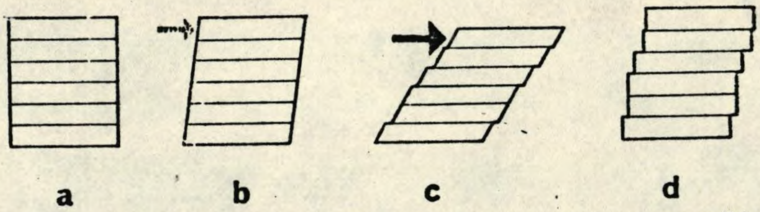


Figure 19. Deformation of metal by slip. (a) Metal unstressed showing possible slip planes. (b) Elastic deformation. (c) Deformation under greater stress. (d) Permanent deformation remaining after removal of stress.

Metal crystals usually show lattice imperfections and the planes of atoms are not all complete.An incomplete plane is known as a dislocation.Slip takes place by propagation of a dislocation along a slip plane.

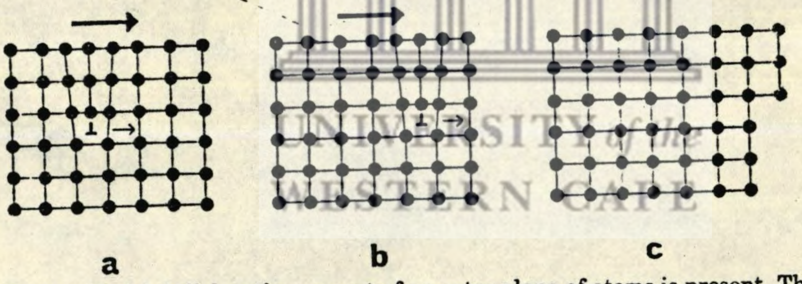


Figure 20. (a) A dislocation or part of an extra plane of atoms is present. The dislocation is indicated by the sign: ⊥. (b) Propagation of this dislocation due to a shear stress. (c) Resultant change in shape.

Cold Work and Strain Hardening

If shaping of a metal is carried out at relatively low temperatures,it is called cold work. During cold working the metal is deformed plastically ,it becomes stronger and harder and is said to show work or strain hardening.Cold work increases elasticity and reduces plasticity. During cold work there is a large increase in the number of dislocations present and strain hardening can be largely accounted for by the interaction of dislocations with one another,which resists further motion of the dislocations,thus more energy is required before further slip can occur.

The drawing of a wire is cold working and the direction of the grain elongation is the same as the direction of working,this is why wire has such excellent elastic properties when subjected to bending or stretching forces.

Although cold worked metals have increased mechanical strength and elasticity, they have poorer ductility and malleability than unstrained metals and may fracture if further attempts are made to alter their shape.

Stress Relief Anneal

In cold worked metal the increased strength and hardness are associated with a distortion of the crystal structure and the setting up of internal stresses which arise due to different parts of the metal having been deformed to different extents.Further adjustment brings forth the problem of fracture.By a stress relief anneal,sufficient heat energy is applied to allow the dislocations to group into lower energy configurations so that a small amount of further cold work may be carried out.This process of cold work and annealling can be continued until the desired shape is achieved..The grain size is reduced by annealling thus providing a method of refining the grain structure.

The annealling temperature is not constant for a given metal but depends on the amount of cold work that has been carried out.The greater the cold work the lower the annealling temperature.

For an 18-8 stainless steel wire the effect of stress relief annealing is to increase yield strength and modulus of resilience and modulus of elasticity.

If a wire is bent into tight loops of 180° the measured increase in elastic strength may be as great as 50%.The explanation for this is the release of residual stress.

Backofen and Gales (1952) reported a slight increase in the modulus of elasticity following heat treatment of a stainless steel wire either straight or looped ,when heated to 370°C for 5 to 15minutes .

Phillips(1973) reported that nickel-chromium and cobalt-nickel-chromium wires are more responsive to low temperature heat treatment than stainless steels

Eleven minutes at 370°C gives maximum proportional limit for a severely cold worked appliane

Heat treatment of stainless steel wire in orthodontics allows the removal of stresses thus increasing the wire resiliemce and also it helps to prevent creep of the wire ,which occurs in time ,in an attempt to reassume its former straight line configuration.

Backofen and Gales (1951) compared various temperatures for varying times and found that 20minutes at 500°C and 10 minutes at 750°c were adequate for reproducible heat treatment results.

Anderson (1972) states that there is a danger of spontaneous cracking if a cold worked wire is placed in a hot furnace, due to stress relief.He advocates placing the wire in the furnace while it is still cool.

Soldering

Soldering is the melting of an alloy between the two or more metals to be joined.When the solder solidifies it joins the pieces of metal together.

Solders are divided into two types,soft and hard.Soft solders are alloys of lead and tin .These only have a limited use in dentistry.

Pure tin is used as a low fusing solder for stainless steel.

Hard solders are used to join parts of appliances for the mouth These can be precious metal or silver solders.

When a solder is melted between two pieces of metal it may alloy slightly with their surface layers,thus the atoms of the metals being soldered become continuous with the atoms of the solder.To give a good joint,the surface must be clean and free from oxide coating at the moment the solder is molten.The chemicals used to prevent or remove the oxide film are called fluxes.

A flux for hard soldering stainless steel or Nichrome must contain a fluoride.Mixtures of borax or boric acid with potassium fluoride or acid potassium fluoride are suitable.

If the application of the flux is left until the metals are hot,some patches of oxide may still remain despite the flux and a weak joint will result.

On overheating,borax forms beads of metallic borates which are difficult to remove from the metal surface after soldering.Therefore care must be taken to prevent overheating the flux.

Graphite,whitening or rouge can be used to restrict the flow of the solder on clean metal surfaces.These are called atifluxes when employed for this purpose.

The melting point of the solder should be fairly close to the melting point of the alloys being soldered to create good conditions for the alloying of the solder and the metals being joined.Anderson(1972) suggests 50-100°C as a safety margin in the melting point differences.

Overheating the solder will create a bad joint by oxidizing the lower melting point metals thus causing porosity.

Molten solder flows from cooler places to hotter areas thus it will follow the flame and allow a little control of its movement.

The strength of most solders is less than that of the metals they join, since solder is not formulated for its strength but rather for its melting point and corrosion resistance, also it is a cast metal. It has been shown, however, that the strength of a soldered joint is greater than the strength of the solder itself. This is probably due to a change in the composition of the solder due to the slight alloying between itself and the metal surfaces being joined.
If heating is prolonged during soldering then a deeper alloying takes place which weakens the joint.

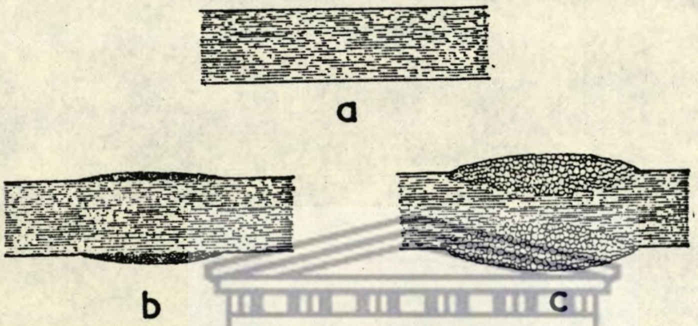


Figure 34. Effect of soldering time. (a) Fibrous wire structure. (b) Solder applied quickly. (c) Soldering time too long.

For soldering stainless steel the melting point of the solder used must be below 700°C since above this temperature chromium carbide is precipitated within the grain boundaries of the steel thus lowering its corrosion resistance. Annealing takes place above this temperature also, and the wrought metal will lose its excellent cold worked properties.

Gold solders may be used to join stainless steel but to produce an alloy with a sufficiently low fusion temperature requires that the proportion of gold be reduced below 45% which gives an alloy with very poor corrosion resistance. High silver content solders can be used for joining stainless steel but their fusion temperature is quite high. A solder containing less silver and which fuses at a lower temperature is known as a turbine solder.

	Silver solder	*Turbine solder*
Silver	63 per cent	45 per cent
Copper	27 per cent	25 per cent
Zinc	10 per cent	15 per cent
Cadmium	—	15 per cent
Melting range	700–730°C	580–660°C

The elongation of silver solders is usually between 10 and 15% allowing adjustment of the appliance close to the joint without fear of fracture.

During clinical use, a soldered joint of stainless steel or Nichrome wire tends to undergo crevicular corrosion at the edge of the solder.

Spot Welding

In spot welding ,the two pieces of metal to be joined are pressed together at one point by two electrodes, one on each side of the proposed joint.An electric current of high amperage is passed through the electrodes and through the metal.This current generates sufficient heat in the small area through which it passes to cause partial fusion of the metal surfaces.

The electrodes are made of copper-chromium or copper-beryllium alloy and have pointed ends which act to concentrate the current.

Many spot welds are necessary to produce a fairly strong joint.

The resistance of the metals to be joined and their heat conductivity play an important part in spot welding.The metals which conduct heat and electricity easily do notweld satisfactorily as less heat is produced and this tends to be dissapated through too large an area of metal.

Stainless steel and Nichrome are satisfactory alloys for spot welding.

The current necessary to spot weld varies with the thickness of metal to be joined.Currents up to 5000 amperes are employed.This current is produced by a step down transformer which reduces the mains voltage to 2-6 volts.

If too little current is passed,a very weak weld results which can be broken easily.Such a tack weld is useful for checking the relationship of the parts before joining them permanently.

Too large a current willfuse the metal between the electrodes completely ,and the pressure applied will squash the molten metal to a very thin section.Such a weld will break easily when bent.

The disadvantage of spot welding lies in the effect of the heat generated on the properties of the metal.At each welded joint this heat will cause some recrystallization of the grain structure.This reduces the strength at the place where strength is required.

At the centre of each spot weld on stainless steel the metal is heated to a temperature above 900°C.No weld decay occurs in this area,but there is a surrounding ring of metal which has been heated to within the range of temperatures at which weld decay may occur.

Electrolytic Polishing

If a rough metal surface is the anode in a bath of strongly acid electrolyte,a current passing between it and a non reacting cathode will cause the anode to ionize and thus lose a surface film of metal.With a suitable electrolyte and the correct current density the first products of electrolysis will collect in the hollows and irregularities of the rough metal surface and so prevent further attack of these areas.The prominent areas of the metal surface will continue to be dissolved therefore the contours of the surface will be smoothed.

The electrolyte usually consists of a mixture of sulphuric and phosphoric acids together with water.A current density of about lamp per square mm. is passed for a few minutes at room temperature with a voltage of 4-10 volts.The cathode gases due to the release of hydrogen and the solution rises in temperature.

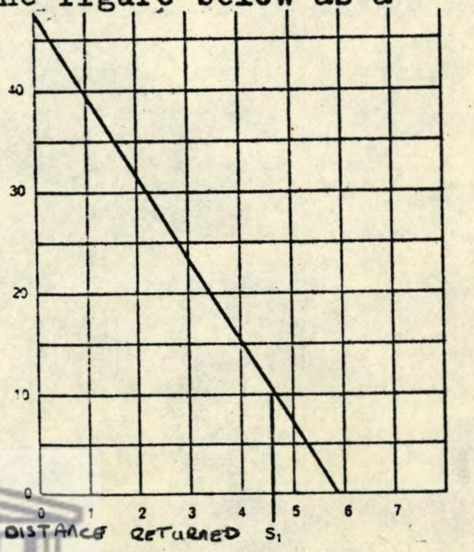
If the current density is too low the metal surface will become etched

This process is invaluable for giving a bright surface to complicated orthodontic appliances,and may also be used for reducing the section of stainless steel wires.

MECHANICS IN ORTHODONTICS

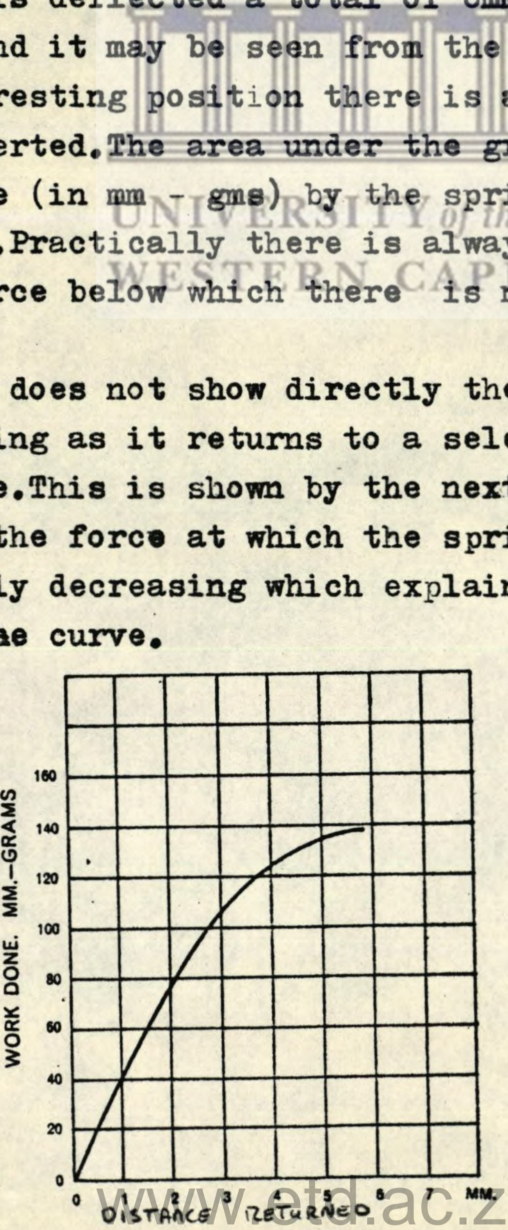
The Cantiliver Beam

This is the simplest type of beam and is useful in orthodontics because it can perform work over an extended period,thus although it is termed a beam from an engineering point of view ,in orthodontics it is regarded as a spring.A model of this is shown in the figure below as a wire protruding from a fixed block.



If this spring is deflected a total of 6mm. it is the same as activating it and it may be seen from the graph that as it returns to its resting position there is a linear reduction in the force exerted.The area under the graph is proportional to the work done (in mm - gms) by the spring in returning to a rest position.Practically there is always a minimum or threshold force below which there is no useful work performed,(S_1).

The above graph does not show directly the amount of work done by the spring as it returns to a selected point along the deflection scale.This is shown by the next graph ,the slope of which shows the force at which the spring was working.The force is steadily decreasing which explains the tailing off at the top of the curve.



If the vertical scale is now altered on the graph to show the percentage of total work done by the spring we can see that the last 30% of return travel performs less than 10% of the total work.This suggests that the spring must be deflected or activated,more for it to provide more work.It is apparent that there is a limit to the amount of activation possible determined by the wire properties.

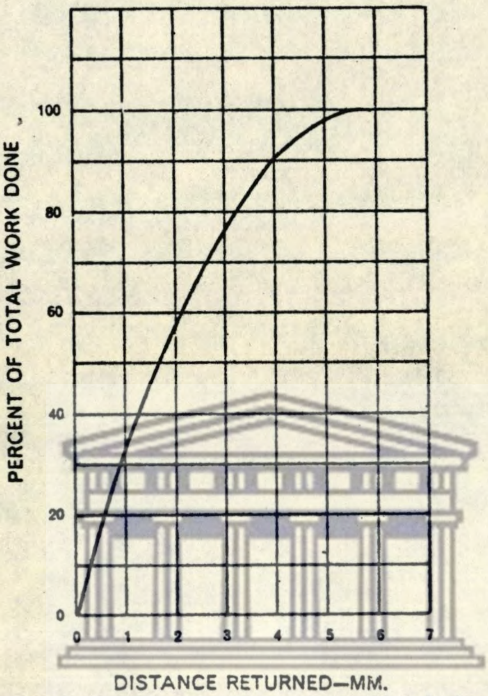


Fig. 18. Characteristics of the cantilever beam. Percent of work done vs. distance returned.

It must be borne in mind that there is always a reciprocal action resulting from the force applied to a body i.e. in the case of a spring on a removable orthodontic appliance the spring tends to move a tooth, but the reciprocal force which is equal and opposite (Newton's third law) tends to move the appliance in the opposite direction,it is counteracted by anchorage considerations.

To illustrate this idea let us deviate from the pure cantiliver beam and consider a reflex rotation lever illustrated below.

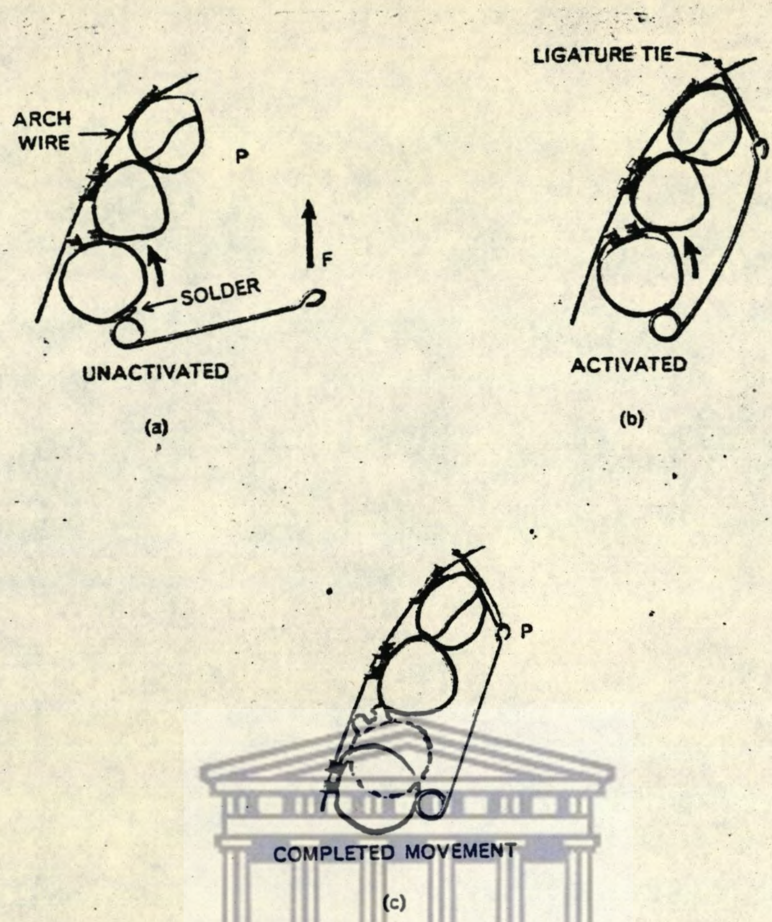
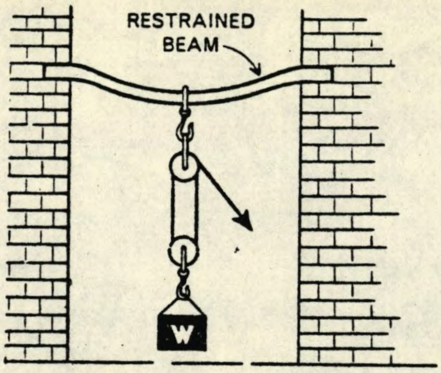


Fig. 19. Demonstration of a reflex rotation lever.

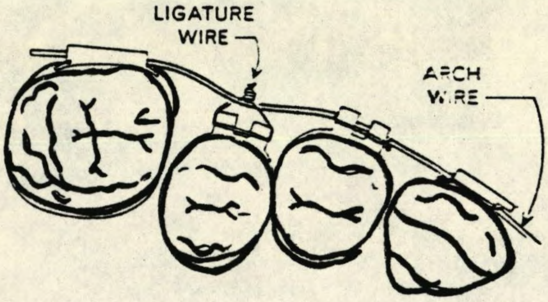
The action of this reflex rotation lever is to rotate the premolar and move it buccally .It should be noted that the lever is attached to the archwire and not another single tooth because a single tooth could not have resisted the reciprocal force and would have moved lingually somewhat instead of the desired full rotation of the premolar thus reducing the efficiency of the system.

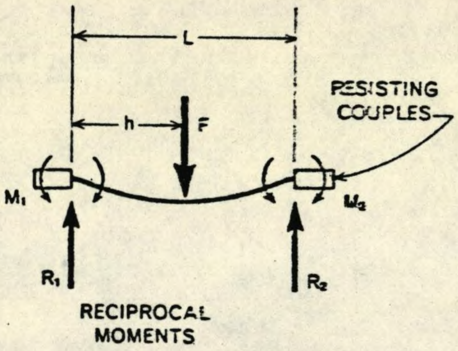
A spring wire develops a force at one end and a moment at the other end i.e.if one end provides the working force then the other end develops the working moment.

The Restrained beam

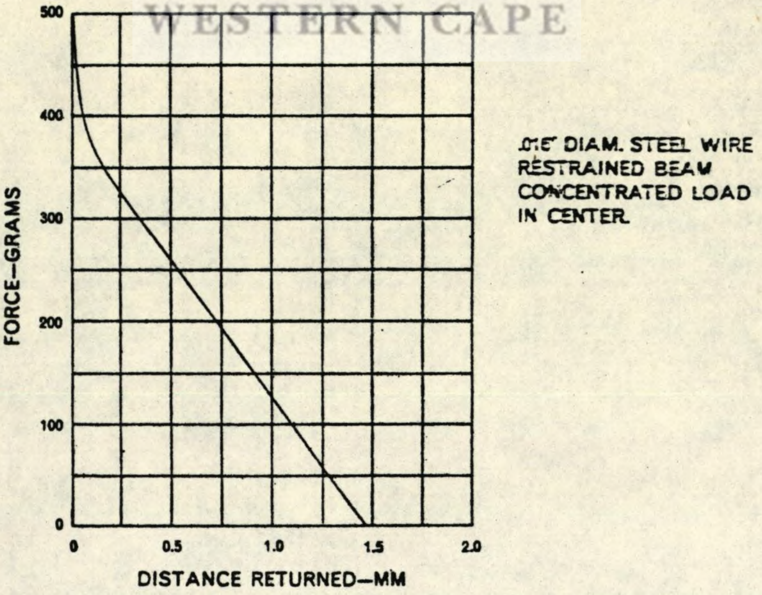


This beam arrangement is used often in orthodontics .An example of its use is in pulling a lingually tipped tooth buccally by tying it to an archwire.The tooth forms the load that stresses or activates the archwire.





The above figure shows a vector diagram of the restrained beam. If a force of 500gms (F) is applied at the centre of this beam (say ,L=20 and h=10), the initial deflection from the relaxed state is about 1.7 mm. If the beam (spring) is now allowed to relax the force that it can exert is decreased rapidly at first and then more slowly but linearly until zero. The total distance that it returns is only 1.45mm. indicating a set of 0.25mm.



. Force vs. distance characteristic of restrained beam.

This permanent deformation and non linear characteristic show that the spring was overloaded assuming that there was no preexisting deformation in the wire.To prevent this excessive stressing the force applied should have been to a maximum of 350 gms.

By comparing the'force to distance returned'graphs it is obvious that although the restrained beam has a much smaller working distance than the cantilever type ,the force supplied,and therefore the amount of work done,is much greater.

It may have been expected that the two adjacent teeth supporting the restrained beam should have started to rotate due to the reciprocal moments,however as soon as they show signs of rotation the adjacent segments of the archwire exert a resisting moment which takes some of the force off the adjacent teeth.

Let us consider the reaction force R_1 .

It is affected by the two resisting moments and by the force applied (F)

$$R_1 = \frac{Mi - M_2 + F(L-h)}{L}$$

This reaction force and the resisting moment increase as h becomes less than L/2.

R_2 and M_2 increase if h becomes greater than L/2.

i.e.

$$M_1 = \frac{Fh(L-h)^2}{L^2} \text{ gm.-mm.}$$

$$M_2 = \frac{Fh^2(L-h)}{L^2} \text{ gm.-mm.}$$

These may be substituted in the top equation to solve for the reaction force at the left hand support.

The turning moment ,Mi, at the left hand support can be calculated. Assume F=200gms.,L=20 mm.,h=6mm.Then Mi =588gm-mm.This is a substantial turning moment the value of which may come as a surprise to orthodontists who often use this type of structure.

The Simple Loop

This loop may be used to separate teeth or to close spaces between them.

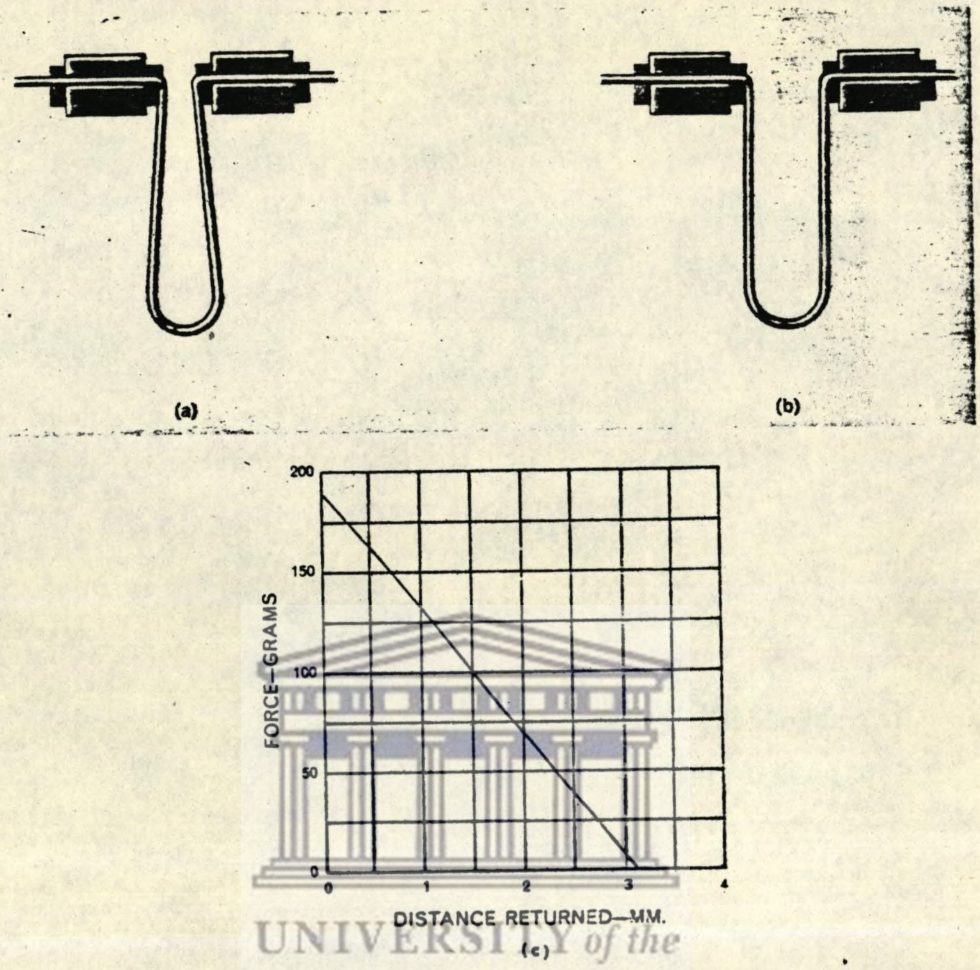
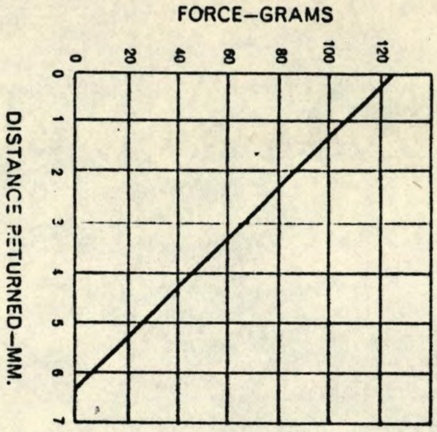


Illustration showing the simple loop restrained by bracket engagement. a, Activated loop. b, Deactivated loop. c, Force vs. distance characteristic for this loop.

The above diagrams show a simple loop activated, deactivated and a graph of force decay. It is evident from the graph that the force decay is approximately 61 gms./mm.
This loop is a restrained loop, that is it is tied into brackets on the teeth it is to move. The restraint maintains the lateral arms in a colinear relationship throughout its working range.
An unrestrained loop made of the same material using the same dimensions has a working range of more than twice the restrained

loop and a force decay rate of one third .



This simple loop is symmetrical and pushes with equal force against both teeth.When the two legs are equal ,the tipping couples applied to the brackets are equal.Thus either side may be regarded as the working side or the reciprocal side.

Let us now consider this loop in a slightly modified state as a device for closing spaces between teeth.

The force decay rate is about 41.5gms./mm.This loop is not as stiff as the previous loop used to separate teeth which had a force decay rate of 61gms/mm.Thus it can be seen that the opening loop requires about 47% more change in force to cause a given deflection than the closing loop with the crossed arms.

In both opening and closing loops the wire was working as the loop expanded.The wire works best as it tries to straighten itself back to its original flat piece of wire.

It should be noted that this statement is true for wire that has not been heat treated.If the wire has been heat treated then it will tend to return to the shape in which it was formed on heat treating and not back to a flat wire.

The loop with the crossed arms had more wire incorporated in it than the opening loop which shows that if we want to increase the range of motion of a loop or make it more flexible then more wire must be incorporated in it.

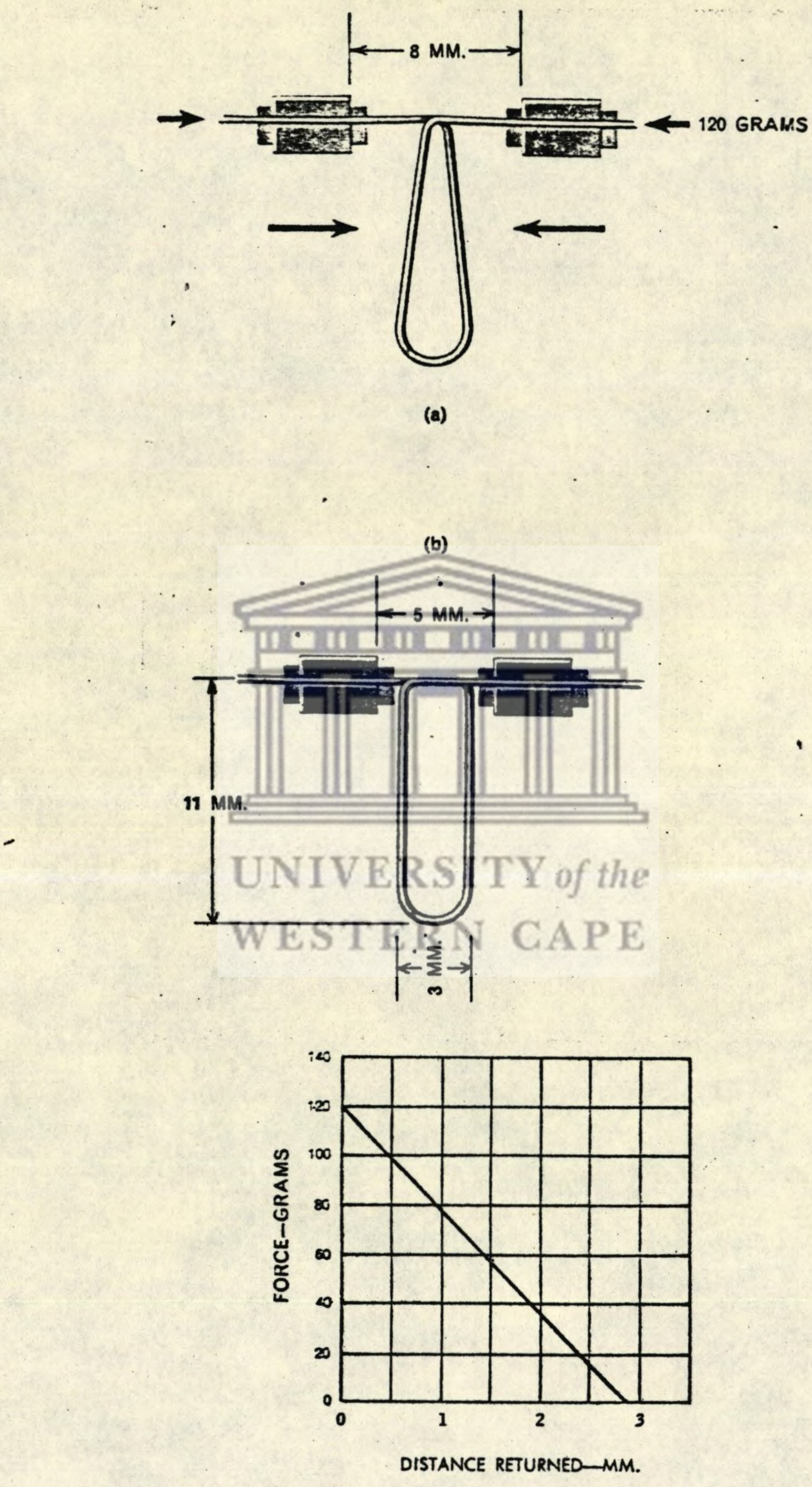
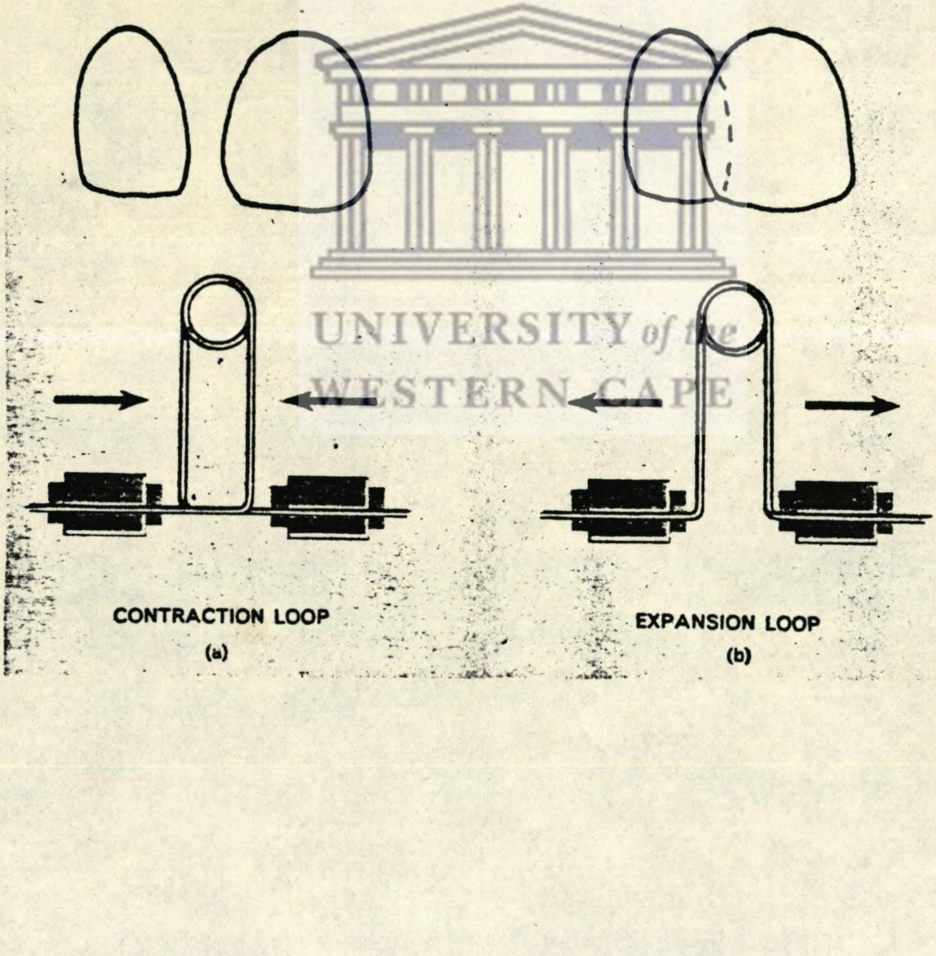


Fig. 27. Simple contraction loop with restrained ends. a, Activated loop. b, Deactivated loop. c, Force vs. distance characteristic.

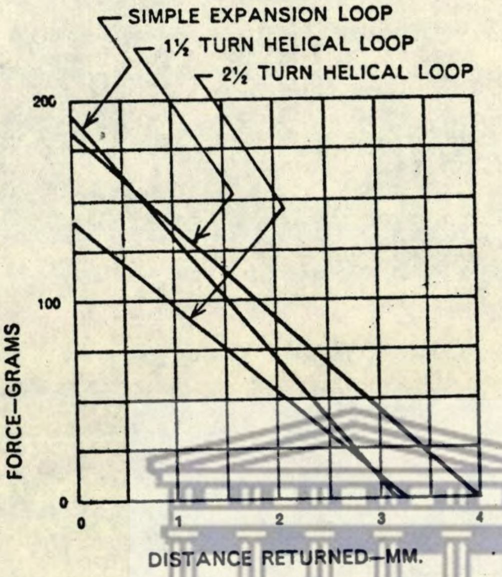
The Helical Loop

If we try to incorporate more wire into a loop by increasing the length of the legs then there is a definite limitation due to the size of the oral vestibule.An alternative is to incorporate the extra wire at the reflex point of the loop by making a helix there.This type of loop can have 1½ or 2½ turns in the helix.The initial force developed when such a loop is activated is less than that from a loop made from less wire ,but the force decay rate is always less from the more resilient loop and so its range of action is greater.



. Helical expansion and contraction loops with restrained ends.

The graph below compares the characteristics of a simple loop a 1½ turn helical loop and a 2½ turn helical loop.The gradient of the linear characteristic is a measure of the resilience of the loop(the greater the gradient the stiffer the loop).The helical loops are seen to be more resilient than the simple loop,however the gradients of the two helical loops are seen to be almost identical.



This is unexpected from our consideration of the theory of loops so far.

It was shown earlier that a restrained loop was stiffer than a loop with its ends free.The restraining of the lateral arms in the brackets increases the stiffness by twice as much.This indicates that wire between the brackets and the right angle bends of the loop are the principal parts for determining stiffness.Adding the helices to the loop allows a little more resilience by the loops of the helix sliding past each other as the loop is activated but it makes little difference whether there are 1½ turns or 2½ turns at the reflex point.

If helical loops are placed at the right angle bends of the loop there is an increase in flexibility.This type of loop also reduces the tendency of the adjacent teeth to tip when moved. There is a lower force decay rate with this type of loop.

Loops are very versatile structures in orthodontics,but a general rule must be observed:Each one of the legs of a loop in its relaxed state must face at right angles to the direction of motion.Of course,this angle changes with tooth movement but its observance reduces errors .

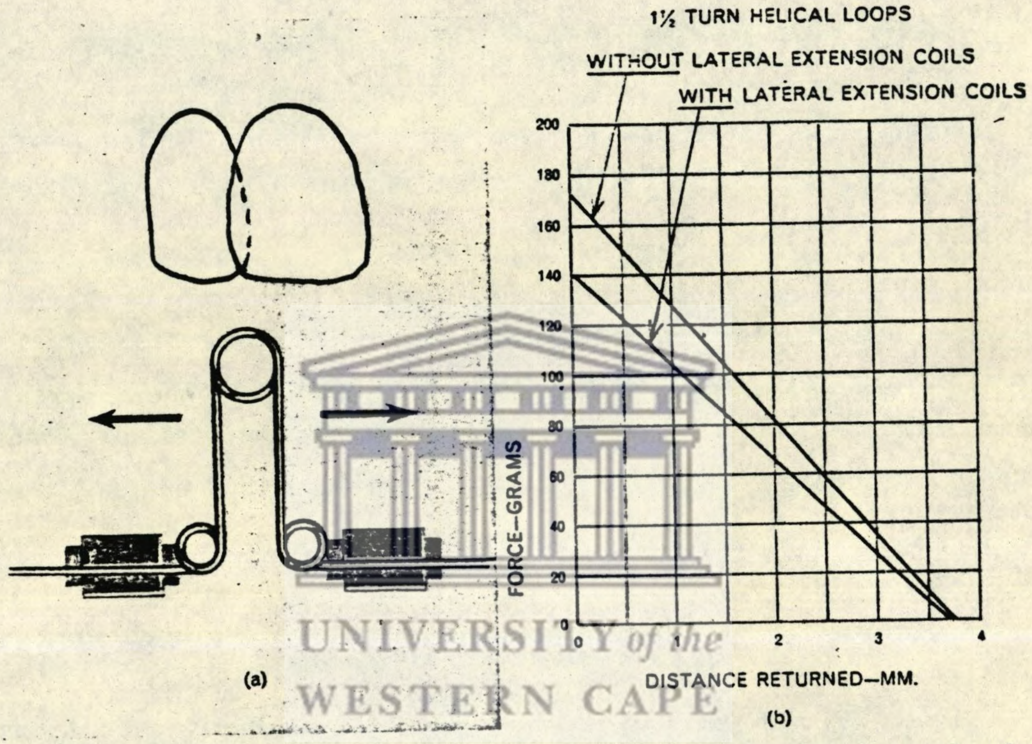
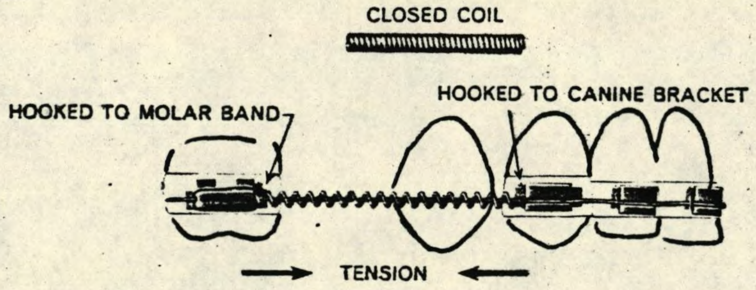


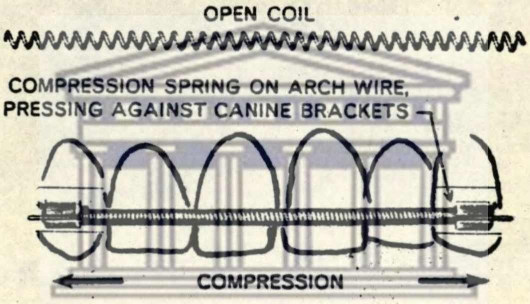
Fig. 29. Helical expansion loop with two lateral loops. **a,** Helical loop spring having lateral loops at points of greatest bending moment. **b,** Force vs. distance characteristics of springs with and without the lateral loops.

The Helical Spring

This device can be activated by stretching it ,in which case it pulls teeth,or it can be activated by compressing ,in which case it pushes teeth.



(a)

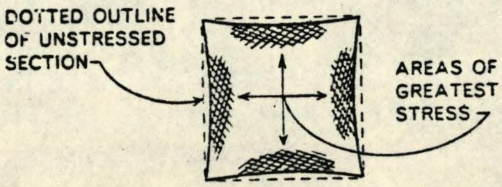


(b)

There is always a reciprocal force when any force is applied When helical springs are employed as shown above,the reciprocal force acts to pull the anchor teeth forwards and tends to apply a rotating moment to the molar.Provided anchorage is sufficient the forwards and rotating effects are resisted. The rotating moment applied to the canine is resisted partly by the archwire onto which the helical spring is threaded but may require one end of its bracket to be tied to the archwire to completely resist the rotational tendency. The force decay rate of helical springs is almost linear.

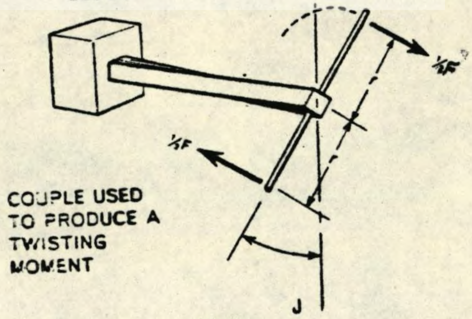
Torque with Rectangular Wire

Torque is produced by stressing the wire in torsion.If this stressed wire is now slipped into an appropriate bracket it will tend to move that tooth in such a direction as to relieve the stresses in the wire. When a rectangular or square wire is stressed in torsion the metal in the corners of it accept little of the stresses as does the metal in the central core .



The greatest stresses occur at the middle of the long sides of the wire.

When discussing the force delivered to a tooth by torquing action,the basic force system is the moment of force or the couple,thus force units are gram-millimetres.



(a)

In the above diagram a square wire is having a force applied to one end and is attached to a solid block at its other end. As the force F is allowed to reduce ,its point of action will move along the dotted line.If the force is always applied at right angles to the radius arm ,and assuming that the force decreases linearly,then the amount of workdone by the wire may be calculated from the expression;

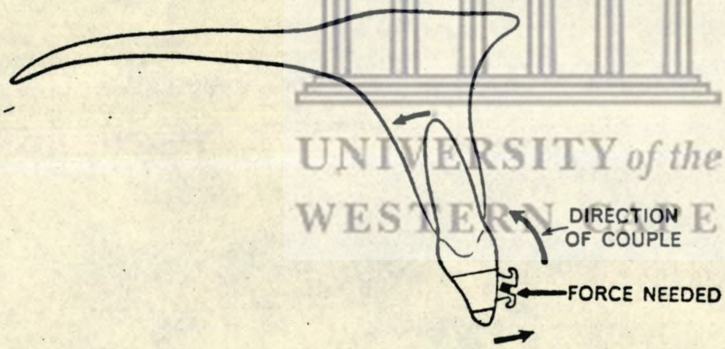
Work = Average force x $2\pi r$ (degrees turned / 360) mm.-gms.

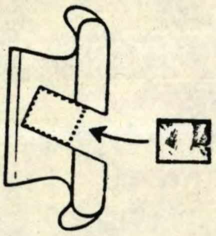
The force varies as a function of the angular position of the radius arm and need not be a linear function

$$\text{Work} = \pi r \int_{\theta_1}^{\theta_2} F_{(\theta)}\, \theta d\theta$$

F is the variable force which is a function of the angle θ and is applied at the end of the radius arm r.The limits θ_1 and θ represent positions of the radius arm.This formula allows the calculation of work done in turning the radius arm from the first position to the second position.

In orthodontics the principal use for a torqued wire is in the lingual tipping of the roots of anterior teeth





THe force system needed is a combination of a force and a couple.The above diagram shows the couple required to tip the root and the force used to maintain the position of the crown or in some cases to tip it lingually.As the torquing action moves the tooth there is a reciprocal force acting to move the molars mesially.This force can be so great in some cases that external forces are required to stabilize these teeth.

There are limitations to torquing with square or rectangular wire.It has a short range of motion although it can develop strong couples.After the teeth have rotated a few degrees the couple has relaxed and no longer works.Another disadvantage is the loss of twisting motion due to the clearance between archwire and bracket.

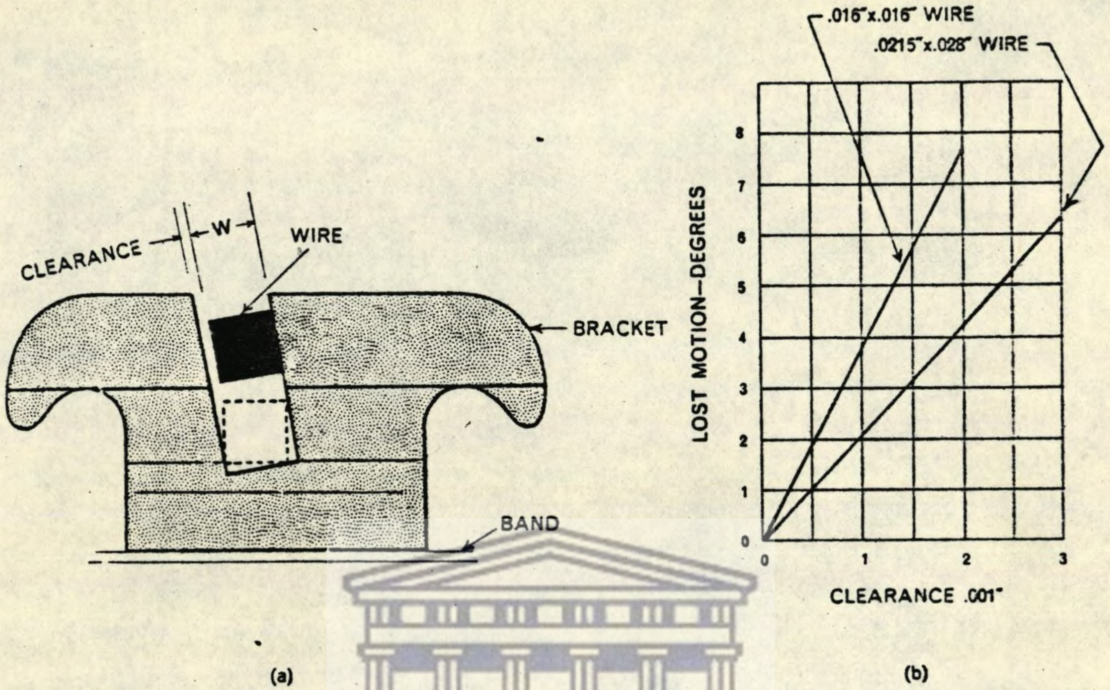


Fig. 35. Loss of twisting action due to wire-to-bracket clearance. a, Illustration of clearance. b, Graph showing loss of twisting action.

A small rotation of the wire is necessary before the two diagonally opposite points of the wire can contact the inner surfaces of the slot,the resulting two point contact is the means whereby the square or rectangular wire transmits its torque. The graph relates the clearance and degrees of twist in the wire before two point contact is established.The wider wire is seen to require less derees of twist to allow two point contact at a given clearance.

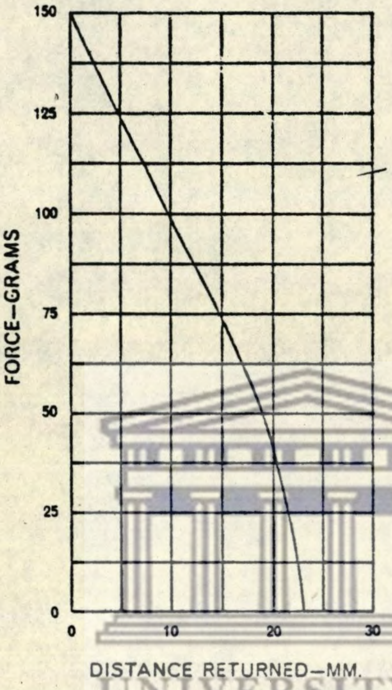
Torque with Round Wire

This requires either the use of two archwires or the addition of torquing auxiliaries to an archwire. The basic torquing unit is a loop formed in a directly labial Position to theteeth to which a torquing force is to be applied. The loop is then bent lingually i.e. in the desired torquing direction. By drawing the buccal segments of the torquing wire through the molar tubes distally the loops are activated. In this type of system using a complete archwire to torquethe teeth a second wire is inserted to stabilize the teeth. Once again a reciprocal force is applied to the molar teeth which acts to draw them mesially, external forces may be required to prevent this.

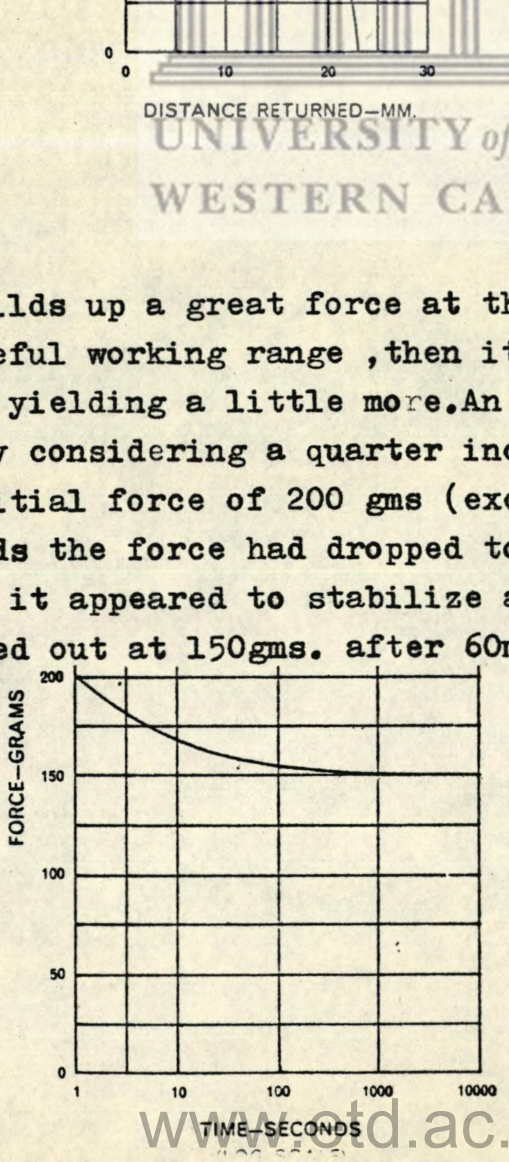
Fig. 37. Reflex horizontal loop torque, using round wire.

Parallel Strand Elastics

Consider a standard quarter inch heavy latex elastic. On stretching, an initial force of about 150 gms. will be generated. As the elastic works the distance between its ends decreases and the force reduces. This is almost a linear relationship while the forces are fairly high, but not so as we come to the region of low forces.



An elastic builds up a great force at the instant it is stretched beyond its useful working range , then it slowly reduces this force by yielding a little more. An ilustration of this is provided by considering a quarter inch elastic stretched to give an initial force of 200 gms (excessive for this elastic) In five seconds the force had dropped to 175gms. and continued to drop until it appeared to stabilize at 165gms. The force finally settled out at 150gms. after 60minutes.



The table below provides a guide for the use of elastics suggesting the maximum useful force that the elastic can be expected to exert and the maximum distance the elastic will return from its maximally stressed position to a completely relaxed state.

Table 1. Limiting forces for elastics

Type of elastic	*Max. force (gm.)*	*Max. dist. returned (mm.)*
¼-inch heavy	150	23
¼-inch light	80	15.5
O	350	23.5
X	250	21
2X	250	25

On initial placement of a dry elastic the two strands will not have equal tensions .However lubrication by saliva and the movements of the jaws ,tongue and lips causes the two strands to equalise their tensions.

Class 11 Elastics

this important application of parallel strand elastics is illustrated below.

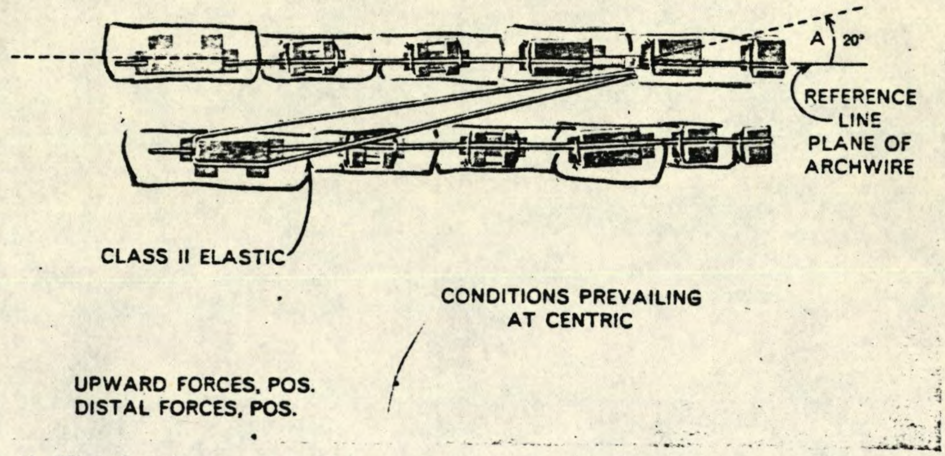


Fig. 40. Clinical application of parallel strand elastic in centric occlusion.

The teeth in this example are considered to be in centric occlusion and both distal and superior forces are designated as positive.Force exerted by the elastic is 100gms.The horizontal component of force is therefore 100 x cos.20° This equals 93.9gms.

The vertical component of force is - 100 x sin.20° which is -34.2gms.These are the forces applied to the sliding hook in the maxilla .The horizontal component of force on the mandibular molar is -93.9gms and the vertical component is 34.2gms.This calculation assumed the two arches to be parallel.

If the mouth opens to allow a space of 10mm between the central incisors.This stretches the elastic a little more and changes the angle of application.

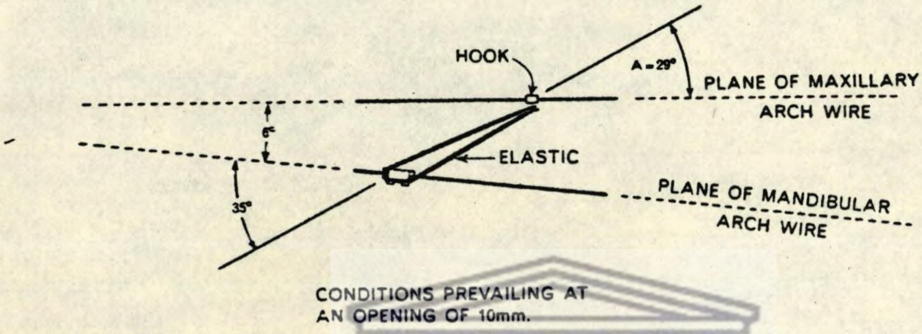


Fig. 41. Clinical application of parallel strands at 10 mm. opening.

The force exerted by the elastic has increased to 160gms and the angle has become 29°,this makes the vertical component of force on the sliding hook -160 x sin 29° which equals-77.6 gms.
The horizontal force is 160 x cos.29° which is 139.9gms.
In this position the elastic makes an angle of 35° with the mandibular archwire,thus the mesial component of force on the mandibular molar is -160 x cos 35° which equals -131gms.
The extrusive force is 160 x sin 35° =91.8gms.
If we take this discussion a step further we consider the peak transient forces which may act on the teeth via the elastic by yawning or other excessive movement.In the case under discussion the elastic force increases to 190gms.instantly
The peak distal force acting on the maxillary hook is 190 x cos.38.5° = 148.7gms.The peak extrusive force in this region is -190 x sin.38.5° = 118.3gms.

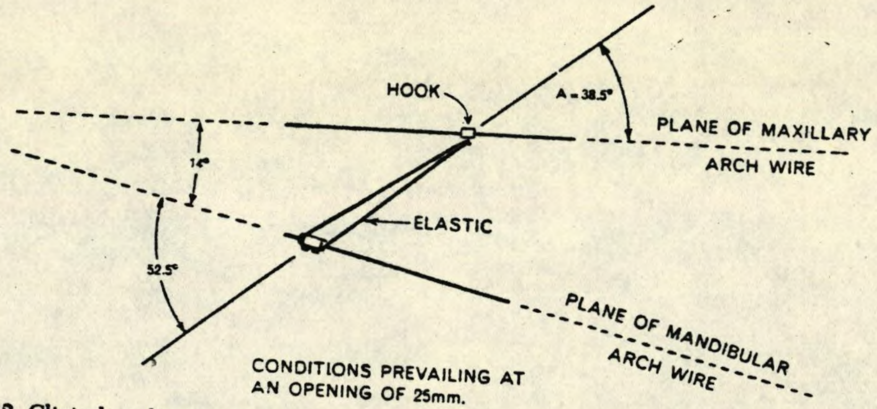


Fig. 42. Clinical application of parallel strands at 25 mm. opening.

In the mandible the mesial force is $-190 \times \cos.52.5^{\circ} = -115.7$gms.
The extrusive force is $190 \times \sin.52.5^{\circ} = 150.7$gms.
It is obvious that as the mandible drops to open the mouth the horizontal forces exerted on the teeth in both upper and lower jaws decrease while the vertical components of force increase.

Bertran (1931) stated that during the course of a day of opening and closing the mouth,approximately one third of the elasticity of elastics is lost.He therefore advocated daily changing of the elastics.
Generally elastics are supplied in a container which states the size and the force of the elastics.This force is generated when the lumen size of the elastic increases by three times i.e. quarter inch ,3½ oz. elastics will give a force of 3½ oz. on extension to three quarters of an inch.
Bales,Chaconas and Caputo (1977) tested this'three times'convention and found that the stated force correlated better with a 'two times' convention.If this is so,then selection of elastics on the basis of the 'three times' convention will result in more force being applied than was expected.

Tip Back Bends

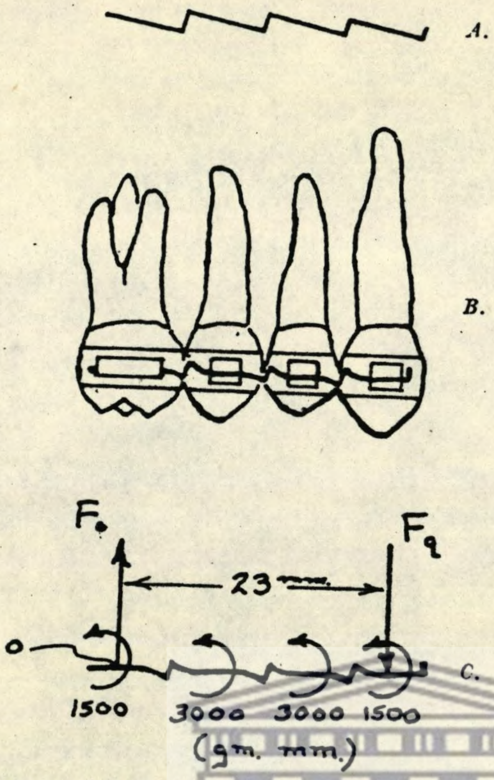


Fig. 3. Tip-back bends. *A*, Passive configuration; *B*, as applied to buccal segment; *C*, equilibrium diagram.

A. shows the passive configuration of a sectional archwire for a four tooth buccal segment with tip back bends. B. shows the wire engaged in the brackets, while C. is an equilibrium diagram showing the forces acting on the deformed archwire. In this case it is assumed that only the cuspid and molar will be called upon to exert the vertical forces on the wire which are required to hold it in equilibrium, F_o and F_q are these unknown vertical forces.

The equilibrium equation for the sum of moments in this system is,

$$M_o = 0$$

$$1500 + 3000 + 3000 + 1500 - F_q \times 23 = 0$$

$$F_q = \frac{9000}{23} = 392\text{gms.}$$

since $F_o - F_q$ must equal zero, $F_o = 392$gms.

These vertical forces are easily overlooked (Haack 1963) and one of the values of this analysis is the proof of their existence.The forces shown in C.above are those acting on the wire.Since the forces with which the wire acts on the teeth are the opposite of these ,the molar will tend to be extruded while the cuspid will tend to be intruded.

REMOVABLE APPLIANCES

Removable Appliances

Removable appliances may be divided into two main types,those calling upon a force of extrinsic nature and those utilizing forces generated within the appliance itself,or intrinsic forces.
The first type usually sit loosely in the mouth retained mainly by the muscular balance ,and are effective by virtue of the utilization of muscle forces to exert force on the teeth and alveolar processes.This type of appliance is generally termed a 'functional appliance'.
The second group of removable appliances using intrinsic forces is a variety of acrylic plates that utilize screws,finger springs, rubber bands etc. the design of which is only limited by the imagination of the orthodontist.

Both types of removable appliances are at the mercy of the patient since a good orthodontic result can only be achieved by wearing the appliance ,since these appliances can be removed from the mouth the orthodontist's control over the treatment is reduced.

FUNCTIONAL APPLIANCES

This group of removable appliances consists of ,bite planes, oral screen,the monobloc and its modifications and the function corrector.

Whatever the appliance that is used ,the central purpose is to produce a temporary redirection of the forces that are already present in the oral cavity until such time as the desired changes in tooth position and occlusal arrangement have been brought about.

A different approach to treatment with functional appliance therapy is that of Frankel in which the pressures of the tongue, lips and cheeks are prevented from impinging on the teeth and alveolar processes by the'function corrector' or'function regulator' producing changes in the growth patterns of these structures.

Theory of Functional Appliances

The theoretical basis of the system of functional treatment suggests that the new pattern of function dictated by the appliance leads to the development of a new morphological pattern of tooth arrangement and occclusion and also of facial size and proportions (Adams ,1970)

SOme proponents of the functional school believe that changes occur in the mandibular condyle as a result of growth stimulation leading to an increase in mandibular length.

Korkaus (1960)examined the cephalometrics of a number of cases treated with an activator and suggested that in the class 11 division i malocclusions the changes in mandibular conformation rapidly produced correction of the occlusal relationship and thus no changes in tooth position were necessary,this made for a more stable end result and also reduced the likelyhood of damage to the periodontal tissues.

Theoretical advantages arising from the use of functional appliances concern the periodontal reaction to the influence of activators in putting forces against the teeth.

Pressures from activators differ from forces exerted by active appliances in that the pressure from an activator is intermittent even while the appliance is being worn and most functional appliances are only worn at night.Compare this type of force to the force exerted by an active appliance which is continuous and usually present for most of the 24 hours of a day.

The effect of functional appliances is to impose 'shocks ' on the teeth and their surrounding tissues .These shocks come from the masticatory musculature and therefore may be considered physiological in character.The nature of this type of force is thought to avoid the stretching and compression of the periodontal membrane found in active appliances.As a possible result of this type of force system tooth movement effected by functional appliances is characterized by a maintenance of normal periodontal membrane thickness throughout the period of tooth movement (Haupl,Grossman and Clarkson 1952).

The Inclined Plane

Neumann (1969) considered this appliance to be the oldest orthodontic appliance still in use.Its purpose is to eliminate a crossbite of the incisors .
According to Lundstrom (1960) the simplest removable inclined plane is Oppenheim's splint which covers all the mandibular teeth and has a built in inclined plane for the labial movement of the upper incisors.

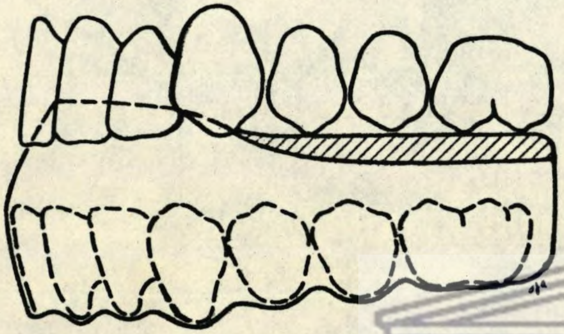


Figure 8-5. Oppenheim mandibular splint with inclined plane to engage and move maxillary incisors labially. (After Lundstrom, A.: Introduction to Orthodontics. Stockholm, Ivar Haeggströms Boktryckeri AB. 1960, Figure 207.)

The appliance is usually inserted with the cheek teeth occluding on it.The occlusal surface is them ground away progressively so that the incisors are the only teeth which touch the inclined plane.As soon as the incisors move and the posterior teeth occlude again,the posterior section of the splint is ground so that once again the incisors are the only teeth in contact with it.
One of the simplest ways of making an inclined bite plane is to add such a plane to a mandibular Hawley type of appliance .
In such an appliance mandibular incisors that have been moved labiallyb y the crossbite may be brought into alignement by grinding away the acrylic from the lingual surfaces of the incisors and activating the labial arch.
The resultant force acting on the teeth during therapy with an inclined bite plane is the by product of a depressing force and an anterior vector.The steeper the plane ,the greater will be the anterior component of force.
Neumann (1969) suggested that even with a steep plane there is still

a depressing force on the incisor and in most cases the posterior teeth overerupt and thus open the bite.For this reason an inclined plane is contraindicated unless there is an appreciable amount of overbite

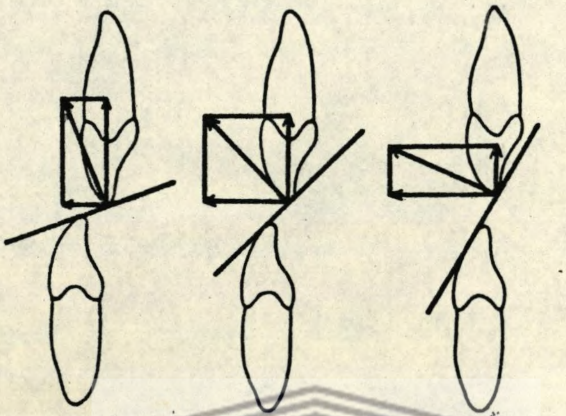


Figure 8-8. Force vectors of the inclined plane, with different angulations. The steeper the plane, the greater the forward pressure on the maxillary incisor. (After Lundstrom, A.: Introduction to Orthodontics. Stockholm, Ivar Haeggströms Boktryckeri AB, 1960.)

Adams (1970) suggests that the lower inclined bite plane is useful when the incisor teeth are at a relatively early stage of eruption and agrees with Neumann that there should be a good degree of overbite

ADams also suggests that the most satisfactory anterior bite plane is the removable clear acrylic plane.If the anterior bite plane is cemented into place then it is impossible to check the progress in the tooth movement unless the appliance is removed which may involve damaging it.

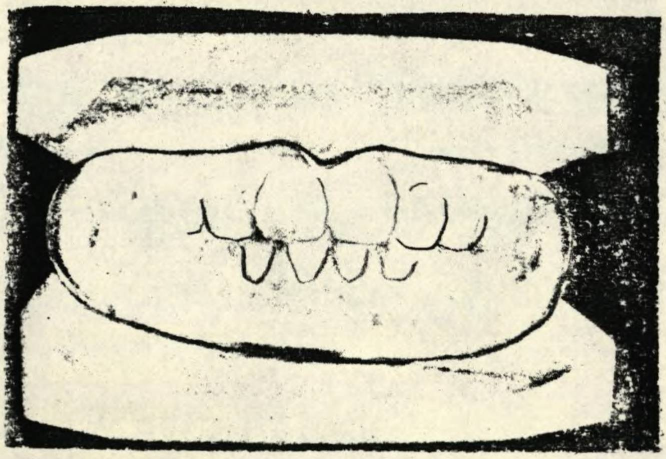
Woodside considers this appliance along with high pull headgear to be the basis of control of the vertical dimension.

The Maxillary Anterior Bite Plane

This appliance is widely used either by itself or in conjunction with another appliance e.g. fixed appliance therapy, to reduce the overbite.As with the mandibular anterior bite plane ,only the anterior teeth are in occlusion with it ,the posterior teeth being apart.Theoretically, the appliance works by permitting overeruption of the mandibular posterior teeth thus reducing the overbite.

The Oral Screen

Many achievements in improvements of the oral environment have been attributed to the oral screen .



It has been suggested that the oral screen can improve tooth arrangements and occlusal relationship, train the labial musculature to improve its posture and function and improve the health of the pharyngeal tissues by preventing oral respiration.
Adams (1970) suggested that it is only in the region of the lips andlabial segments of the dental arches that predictable results can be achieved with the use of the oral screen.
For tooth movement the oral screen is mainly used to retract proclined, spaced upper anterior teeth.To effect this the appliance is made so that it touches only the proclined incisorsand is not in contact with the teeth of the buccal segments, thus the pressure generated by function of the lips and cheeks which lie in contact with the divergent lateral wings of the appliance will be concentrated on the labial surfaces of the upper incisors near the incisal edges and will act to retrocline these teeth provided that the lower incisors do not contact the lingual of the upper incisors thus acting to prevent this distal movement

If the patient is amouth breather the oral screen can have a series of holes drilled into it until the patient gets used to it .The holes may then be progressively filled with acrylic thus reducing the mouthbreathing habit.

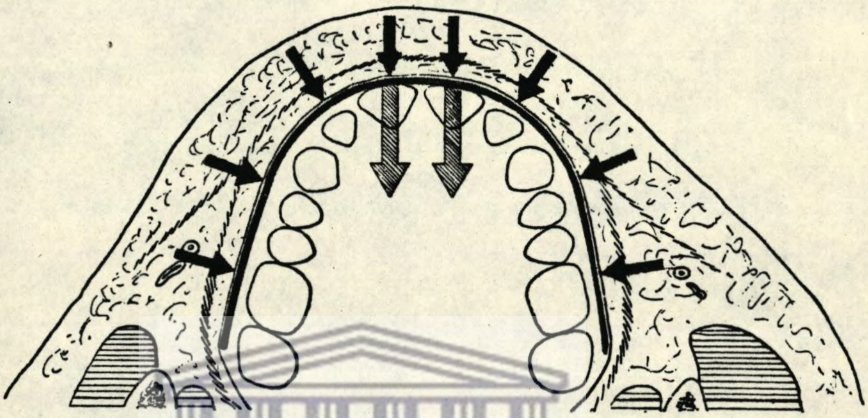


Fig. 198.—The oral screen. The entire pressure of the soft tissues of the lips and cheeks is concentrated on the central incisors. The lateral pressure of the cheeks on the smooth sloping surface of the screen is resolved in a posterior direction. The appliance may be designed to act upon the lateral incisors as well.

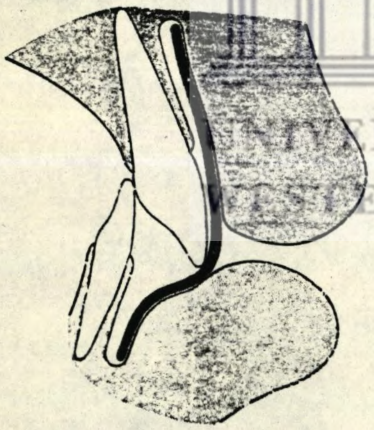


Fig. 199.—An oral screen fitted in a case in which there is proclination of the upper incisor and the lower incisor touches the upper incisors when the teeth are in centric occlusion. In this position the pressure on the upper incisor is also transmitted to the lower incisors. It is doubtful whether the upper incisors can be retroclined in this way.

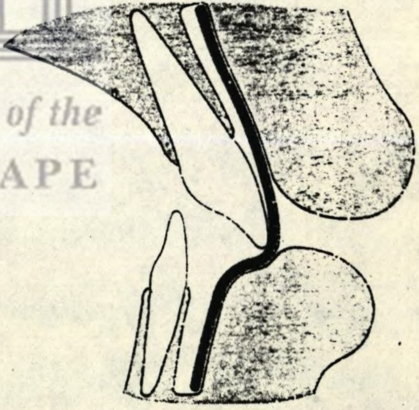


Fig. 200.—An oral screen fitted in a case in which the upper incisors are proclined and spaced but the lower incisors do not touch the upper incisors when the teeth are in centric occlusion. In these circumstances the oral screen will retrocline the upper incisors.

The oral screen may be used as an exercising appliance especially to improve the mobility and posture of lips which have been scarified by burns or in a cleft lip case. Hotz (1961) has suggested that this mode of use be facilitated by inserting a wire loop allowing the patient to pull the appliance forwards against the lips and also to push it backwards.

Figure 8-10. To prevent breathing difficulties, Kraus has recommended the use of breathing holes (top). Breathing difficulties are more psychological than real, however. When oral screen is used as an exerciser to develop tonicity of perioral musculature. Hotz recommends use of an embedded metal ring for insertion and withdrawal (bottom).

It should be apparent that use of this appliance to reposition the upper anteriors lingually is best limited to cases with a slight overbite since this will increase with lingual tipping of the upper anteriors.

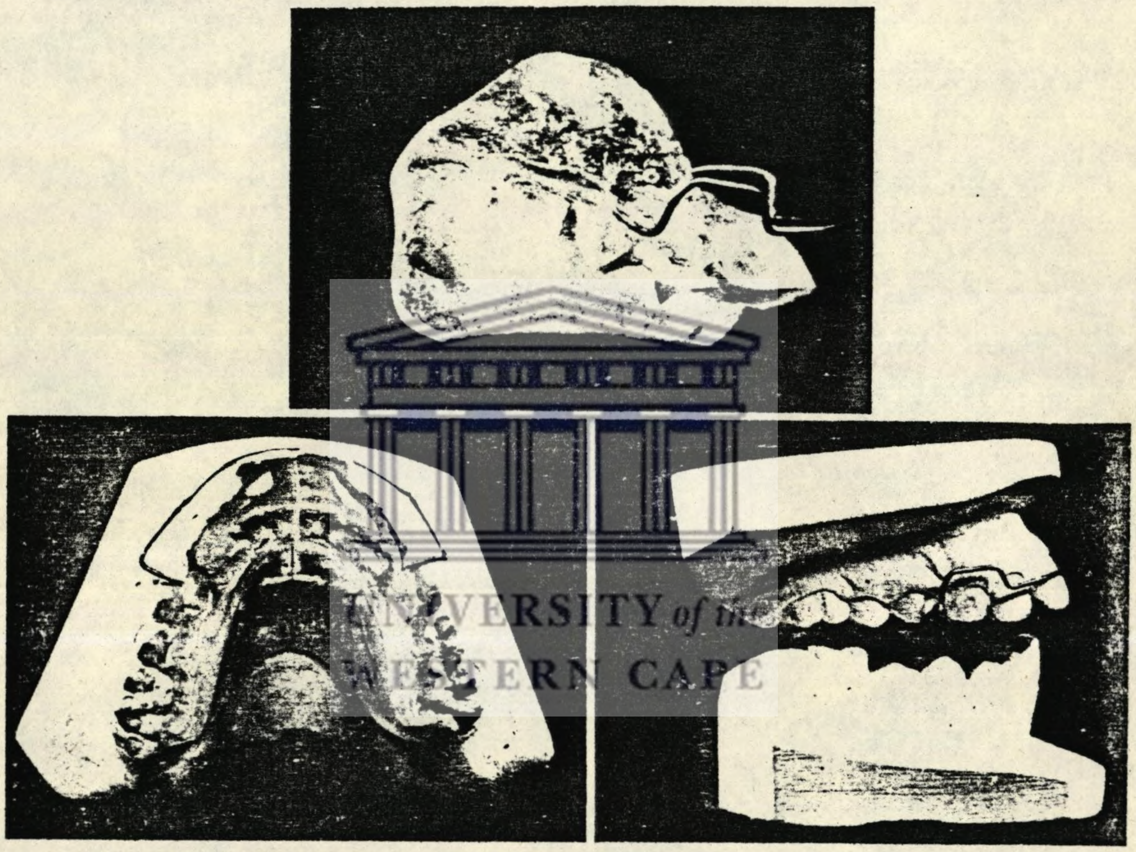
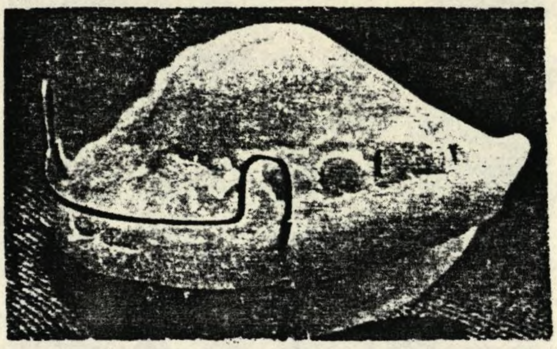
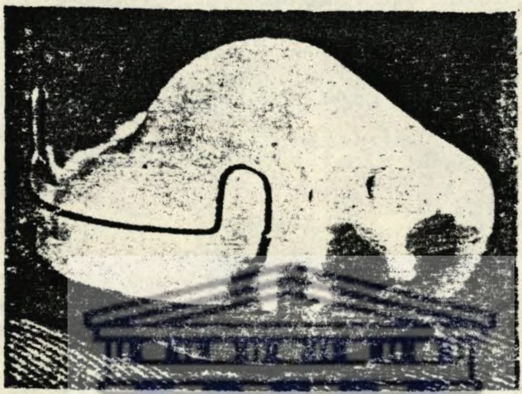


Figure 8-15. Monobloc (activator) appliance of the type used in case shown in Figures 8-13 and 8-14. Lower left, appliance in place on mandibular cast. Lower right, upper and lower casts articulated with appliance in place. Note labial wire to assist in retention and in adjustment of maxillary incisor tooth positions.

The Andresen Appliance or Monobloc





This appliance is especially useful in the treatment of Class 11 division i malocclusions and Class 1 cases which have Class 11 division i characteristics.In these cases the appliance is used in its simplest form ,that is with an upper and lower acrylic plate joined together and a labial arch added.
The basic philosophy of the Andresen appliance depends on the working bite taken prior to its construction.
Points for the making of a working bite for the treatment of a Class 11 division i malocclusion include the following :-
1)The mandible must be brought forward until the buccal occlusal relationship is normal anteroposteriorly.

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.
3)The centre lines must be made to correspond

This repositioning of the mandible must be to such a position that the patient can tolerate it while at the same time being sufficient to exceed the postural position and thus initiate force development during occlusion.

For the treatment of the Class 11 division i type of patient the trimming of the appliance is the method of activation to facilitate the required tooth movements.In this case the baseplate is 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 incisal edges of the mandibular incisors remain covered and in contactwith the acrylic thus making eruption of the posterior teeth possible to reduce the increased curve of Spee. Since this appliance can only fit loosely in the mouth and consists of upper and lower baseplates joined together it can only be worn when the patient is at rest i.e.at night and when the patient does not have to eat or talk.

Factors indicating doubt as to the advisability of using the Andresen appliance include,irregularity of the dental arches following early loss of deciduous teeth or due to the disproportion in the size of the teeth and jaws,breaks in the integrity of the dental arch,open bite due to habits and the inability of the lips to lie together at rest.

The question of whether the mandible can be brought forward and held there in a stable healthy position by this appliance is very controversial.Graber (1966) has shown that the anteroposterior change that occurs is due primarily to the elimination of the functional retrusion and excessive overbite.If there is no functional retrusion ,the anteroposterior change stimulated by the Andresen appliance is nil.

Schwartz (1966),Hotz (1961) and Korkaus (1962) ,all European orthodontists are unanimous in asserting the possibility of this functional appliance in bringing the mandible forward.

Neumann (1969) stated that in many patients distal occlusion (Class 11) is corrected rapidly with the monobloc ,the anteroposterior relationship of the molars improving by 1mm. per month.It is from such data as this that the question of whether the monobloc stimulates growth of the mandible arises and remains unanswered.

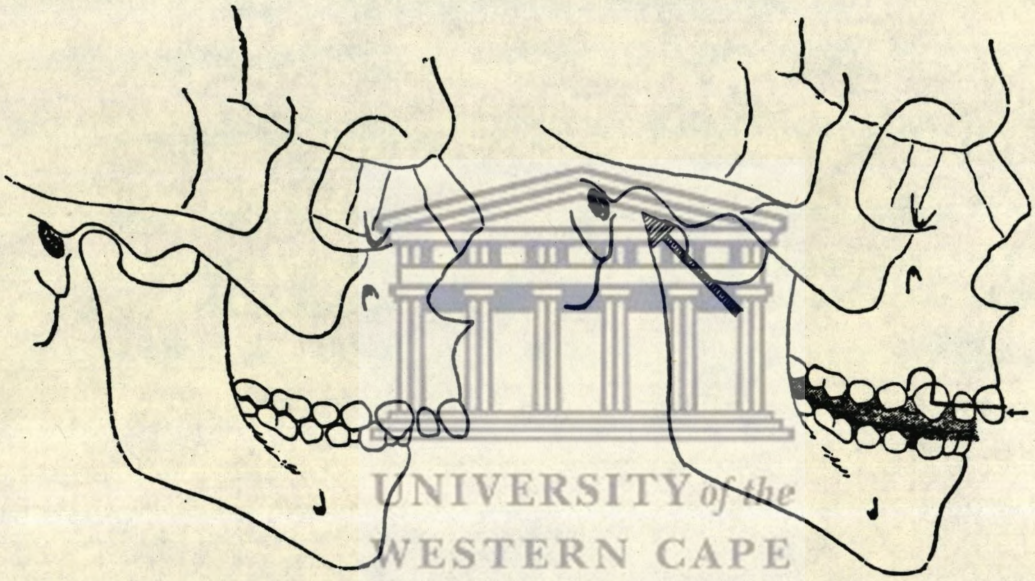


Fig. 161.—The main backward pull of the muscles of mastication is transferred to the teeth individually through the Andresen plate. The upper teeth are pushed in a distal direction, the lower teeth in a mesial direction.

The Function Regulator

This appliance is also known by the names, vestibular appliance, function corrector and Frankel appliance. Frankel, (1966) stated that'the configuration and structure of the tooth bearing area are subject to the mechanical influences of the environmentwhich 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 soft tissues.

2.Mechanical factors of a functional nature i.e. the influence of physical functions such as oral seal, mastication, deglutition, respiration etc.

3.The mechanical potential of the atmospheric pressure which by acting on the soft tissue mass is responsible to a large 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 mandible.

It should therefore be the chief aim of orthodontic therapy to trace and eliminate any abnormal mechanical potentials in the environmental soft tissues.'

There are three types of function regulators,

Type 1 (F.R.1.)

This type is used in the treatment of Angle class 1 and class 11 division i malocclusions.
There are lower lip shields which act as supports for the lower lip and prevent the action of mentalis muscle in producing pressure on the lower incisors. The action of these lower lip shields is valuable where there is retroclination or crowding of the lower incisors
The buccal shields relieve pressure on the lateral aspects of the dental arches which leads to expansion, especially in the upper arch.
In class 11 division i cases the lower lip shield has the function of encouraging the adoption of a forward position of the lower lip which embraces the shield on lip closure.

There are U-loops in the lingual bow which are important in the reduction of distocclusion(class 11) .If the lower jaw slips back from the protruded position in which the function regulator was made,the U-loops contact the alveolar mucosa on the lingual side of the lower anterior alveolar tissues and encourage the lower jaw to adopt a forward position.This forward positioning of the mandible is always necessaryin the treatment of distocclusion when taking the functional bite.

The F.R.1. is also used in the treatment of open bite.In this sort of case Frankel suggests that lip pads should be placed below both upper and 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 11 (F.R.2.)

This is used for the treatment of class 11 division ii 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.Apart from this arch the regulator is the same in action as in class 11 division i cases in that the labial pads at the lower incisors relieve the pressure of the lower lip on the lower incisors and the correct occlusal relationship is established by the protrusive bite to which the appliance is made.

Type 111 (F.R.3.)

In this type of appliance 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 corrects the incisor relationship if this is necessary ,by retroclinatiom of the lower incisors.

Taking the Bite

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.

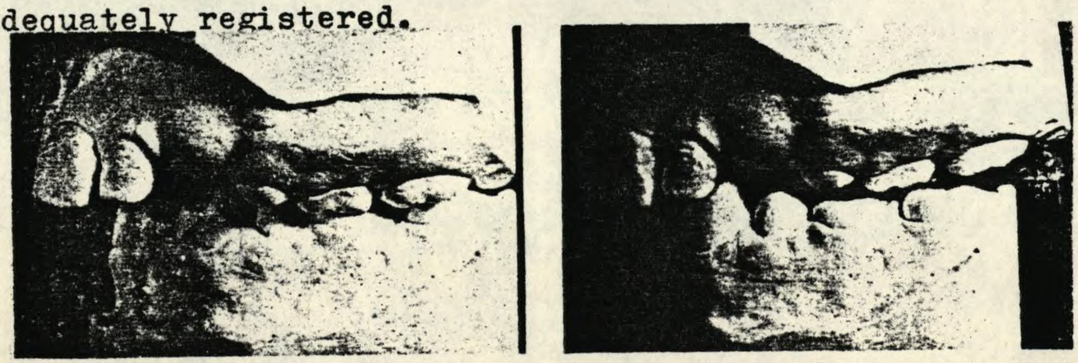


Fig. 181.—Construction of the function regulator. Taking the bite. A, Postnormal occlusion. B, The mandible is brought forward and the teeth brought together into contact.

Class 1 malocclusion

The bite is registered with the incisors edge to edge and in contact.

Class 11 malocclusions

The mandible is moved forward to bring the buccal segments into a normal antero-posterior relationship and the teeth are closed into contact.Obviously the amount by which the mandible can be protruded is influenced by the degree of overjet and overbite and the inclination of the incisor segments. It must also be remembered that the comfort of the patient will limit the amount of anteroposterior positioning possible and it may be necessary to construct more than one appliance to fully correct the malocclusion in the anteroposterior component.

Class 111 malocclusions

In these cases no protrusion of the mandible is permissible and the bite is registered with the incisors as close to edge to edge as possible.
If the lower incisors overlap the upper to any marked degree it may be necessary to place bite blocks between the buccal segments to prop the bite open sufficiently to allow the upper incisors to procline without the interference of the lower teeth.
When taking the bite for a case with a deep reverse overjet the teeth are not closed into contact.

In fabrication of the F.R.1 the labial sulcus of the lower working model must be sufficiently deep,since if the impression does not record the full depth of the sulcus in the lower incisor region the labial pads will not hold the lower lip away from the lower incisor teeth.

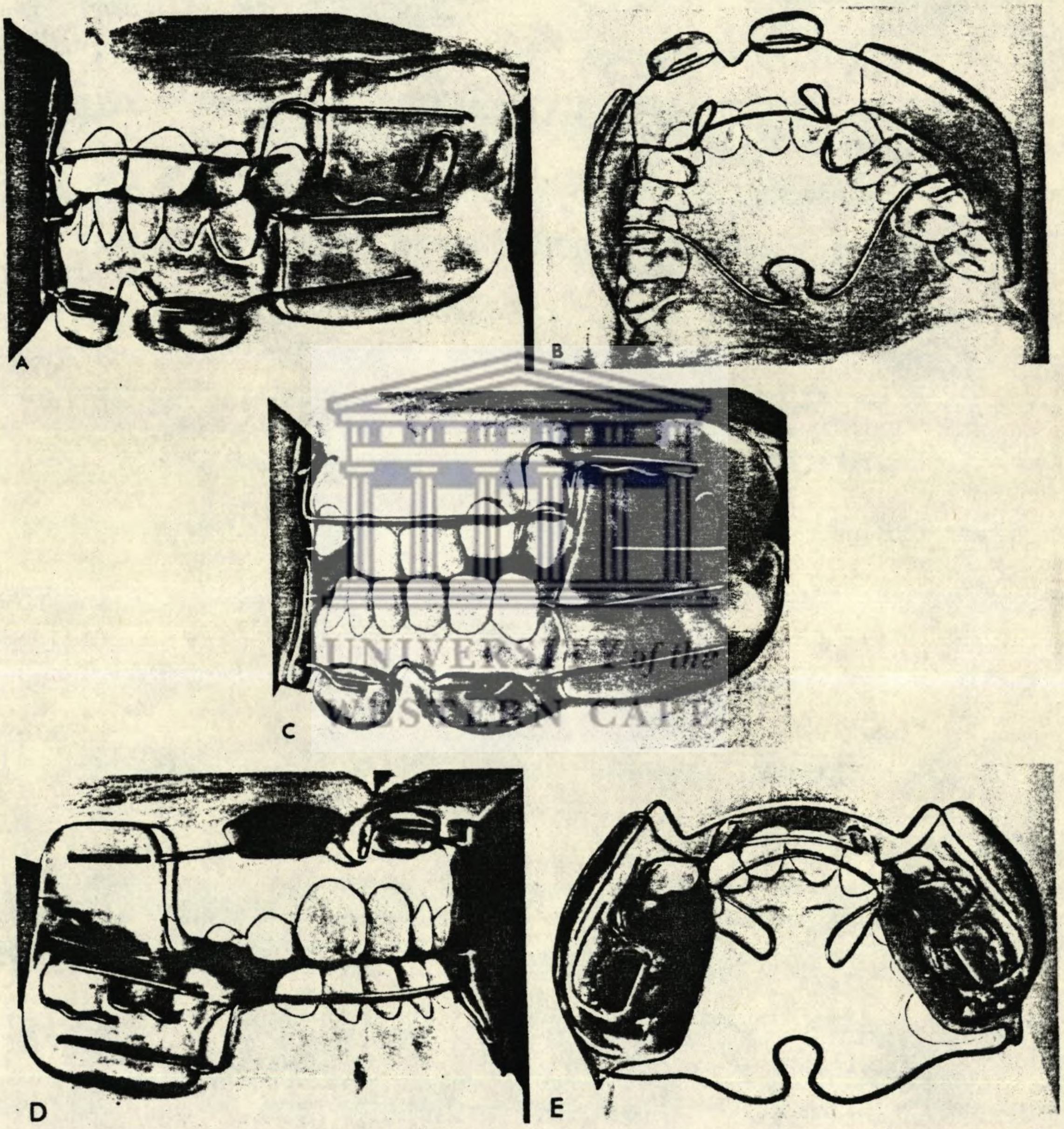


Figure 8-30. The three types of functional correctors of Fränkel. *A*, Type 1 on upper and lower casts. *B*, Type 1 on maxillary cast only. *C*, Type 2. *D*, Type 3. *E*, Type 3 on maxillary cast only. (Courtesy of Dr. R. Fränkel, Zwickau, GDR.)

Removable Appliances Utilizing Intrinsic Force

These appliances consist of three parts: the base plate, the clasps for retention of the base plate and the active elements producing the tooth movement.

The Baseplate

This part of the appliance acts as a support for the clasps and the springs and distributing the force reaction of the springs to the anchorage.

The base plate must be large enough to prevent any rocking or displacement of the appliance in the mouth and so provide the greatest amount of anchorage ,it must also be thin enough in all regions to be comfortable to the patient without sacrificing strength.The baseplate may incorporate bite planes either anteriorly or posteriorly for the purpose of stimulating eruption of the teethand so increasing the vertical dimension where indicated.

Retention of the Baseplate

To be of any use in orthodontic therapy the appliance must be held firmly in place.Clasps and the labial arch are the primary retention elements along with tissue apposition.

Clasps of any kind depend on undercuts on the tooth for their retentive properties.The clasp is made to fit below such an undercut and grip the tooth so that displacement of the appliance is resisted.

The following diagram illustrates the retentive surfaces of the upper molar.

The buccal surface is mainly flat but there is a small undercut just at the cervical margin.

The lingual surface has a distinct undercut towards the anatomical neck of the tooth.

The above two undercuts are not usable for appliance retention until the tooth is fully erupted.

The widest mesiodistal diameter of the tooth is at the level of the contact points below which the mesial and distal surface slope inwards sharply to the relatively narrow neck of the tooth.These two undercuts are more extensive than those on the buccal and lingual sides .They are also much nearer to the occlusal surface of the tooth and are accessible at an earlier stage of eruption than 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.

TYPES OF CLASPS

The Jackson Clasp

This clasp was designed to utilize the mesial and distal undercuts described above,(Jackson 1906)
The clasp ran around the cervical margin of thetooth buccally and then as far as possible interproximally mesial and distal at the gingival margin.This type of clasp does not utilize the interproximal undercuts to the best advantage ,however , in a fully erupted deciduous tooth there is often a marked ridge of enamel at the anatomical neck.The Jackson clasp can achieve very adequate retention over the sharp undercut available at this point.Fully erupted premolars and molars may also be clasped with the Jackson clasp using the buccal and lingual undercuts only
Thus this clasp design is not very useful where teeth are only partly erupted.

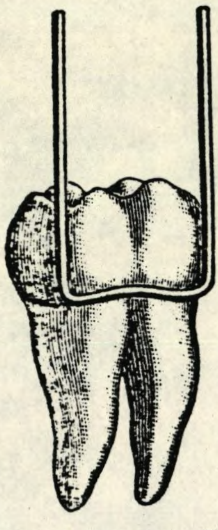


Fig. 53.—The Jackson clasp Note that the wire is carried mesially and distally into the undercut areas on the neck of the tooth. (*From V. H. Jackson in "Orthodontia and Orthopedia of the Face", Philadelphia, Lippincott,* 1904.)

Crozat Clasp

Crozat (1920) suggested a clasp design based on the plain crib form, however he made use of the mesial and distal undercuts of the teeth by incorporating a short piece of wire soldered to the basic crib which engages the mesial and distal undercuts.

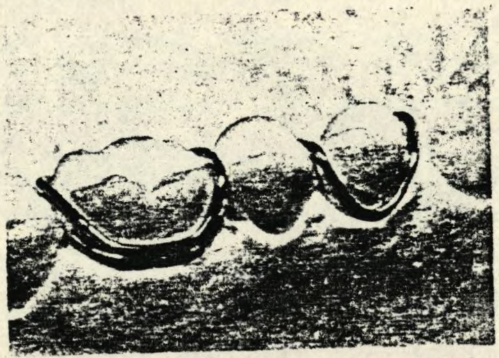


Fig. 54.—Right, the plain Jackson clasp. Left, the Crozat clasp, here made for illustration in stainless steel wire welded, but usually made in precious metal soldered. (*From Adams, C. P., "Removable Appliances Yesterday and Today", American Journal of Orthodontics*, 55, 748–64, 1969. *By kind permission.)*

Arrowhead Clasps

These are the most popular types of clasp for appliance retention and the most effective. The arrowhead type of clasp was designed by Schwartz in 1938 according to Neumann (1969). The basic principle of these clasps is that an arrowhead is bent in a light wire and inserted between two teeth in approximal contact just below their contact points. A continuous arrowhead design may be used where a number of teeth all in approximal contact are present in the arch.

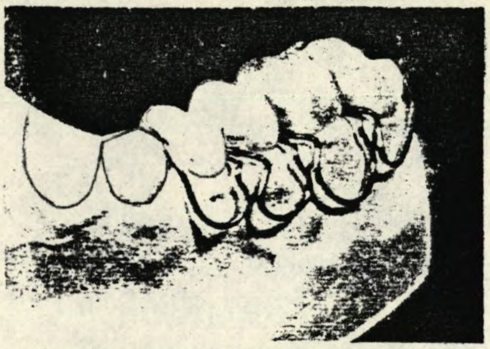


Fig. 55.—The arrowhead clasp attributed to Schwarz (1956). The arrowheads are formed by special pliers and are inserted into the spaces below the contact points between two teeth. A number of arrowheads may be embodied in one clasp as shown or only one or two may be used. (*From Adams, C. P., "Removable Appliances Yesterday and Today", American Journal of Orthodontics*, 55, 748–64, 1969. *By kind permission.)*

The arrowhead design brought to removable appliance technique the great advantages of axtereme security and reliability of retention on even semi erupted teeth (Adams 1970)
The arrowhead clasp has some disadvantages limiting its use in that teeth in approximal contact are required and also that in the continuous clasp design there is a lot of wire occupying the buccal sulcus acting only to retain the appliance i.e. before the active elements are added.

Adams Clasp

This clasp may also be referred to in the literature as the Liverpool clasp or the universal clasp.
It is a modification ofthe arrowhead clasp described above and is made to fit a single tooth i.e. teeth in approximal contact are not necessary .
Each clasp consists of two arrowheads which engage the mesial and distal undercuts where they continue onto the buccal surface.
Advantages of the Adams clasp are :-

1. It is neat and compact so occupying minimal space in the buccal sulcus.
2. The clasp may be used on any tooth either permanent or deciduous, erupted or semi erupted.
3. A short piece of wire is used in its fabrication ,so giving adequate strength to resist the distorting and displacing forces of occlusion.

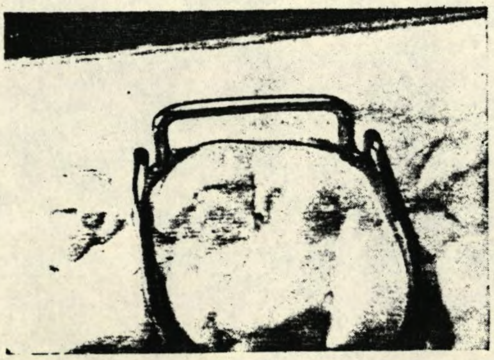


Fig. 65.

a. The arrowheads must not impinge on the adjoining teeth.

b. The arrowheads must be squeezed up to an appropriate narrowness *but not so far that the wire becomes damaged at the bend at the tip of the arrowhead.*

c. The arrowheads are not made as short as is possible. Extreme shortness is not of itself a virtue. The arrowheads should be made reasonably long; this facilitates construction and has the effect also of keeping the bridge away from the tooth and from the soft tissue adjoining the cervical margin.

d. It has been found that the practice of adjusting the width between the arrowheads by bending the bridge between them should be avoided. The bridge between the arrowheads should be straight and the arrowheads themselves parallel to one another.

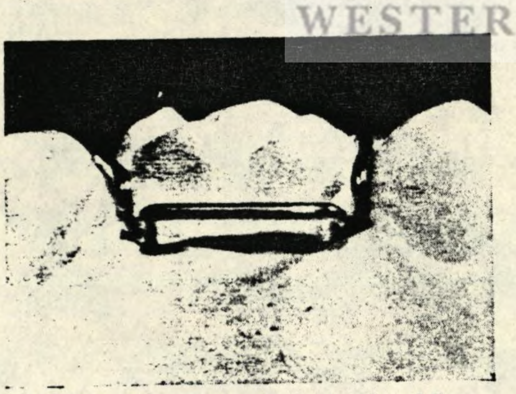


Fig. 67.—The arrowheads are sloped to follow the line of the gum margin.

Fig. 66.

a. The bridge between the arrowheads should project and be arranged midway between the buccal surface of the tooth and the adjoining gingival tissue, so avoiding contact with either. If the bridge lies near the gum margin, when the clasp is tightened the bridge will come down on the soft tissue causing pain and irritation.

b. The point at which the wire bends from the arrowhead to cross over the contact point should not project beyond the bridge but should be well inside it.

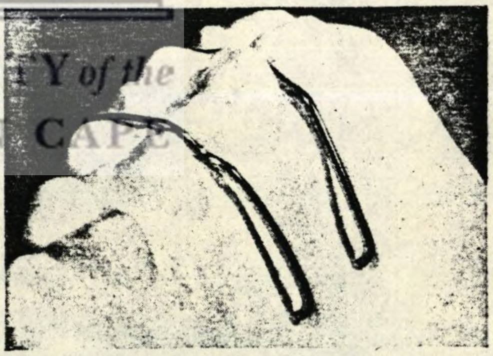


Fig. 68.—The tags should cross the contact points lying as closely as possible against the teeth and should be fitted into the lingual embrasure. The ends of the tags are turned down sharply to support the tag with a definite space between it and the soft tissue so that the baseplate material will flow completely around the tag and hold it firmly. This feature also has the effect of stabilizing the clasp during the laboratory packing process.

Variations of the Adams Clasp

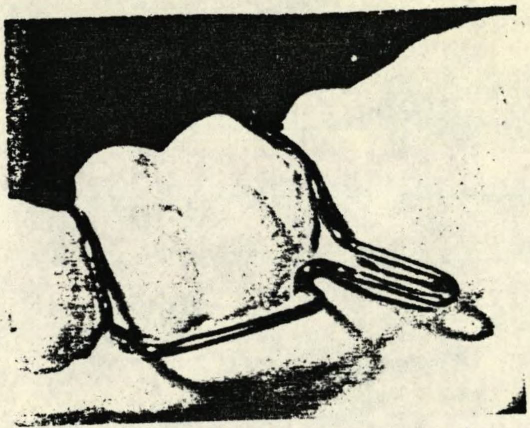


Fig. 74.—The standard lower posterior traction hook. Very strong, simple to construct.

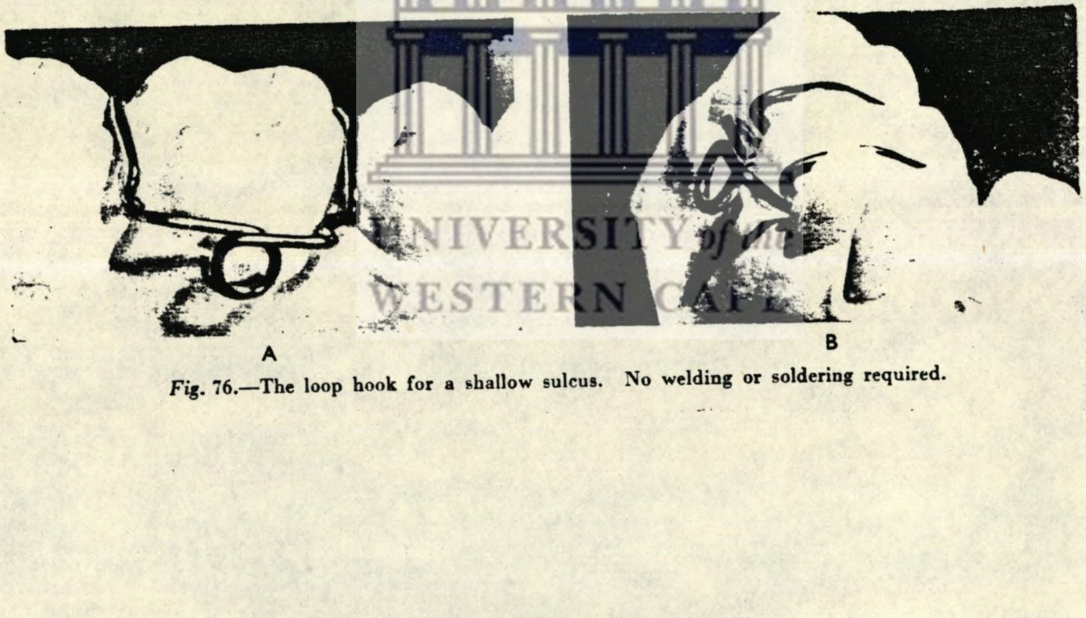


Fig. 76.—The loop hook for a shallow sulcus. No welding or soldering required.

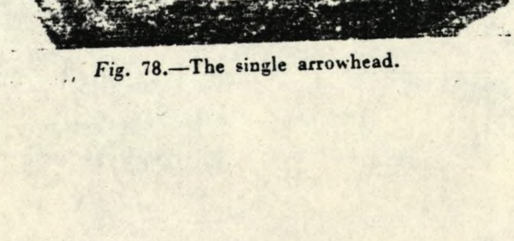


Fig. 78.—The single arrowhead.

The design of Springs for Removable Appliances

Springs should have a long range of action, be as efficient as possible, be resistant to damage and be as simple in design as the situation will allow.

The formula

$$D \propto \frac{Pl^3}{t^4}$$

expresses the relationship between the amount of deflection D, the pressure P, the length l, and the thickness t, for a cantilever spring of round section within its elastic limit.

To avoid the necessity for frequent adjustments of a spring it should have a range of action a little longer than the distance over which the tooth is to be moved. From the above formula it can be seen that thin wires have a greater range of action than thicker wires. The range of action of thick wires may be increased by increasing the amount of wire incorporated in the spring, however, the dimensions of the dental arches and the depth of the buccal sulci impose strict limitations on the length of these springs. Therefore the range of action of springs is usually increased by making them from thin wire and also by incorporating a coil or number of coils at the point of attachment of the spring. The use of thin wire in the fabrication of springs for use in the mouth make necessary certain measures for their protection.

The efficiency of the spring depends on the path of movement of its free end corresponding with the desired path of tooth movement. This is not always possible since the effective pressure on a tooth is at right angles to the tangent at the point of application of the spring, there being no friction for practical purposes between a spring and the hard polished surface of a tooth, and it is then necessary to adjust the point of application very carefully and possibly a series of adjustments will prove necessary to see that the spring remains applied to the correct spot on the tooth.

The simplest spring design is the straightforward cantilever, fixed at one end and movable at the other. This type of spring can be adapted to a wide variety of situations and

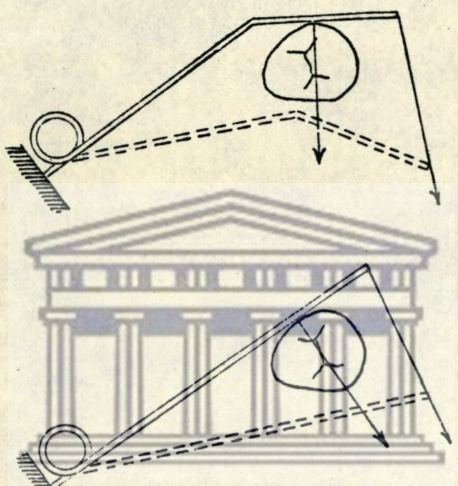
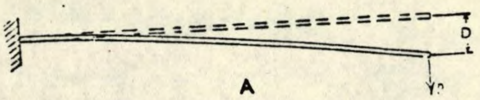


Fig. 3.—The direction in which pressure acts on a tooth does not always correspond with the direction of movement of the free end of the spring, but is determined by the point of application of the spring to the tooth.

has the further advantage that its mode of action is clear and patients find it easy to compress and hold in position when inserting the appliance.



Springs may be self-supporting or protected and guided.
The <u>self-supporting</u> type withstand the interference of function in the mouth without suffering damage. At the same time they are flexible enough to have a useful range of action.

Fig. 116.—A, The buccal canine retractor. Note that the front leg of the spring will act in a backward and not a downward direction. B, The operating end of the retractor is flattened and bears accurately on or above the mesial contact point.

These springs are used in limited space situarions where a supported spring is too bulky or not adaptable to produce the required tooth movement.
The wire used in such a spring must combine sufficient rigidity to avoid distortion and to maintain its point of application to the tooth ,and sufficient elasticity to be effective as a spring. These properties are found in wires of .028 (0.7mm)

The protected and guided springs are made of thinner wire than the self supporting type (.020" or 0.5mm)and usually incorporate one or more coils at their point of attachment.

This gives the springs a long range of action but also allows them to flex at right angles to the desired direction .Since these springs are often required to exert a force on inclined surfaces they have a tendency to slip along them reducing the efficiency of the spring and maybe producing the wrong direction of tooth movement.

It should now be obvious that some method of controlling a fine spring is necessary.Often this type of spring can be protected and guided by a wire overlying it,a single wire is usually sufficient and if the reaction of the spring against the tooth directs the spring against the guide wire good control of the spring action can be achieved.

As an alternative the spring may be linked to the guide wire by a small link of hard wire.This is a very efficient method of controlling the unwanted vertical movement.

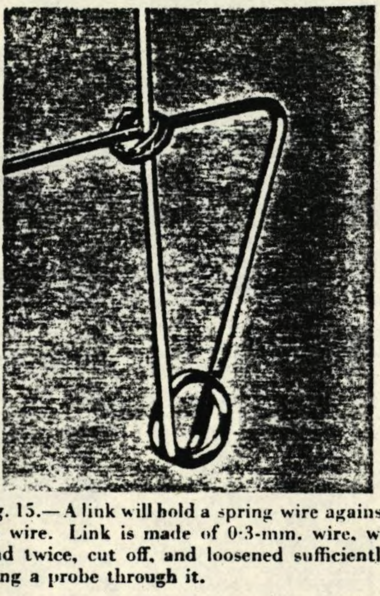


Fig. 15.—A link will hold a spring wire against the guide wire. Link is made of 0·3-mm. wire, wound around twice, cut off, and loosened sufficiently by running a probe through it.

Springs may be supported in the appliance by boxing it in under the baseplate.

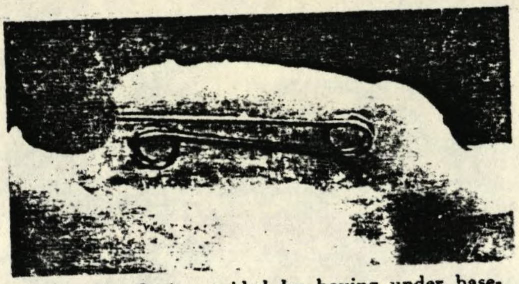


Fig. 16.—Spring guided by boxing under baseplate. Further control of this spring may be achieved by bending the free end at right angles, so forming an arm which will run beneath the acrylic plane and prevent the free end of the spring from rising above the level of the plane.

This method has distinct disadvantages since the cavity so formed provides a food trap ,allows the spring to be displaced more readily by the careless patient ,the spring does not have a smooth surface to run againstand may also be displaced along a sloping tooth surface.

The Crozat Appliance

This appliance ,named after the man who designed it is a modification of a removable appliance made by Victor Hugo Jackson.

The appliance consists of maxillary palatal and mandibular lingual wires called body wires.The body wire on the maxillary appliance crosses the palate between the anchor teeth and is curved to follow the arch form.Attached to the clasps are lingual and palatal side arms which extend mesially along the lingual surfaces of the premolar teeth at the gingival margin.

This appliance is very adaptable and and may have buccal arms attached when required for elastics,labial wires and finger springs may also be attached to effect certain tooth movements.

As with most removable appliances the anchor teeth are usually the first permanent molars .Obviously,the clasps used on this appliance are the Crozat clasps which are described elsewhere in this manuscript.Often in young patients the second deciduous molars may be better for anchorage if the crowns of the first permanent molars are incompletely erupted.

Wires used in its construction and adjustments for tooth movement are shown in the diagram.

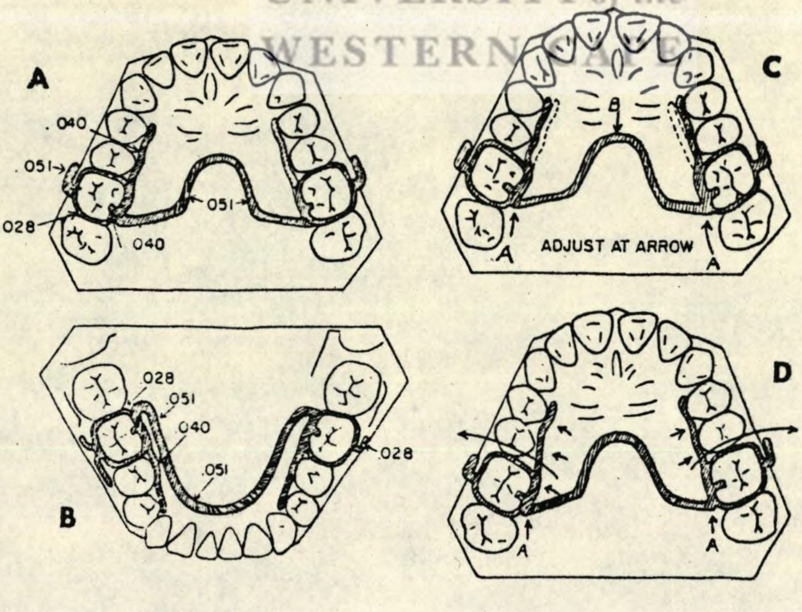


FIG. 622. Diagram showing wire sizes and where used. C. Adjustment may be made at arrow to rotate molars. The lingual arms are adjusted away from the premolars, as shown by dotted lines. D. Adjustment may be made at arrow to gain molar width; this adjustment is always very light. Note direction of adjustment for molar rotation.

Treatment Procedure

The first phase of treatment with this appliance is to correct the arch form in both jaws and correct the molar relationships including their derotation. At the same time the upper arch is expanded. Lamons (1964) points out that this is in fact not expansion, but a restoration of normal molar width.
When all this has been achieved the labial wire is attached to the appliance. Pins are attached from it to the labial surfaces of the incisors or to the cuspids and premolars as required.
Very light forces are used for intermaxillary traction since it is believed that if good arch form has been previously achieved then muscle forces will work to produce a normal anteroposterior arch relationship.
The following description is of a case diagnosed as a Class 11 division i malocclusion with a deep overbite and no crowding which was treated with the Crozat appliance.
In the maxilla the molar rotations were corrected and the arch expanded to restore arch form. 5 months later the lower appliance was fitted. 3 months after that buccal arms were fitted to the maxillary appliance equipped with Class 11 hooks to which a two ounce force was attached to open up spaces between the premolars. Putters were added to the buccal arms resting on the mesial aspect of the canines and the spaces closed in a very short time.
Next the labial arch was added with labial incisor pins and the incisors retracted to their correct inclination. With the help of Class 11 elastices the overbite was reduced to normal.

During treatment rest periods are incorporated during which the oral environment adapts to the new tooth positions etc. These rest periods are at the discretion of the operator.

Advantages of the Crozat Appliance

1. Aesthetics are good
2. Accessibility for oral hygeine and routine dental examination
3. No gingival irritation
4. Rest periods can be set up and treatment proceeds in harmony with growth and development.
5. Forces are very gentle.
6. Easy to add to or alter
7. The appliance can be used as a retainer.
8. The appliance can be made by the operator.

Some of the modifications possible for this appliance are shown below.

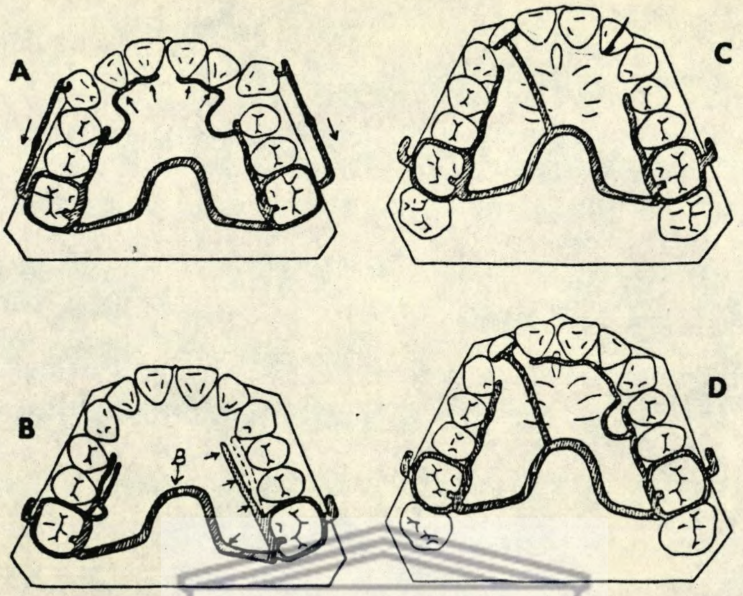


FIG. 623. A. Auxiliary springs added to upper appliance to move incisors labially. When buccal arms are added and used with elastics, the molars will move distally. Molar width can be gained at the same time. B, A smaller (0.028 inch) auxiliary spring is usually added to move premolars. In this manner the molar is not disturbed. If the body wire is adjusted at (B) and the lingual arm is kept away from the premolars on one side, the molar on that side will move. This will correct a cross-bite. C. Diagram showing how a pontic may be added to the appliance when indicated. D. Auxiliary springs may be used at any time. The artificial tooth may be easily changed to a larger one when the space has been opened. (Figs. 622 and 623 courtesy Dr. F. F. Lamous)

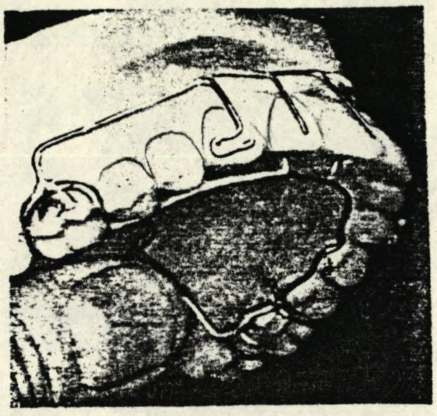


FIG. 624. Crozat maxillary appliance with high labial arch, intermaxillary hooks and molar bands as used by A. F. Jackson.

FIG. 625. Crozat mandibular appliance completed.

This appliance is looked upon by Crozat (1920) as the removable labio lingual appliance.Lamons (1964) summarized the philosophy behind this appliance by saying that . .

> it is not designed as a mechanical tooth moving device,but rather to deliver stress through the medium of the teeth to the supporting structures resulting in tissue changes and,eventually, tooth movement.Thus stress is applied to help this growth change from an undesirable form and shape which is abnormal to a desirable form and shape which is normal and in so doing to make the results aesthetically pleasing.

Lamons (1964) insists that with this appliance treatment cannot be a continuous process beginning with a given deformity and proceeding through a number of months to a termination point when the retainers are fitted.It is rather a progam of helping the patient to grow and develop in the desired direction so that he may be brought up to par for his age and stage of development.

In the Crozat philosophy then,treatment does not suddenly end in retention,but treatment is gradually decreased as harmony in form,structure and function is established.

The Hawley Retainer

This is a removable appliance which strictly is only used for retaining teeth in their new positions after orthodontic therapy.The appliance consists of two clasps for retention ,usually situated on the molars ,a labial bow and an acrylic baseplate.It may or may not incorporate a biteplane.

Stabilizing Plates

These removable appliances are used to maintain molar position in cases of difficult space management.They are lingual appliances attached to molar bands by means of lingual half round shafts embedded in the plastic of the baseplate.The molar band has a lingual sheath attached to it into which these shafts fit precisely.It provides much more stability than most other removable lingual appliances and may be used to back up anchorage when elastic traction is being used.

Positioners

These are flexible appliances which surround the crowns of all the teeth in both jaws.It is used as a retainer and also to complete the detailing of a case e.g. small rotations and alignements.It is usually made of soft rubber and should not be usedto attempt gross movements either orthodontic or orthopaedic.

If the positioner is not constructed to the patient's exact centric occlusion and at a reasonable vertical dimension then the muscle actions are altered and undue straining of the T.M.J. may result.

FIXED APPLIANCES

THE LABIO-LINGUAL APPLIANCE

THe Labio-lingual Appliance

This technique of treatment consists of a lingual and a labial appliance which appear to complement each other in action.

In constructing and using the lingual appliance the operator must decide whether the appliance will be simply a pattern or a source of anchorage or whether it is to be activated . It must be kept in mind that the molars and canines are important sources of anchorage,and that the contour of the lingual appliance as it touches certain teeth is important in Supplementing this anchorage.

Usually the mandibular lingual appliance is constructed before the maxillary one.In planning the mandibular appliance the operator usually carries the appliance to the gingiva of the anterior teeth unless the anterior teeth need moving lingually.After the lingual appliance has been constructed any attachments that are required should be added.

One of the greatest advantages of the labio-lingual appliance is that the appliance is completed before it is placed in the mouth so that many movements can be accomplished at one time.

The lingual appliance is a basis for auxiliary attachments and one of the best sources of anchorage obtainable in the oral cavity.(Tarpley 1961).

Advantages of the Lingual Arch

1.Is less conspicuous than other applainces

2.Less bulky than other appliances.

3.Little chance of caries since the tongue constantly cleanses the appliance.

4.The lingual arch allows for individual and free movement of teeth when pressure is exerted.

5.Both bodily and tipping movements may be obtained through adjustment of the appliance.

6.The lingual arch is easily removable for adjustment.

7.The pressure exerted by the lingual appliance and its auxiliary attachments is as physiologic as that exerted by any other appliance.

8.Lingual arch is an excellent source of anchorage.

Salzmann (1966) suggested that bodily movement is difficult to achieve.

Uses of the Lingual Arch

1.Serves as a pattern for moving teeth into their correct positions
2.It is a source of anchorage for auxiliary springs or attachments
3.Expansion of posterior teeth is easily accomplished.The appliance can be adjusted to expand either the molar or the premolar region.
4.Anterior teeth may be depressed and posterior teeth may be elongated.These movements usually occur at the same time if the appliance is adjusted down against the cingulum of the anterior teeth ,or in some cases ,if auxiliary springs are placed from the lingual surfaces over the incisal edges of the anteriors:this depresses them and at the same time tips the mesialaspects of the molars occlusally,thus the bite is opened.
5.Molars may be rotated buccally and moved posteriorly.This is accomplished by rotating the half round posting (fits in half round tubes on the lingual of the molars)in a buccal direction and expanding the lingual arch a little.
6.Mesial and distal movement of the premolars may be accomplished by means of an inclined looped coiled auxiliary spring from the lingual appliance which rests against the premolars . This same looped spring may be used to move anterior teeth mesially and distally.
7.Arch length can be gained with the split lingual appliance by moving the posterior teeth backwards or the anterior teeth forwards.
8.Molars can be uprighted with a loop lingual appliance by adjusting it so that pressure is exerted in an occlusaldirection at the mesial surface of the molar
9.The lingual appliance can be used for attachment of the occlusal guide plane.

When made from precious metal the lingual arch is fabricated from .040 inch wire,the half round posts being soldered onto it at right angles to facilitate its insertion into the half round lingual tubes on the molars.

The Round Labial Arch

Tarpley (1961) considers that the labial arch was the first orthodontic appliance to be used extensively. Many forms of it have been used such as round labial, flat, rectangular, half round, oval and twin wires. A round wire is used in the labio-lingual technique since it has the least contact with the teeth and therefore is probably the cleanest form of the labial appliance. However, when rotations are required, the twin wire arch is usually substituted for it.

In the labio-lingual appliance the labial appliance is constructed to form the ideal pattern, or the position to which malposed teeth should be moved.

When combined with the lingual appliance, the labial arch acts as a check on buccal movement of the teeth by the lingual appliance.

Both labial and lingual components can achieve the same movements but each excels in certain types of movement, thus they can be coordinated.

Advantages of the Labial Arch

1.The round labial arch is easily kept clean since it has minimum area in contact with the tooth surface.

2.In most cases anterior bands are not used so the appliance is inconspicuous.

3.With auxiliary springs, the round labial arch permits free and individual movement of teeth under the stress of occlusion.

4.Can move anterior teeth anteriorly and posteriorly.

5.It is a fairly robust appliance not easily damaged.

Uses of the Labial Arch

If the labial arch is to function merely as a pattern to which the teeth are to be positioned then it should be constructed to a normal arch shape for that individual. The ideal may not be achieved at first because of one or more teeth severely malpositioned but as treatment proceeds changes may be made in the arch form to achieve symmetry.

The labial arch, like the lingual arch can be used as a source of anchorage by allowing it to touch as many teeth as possible.

The labial arch functions as a base on which may be added auxiliary attachments to give individual tooth movements.

The labial arch has all the required attachments soldered to it before it is placed in the mouth so that many tooth movements are possible all at once.

To depress anterior teeth,perpendicuar auxiliary springs are attached which extend over the incisal edges of the anterior teeth.Pressure is brought to bear on these teeth by activating the labial arch gingivally.This slight pressure tends to depress the teeth and also raises the mesial surfaces of the first molars to which the appliance is attached.

When anterior teeth require elongation the labial arch is activated incisally then sprung gingivally and ligatured to the teeth.If the ligatures cannot hold the teeth because of their anatomy then the teeth must be banded and ligated to the arch from attachments on the bands.If anchorage problems occur as a result of this movement ,up and down elastics can be used from upper to lower lingual arches to help conserve the anchorage

Forward movement of the anteriors is accomplished with this appliance by placing coil springs between the buccal tubes on the first molars and the labial loops anterior to them. Compression of the labial arch and coil springs back against the anterior teeth will transfer the spring pressure to the anteriors when the arch is ligated to them and also have an opposite reaction which tends to move the molars posteriorly.

Retraction of the anteriors is accomplished by direct contact of the labial arch on the anteriors.This is activated by tying the free end of a perpendicular coiled loop spring to the buccal tube.To prevent loss of anchorage (molars moving forward) intermaxillary elastics may need to be used.

For rotation of anteriors Tarpley(1961) suggests the use of a twin wire arch.He considers this method to achieve the goal much easier and efficiently than the labial appliance

For rotation of molars the labial appliance may be used by expanding the arch first and then bending it in a lingual direction at the labial loops.This rotation is accomplished with the lingual appliance out of the mouth preferrably.

To move molars distally the labial arch may be used in the same way as for forward movement of the anteriors but the anteriors are not tied in and the posterior force from the coil springs is supplemented with intermaxillary elastics.As the molars move distally they must be expanded

Auxiliary Attachments For the Labio-lingual Technique

Attachments include all the springs,stabilizing lugs,occlusal guide plane and anterior horizontal incisal guide plane.

Auxiliary Springs

There are seven types of auxiliary spring used in this technique;straight,coiled,curved,recurved,looped, ringed and angular.

1.Straight auxiliary springsare those with no curvature which extend uniformly in a direction paralleling the plane of attachment.

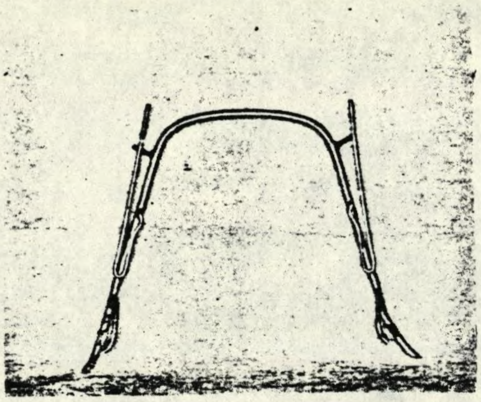
Figure 151. Perpendicular straight auxiliary springs.

2.Coiled auxiliary springs, -those wound around the labial and lingual appliances in a cylindrical fashion

Figure 152. Coiled auxiliary springs, perpendicular looped coiled auxiliary springs, and perpendicular curved auxiliary springs. Class III elastic hooks on mandibular labial arch. Mandibular anterior teeth ligated to labial arch.

3.Curved auxiliary springs are those which have a bend without right angles

4.Recurved auxiliary spring ;-springs bent backwards as the name implies i.e.bent back on itself.



Horizontal posterior recurved auxiliary spring.

5.Looped auxiliary springs are those that are bent or curved from the appliance and return toward it without crossing themselves.

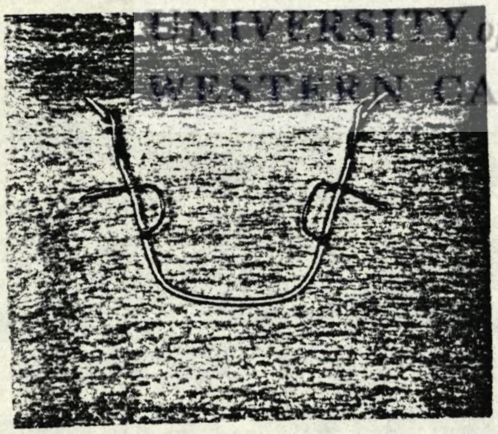


Figure 165. Inclined single loop coiled spring.

6.Ringed auxiliary springs have a circular end.

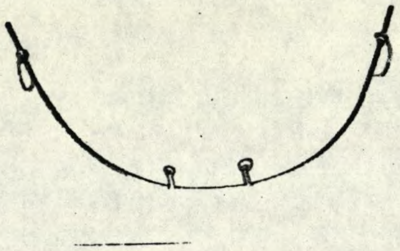
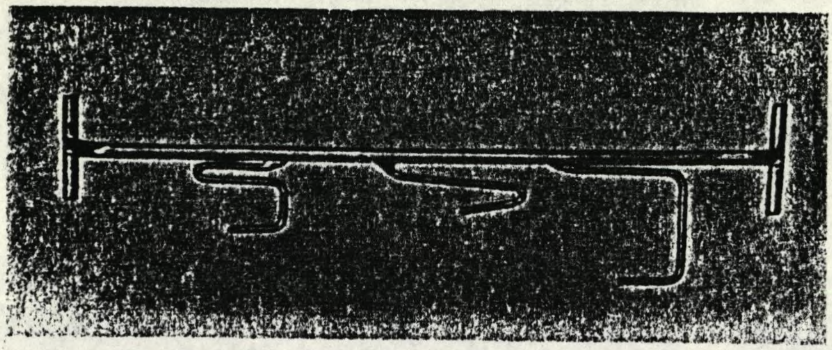


Figure 168. Perpendicular ringed auxiliary spring.

7.Angular auxiliary springs make an abrupt change in shape. they may be a)single,with only one angle ,or b)compound ,with more than one angle.



–Horizontal angular, horizontal recurved, and inclined recurved auxiliary springs.

The Occlusal Guide Plane

The occlusal guide plane is an auxiliary of the maxillary lingual appliance.It has an established inclined plane and heightand causes a change in the occlusal relation of the maxillaryand mandibular teeth thus allowing the two arches to move into a more normal relationship. The occlusal guide plane is constructed on the maxillary lingual arch so that the mandibular incisors are guided anteriorly when the jaws are brought together.

When the guide plane is constructed ,the relation of the maxilla and mandible is set to a predetermined limit.This position may be ideal or approaching ideal ,permitting the cheek teeth to move into normal occlusion.

This alteration of anteroposterior jaw position which is held by the guide plane ,albeit a temporary change ,also alters the incisal relation. When properly constructed the guide plane is perpendicular to or has a slight distal inclination to the upper lingual appliance.If the guide plane tips forward to any great extent care must be taken because it is possible that the patient can bite posterior to the plane.The depth of the occlusal guide plane is dependent on the individual case and is governed by the amount of space betweenthe maxillary lingual arch and the position at which it will strike the mandibular lingual arch

Advantages of the Occlusal Guide Plane

1.The patient cannot take the plane out or put it in at will.

2.Patient has freedom of tooth movement without the use of numerous bands.

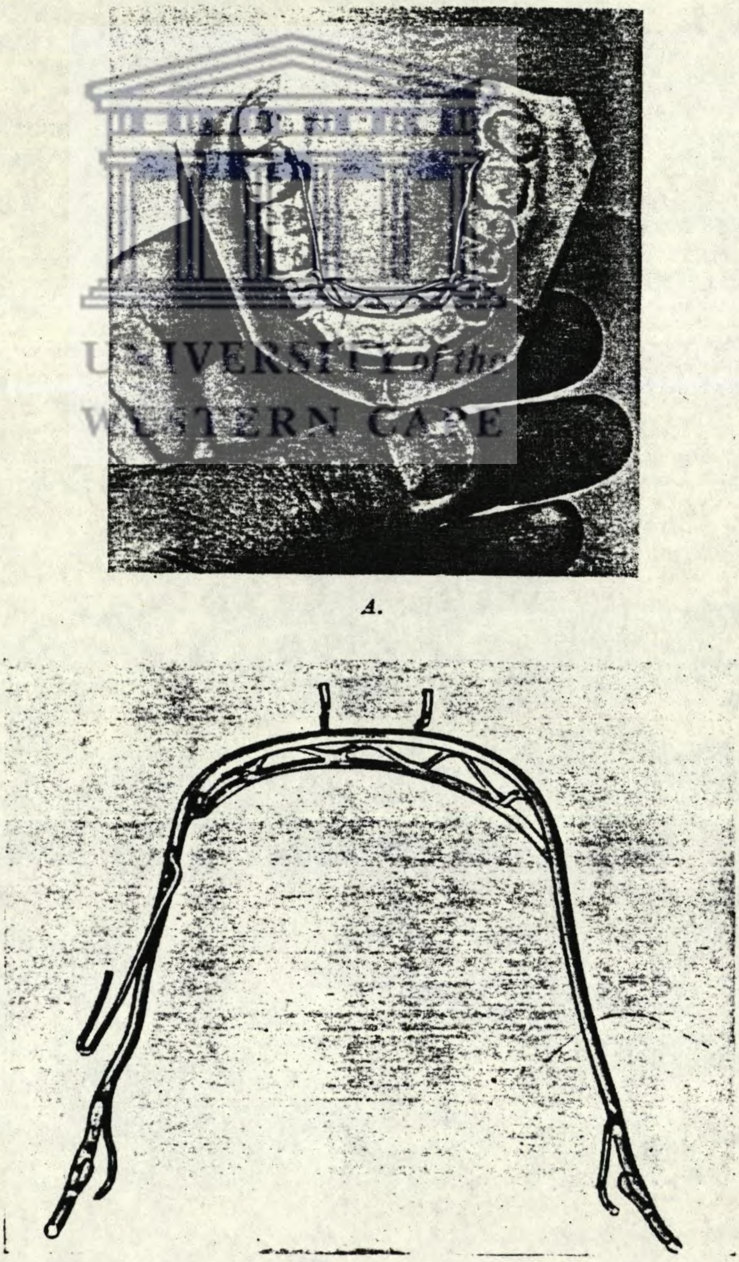
3.In changing the anteroposterior relation of the jaws the occlusalguide plane also changes the incisal relation.In this way nature is set free to let the teeth move into their respective positions,i.e.the intercuspal lock is removed.

4.The occlusal guide plane immediately changes the profile to a pleasing one thus encouraging the patient.

The unlocking of the occlusion by this appliance reduces the necessity for strong intermaxillary elastics.

There has been speculation as to the effect of the guide plane on the T.M.J. and surrounding tissue.It is now apparent that the morphology of the glenoid fossais not changed by treatment. and that the results of treatment are probably due to the changes in position of the teeth and alveolar bone rather than changes in the facial skeletal pattern

Oliver,Irish and Wood (1940) believe that the occlusal guide plane cannot be omitted from the labiolingual technique where there is a deep overbite,where the occlusal plane must be changed,where anteroposterior correction of teeth is necessary, where marked axial inclination change of anterior teeth is necessary and where changes in the musculature of the face is indicated to allow a more normal correlation of the forces of occlusion.



B.

Fig. 217.—*A*, Completed occlusal guide plane.

B, This figure shows the completed guide plane. Note the perpendicular auxiliary springs used to depress the central incisors.

THE EDGEWISE APPLIANCE

The Edgewise Appliance

Many changes and refinements have been made to this appliance since its conception by Dr, Angle in 1928 but the basic design and applications are the same as they were almost fifty years ago.This brainchild of Angle's followed his ribbon arch appliance and he called it'the latest and the best in orthodontic mechanisms'

Thurow (1962) considers that Angle gave the specialty 'an appliance that was perfected in principle and pregnant with possibilities for advancement with progress in related scientific and technological fields'.

Angle (1928) considered balance to be the law of successful maintenance of the treatment of the unbalanced denture or malocclusion.He cites the details of this balance to be ,

'First,there must be established fully normal proximal contact relations of teeth arranged in arches of normal individual typal form and size;

Second,there must be established fully normal cusp and inclined plane interrelationships ;

Third and quite as important as the other two ,though seeming as yet to be little appreciated,there must be established fully normal upright axial positions and relations of the teeth. This is essential if the teeth are to balance with the muscles and sustain and normally maintain the great force of occlusion'.

The objectives of orthodontic treatment remain the same today and the edgewise mechanism gives us the basic machinery to control a tooth in all directions.The mechanical means for exercising this control is the engagement of the rectangular archwire into the matching bracket slot on the tooth.Tipping or twisting the arch before seating it in the brackets will cause the seated arch to tip the root mesially or distally buccally or lingually.

Strang(1958) considers the edge wise appliance to be a nearly perfect mechanism,but states that the one drawback to the mechanism is its complexity.Strang was a pupil and co worker with Dr.Angle and is of the opinion that to understand thoroughly the philosophy of this device it is necessary to delve deeply into growth and development of the face. He concludes that the treatment of malocclusion is a three dimensional problem and that only a mechanism capable of moving teeth mediolaterally,anteroposteriorly and upward and downwards in the vertical plane is efficient

'We know of no device other than the edgewise appliance that meets these exacting demands so completely and effectively.'

The Biomechanical Postulates of the Edgewise Mechanism

(after Strang 1958)

1.There is a correct anatomic position on each tooth for the location of every band.

2.There are auxiliaries to use that are positive in their action for the production of special tooth movements such as rotations, the creation of space within a dental arch or the closing of interdental spaces.

3.The archwire form can be determined previous to treatment and can be used as an activating guide during treatment.

4.There is a specific location on this predetermined arch form for every dental unit.

5.It is possible to adjust each tooth to its correct position on the archwire pattern and when so adjusted to modify its axial inclination to meet the requirements of function, stability and aesthetics.

6.It is practical to coordinate the upper and lower arches in three dimensions.

The very basic ideas of the edgewise applaince will be discussed here to provide a foundation for building on with the later modifications of this idea.

The appliance requires that any teeth that are not in balance or good occlusion i.e.teeth that need moving ,be banded.

onto these bands are fixed edgewise brackets of which there were and are many different designs,however all have the horizontal slot for the arch across the middle and the upper and lower wings for ligation.

The terminal molars have edgewise tubes affixed instead of brackets.These tubes have the same function as the brackets namely, to hold the archwire to the tooth, however there are certain advantages to be gained using these tubes on posterior teeth such as the possibility of eliminating ligature ties in this difficult posterior position, and, more important, the tubes hold the ends of the archwirein place when it is inserted thus facilitating ligature ties further forward.

An auxiliary attachment used in the original edgewise appliance is the staple. This is fixed to the labial or buccal surfaces of the band on the mesial and distal extremities leaving a small eyelet just big enough to pass a ligature wire through. Tying this staple to the archwire causes a rotation of the tooth.

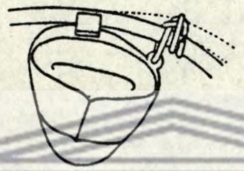


Fig. 24. The use of a staple in rotation. (From Angle, Edward H.: The latest and best in orthodontic mechanism, Dental Cosmos 71:170, 1929.)

Formation of the archwire is critical since all teeth are under its influence and any adjustments to the archwire control the movement or lack of movement for each tooth. The form of the dental arch and the form which the wire arch must have to produce it were carefully described by Angle(1928)

'If asked to demonstrate the form of a normal upper dental arch ,nearly all will give a semi ellipse,or a horseshoe pattern with the central and lateral incisors and cuspids all of the same height and alignement.

'Teeth without artificial support could never possibly remain in such positions for there could not be mechanical balance mesiodistally between the normal proximal contacts of the teeth nor between the inclined occlusal planes of opposing teeth, nor balance of the muscles nor of teeth and muscles with the temporomandibular joint.

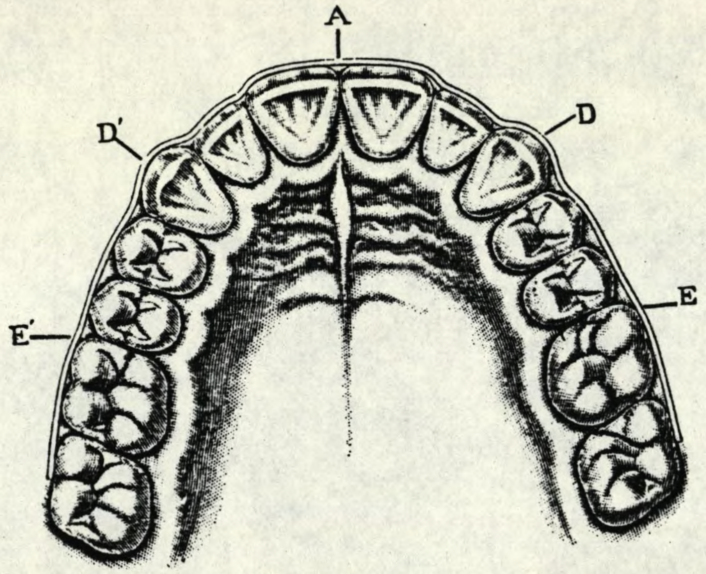


Fig. 25. The upper dental arch with a wire contoured to the buccal surfaces. (From Angle, Edward H.: The latest and best in orthodontic mechanism, Dental Cosmos 70:1154, 1928.)

Angle points out that there are five landmarks in the denture from which the ideal arch form can be determined.These five positions are indicated in the above diagram by A,D,D',E,E'. He points out that there is a straight line from the centre of the labial ridges of the cusps D,D' ,to the centre of the mesiolabial ridges of the first molars,E,E'.This line is always straight regardless of the curvature of the anterior part of the arch or the lateral width between the canines or the molars.

Another frequently neglected detail of arch form is in the lateral incisor region.This tooth is thinner labiolingually than the central incisor and more so when compared to the cuspid.The lingual surfaces of these teeth should form a smooth curve for occlusion with the lower incisors,t hus the labial surfaces must be adjusted to compensate for the labiolingual discrepancies.In most cases this will require that the lateral incisor be placed ligual to the adjacent teeth and it should also be made shorter than its neighbours.

The original archwires were made from gold wire and in determining their form the landmarks were scribed into the wire.This is not very satisfactory for stainless steel wires,especially in the smaller sizes because of the weakening effect(Thurow 1962) Such wires should be marked in the required positions with a suitable marking pen

The first bend to be made determines the labial curvature of the incisor segment .In some ways this is the most important bend since it controls intercuspid width -one of the most impor tant dimensions of the archform.

The second bends are made for the cuspid prominences and the third bends are the subtle adjustments made for the lateral incisor as previously discussed ,and for the molar.

The molar bend deserves special attention because the straight line between the cuspid and this tooth ends at the mesiobuccal ridge of the molarand if the rest ofthe buccal surface of the tooth wereto follow this line the molar would be distobuccally rotated.

This bend in the archwire for the molar can be deceiving.If the mesial end of the buccal tube is positioned at the centre of the mesiobuccal cusp of the tooth ,and if the bend is made exactly at this point only a simple bend will be required.

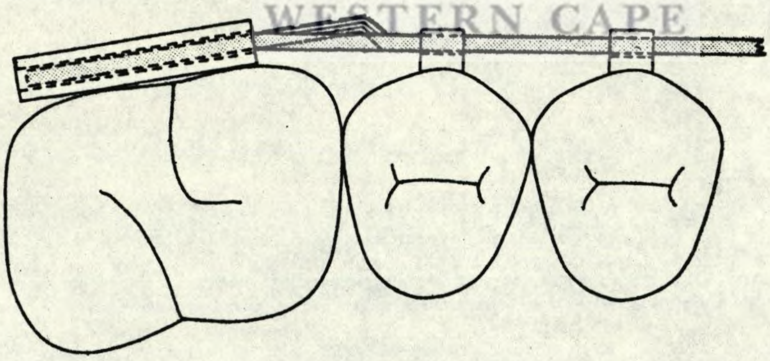


Fig. 30. The bend in the arch at the upper first molar. A simple bend is correct over the mesiobuccal molar cusp, but a double bend is required if the bend is positioned more mesially.

If the same simple bend is positioned too far mesially it will position the bicuspid buccally or the molar too far lingually Thus when the arch is sprung into and secured into the brackets the malposed teeth must have a force exerted immediately upon them in such a direction as to correct their malalignment.

The Tweed Technique

The Tweed method is based on Tweed's contention that the great majority of malocclusions are characterized by a deficiency between teeth and basal bone which shows itself in an abnormally forward relationship of the teeth to the bodies of their jaws. Salzman and Tweed(1966) consider ,in a discussion of the Tweed technique, that the mandible is usually characterised by excessive irregularity of the teeth, alveolo-dental protrusion of the incisors and frequent impaction of the third molars. The forward relationship and axial inclination of the incisors took most responsibility, in their opinion, for malrelation of the dental arches, crowding and imbalance of the facial profile. Tweed noticed that where occlusal and facial balance were achieved by orthodontic treatment, the mandibular incisors are situated over the basal bone of the mandibular body. This observation led to the concept of the Tweed diagnostic facial triangle to position the lower incisors first and then fit the rest of the dentition to them.

Angle's original contention was that extraction of teeth in orthodontic therapy was unecessary and not to be contemplated It took Tweed, one of Angle's pupils (eventually) a long time to break away from this dogma and retreated a number of his early cases to reposition the lower incisor over the mandibular body and if this could not be achieved without reducing the amount of dental tissue in the mouth he extracted.

Strang and Thompson (1958) studied the procedures of the Tweed technique and concluded that this type of treatment is based on the following philosophy;

First, that all malocclusions are characterized by a forward adjustment of the teeth in relation to their basal bones. It has been shown by Brodie and BRoadbent that in the first five years of life the jaw bones grow to 78% of the height, 85% of the width and 82% of the length of the adult jaw size. As the teeth erupt their crowns fall under the the influence of the anterior component of force whose function is to guide them to a balanced position .If the growth of the jaws is retardedthe basal bones over which the teeth should lie are now too close to the ramus in one jaw and too close to the tuberosities in the other, consequently when the teeth are established in positions of balanced force play they are too far forward in relation to the basal structures..This is especially obvious in the incisor area.

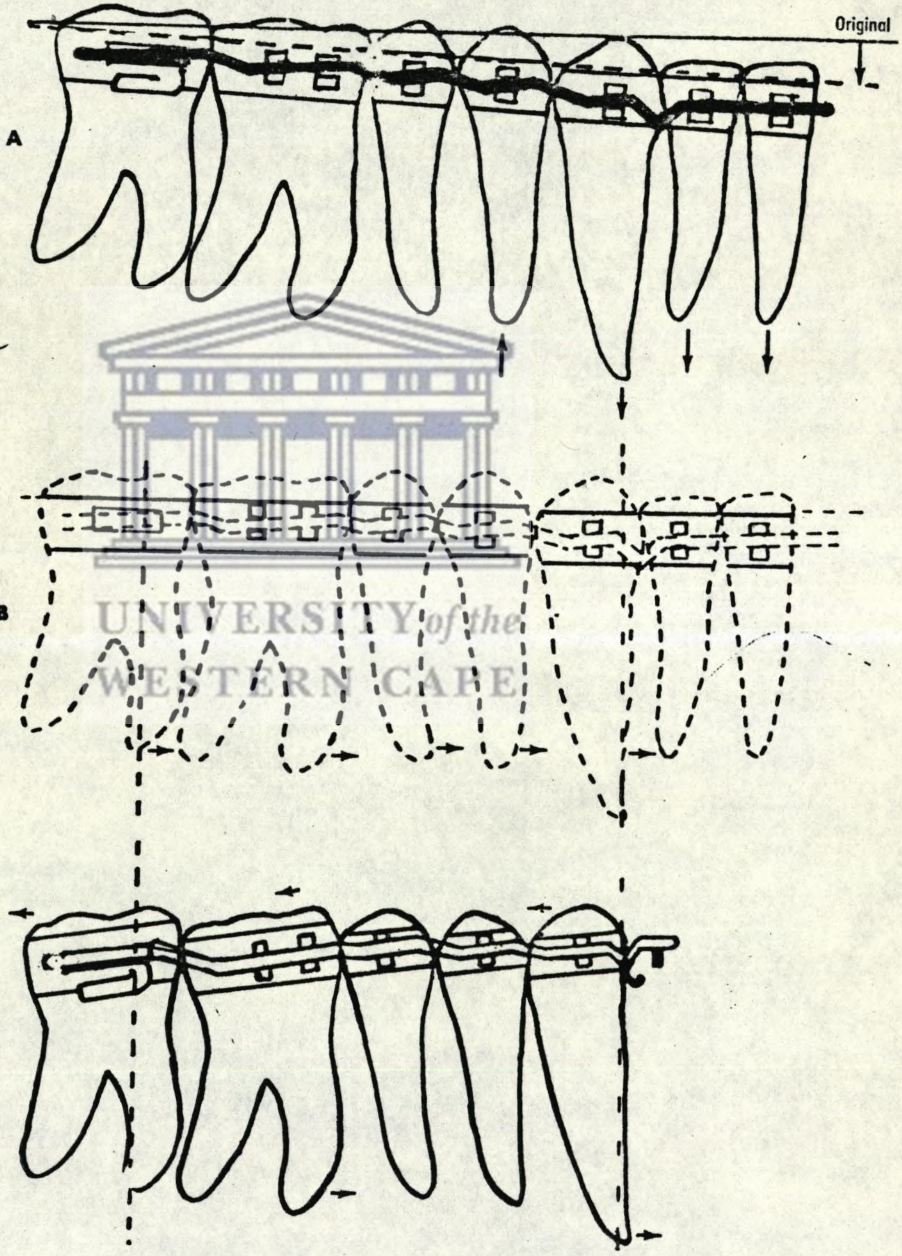
Second:The establishment and maintenance of a stable anchorage is fundamental in TWeed's technique IT was Tweed's contention that for teeth to resist the forward pull of the elastics and the occlusion they must be tipped distally.He likened this to the idea of a tent peg 's best inclination for resisteance against a strong wind.He would conserve this anchorage by tipping teeth which were in an axial inclination such that they were offering excellent mechanical resistance against displacement to reduce this resistance to a minimum.

Third :All forces from an orthodontic appliance must be synchronized if they are to be optimally effective.

A denture is arranged in an arch form ,thus the incisors are arranged in the coronal plane of space while the buccal segments are in the sagittal plane.When using a combination of distal tip backs and lingual torque ,the effect is to tip the tooth crowns distally therefore the degree of tip back force must harmonize with the degree of lingual torque or else one will be acting against the other.

It was once considered that the best anchorage or resistance to tooth movement came from undisturbed bony trabeculae ,however , Tweed disturbs all the bone around his anchor teeth and still adapts the teeth to resist displacement.This is doneby distal tipping of the molars and premolars,Should any of these teeth have such a force put on it that it tends to tip forwards it exerts a downward pressure on the tooth immediately in front of it.Since resistance to downward pressure is greatest of all resisting power (functional demands require this to be so) the anchorage is extremely effective.

Fourth: Tweed found that the lower incisors resisted relapse tendencies best if placed over the bony ridge arising from the mental area of the body of the mandible.From this he constructed the diagnostic facial triangle .So important did he consider this that it became his primary objective in treatment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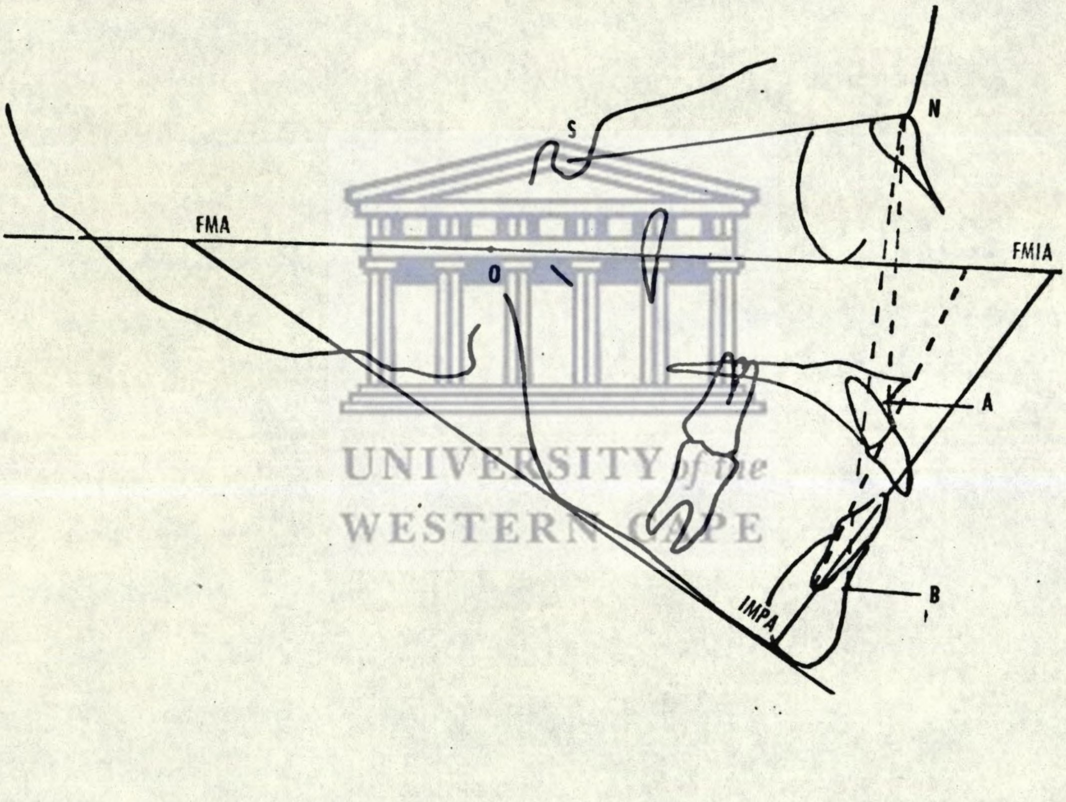
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Holdaway (1952) who was a student of Tweed's suggested certain modifications to the Tweed technique which would eliminate as far as possible the procedures of archwire fabrication which are difficult to reproduce in subsequent arches.He suggested the use of angulated brackets instead of angulated archwires i.e.second order bends.He considered that the roots could be paralleled as part of the treatment,posterior anchorage could be prepared and teeth could be artistically positioned using angulated brackets.

Holdaway stresses the necessity of parallel roots after space closure to prevent relapse .The angulated bracket technique ensures this by moving the roots in front of the crown thus over correcting the paralleling of the roots.

The direction of movement is of course dependent on the tooth's position relative to the extraction site.

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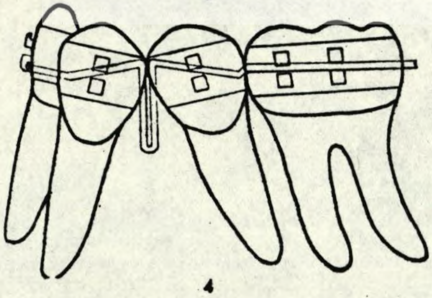

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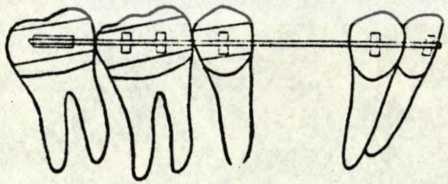
HOldaway considers that the attempted duplication of anchorage preparation arches which incorporate second order bends is not only time consuming but expensive from an anchorage point of view.He considers that the apparent fluidity of supporting bone where anchorage has been lost is not due to the initial backward tipping of the anchor tooth but the continued alteration of the root to supporting bone relationships ,due to the 'jiggling' from new archwireswhich breaks down the supporting structure and thus anchorage.

The degree of tip incorporated in the bracket governs the amount of anchorage prepared.

A reverse curve of Spee is built into the mandibular archwire to aid in anchorage by elevating the premolar and tipping the molar back even further.This also has the advantage of keeping the lower molar out of contact with the upper molar and ao facilitating the distal movement of the upper molar.The bracket on the second bicuspid must be placed at a lower (more gingival)level than the mean bracket position on the molar otherwise the larger molar teeth in tipped back positions would leave the second bicuspid out of occlusion
It must be mentioned that in extraction cases requiring maximum anchoragethe bracket angulation on the second bicuspid must be less to prevent interference with the root of the cuspid near the end of space closure.If this is not taken into account the result may be root resoption of the bicuspid or the cuspid or both.
Bracket angulations may also be used for the artistic positioning of the teeth,especially the upper lateral incisors.It seems more logical to gradually align the teeth in the correct positions than to place artistic positioning bends in the archwire at a later stage as a correction factor.



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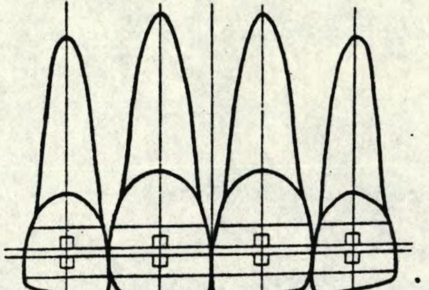

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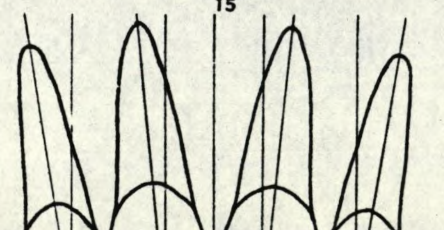


16

The Bull Technique

This technique was evolved by Dr.Harry Bull for extraction cases in the permanent dentition in class 11 and bimaxillary protrusion cases .Triple width brackets are used on the molars,premolars ,canines and maxillary central incisors to counteract rotation tendendies.The maxillary lateral incisors and the lower incisors use double width brackets.An .021 x .025 inch stainless steel archwire is used throughout the treatment except for initial levelling and derotation when round wires are used.

The Bull technique is based on the belief that arch width cannot be increased except in cases of crossbite where there has been collapse of an arch,Also ,dental arch length cannot be increased successfully where crowding of teeth is present ~~and~~ moreover arch length should be maintained or reduced.The technique avoids the necessity of duplicating archwire bends in subsequent archwires and when it is necessary to upright a tooth the bracket is rotated ,this requires removal of the band.In 1951 Bull suggested using sectional arches .0215 x .025 inches from canines through the second premolar to the molar.This sectional arch incorporates a closed loop between canine and premolar with a tie back stop from which to activate it to pull the canines distally.A bite plate is recommended to facilitate the movement of the caninesThe canines are moved distally only sufficiently to upright ,derotate or eliminate crowding,as much space as possible is retained distal to the canine teeth. Where more than half of the first premolar space is necessary to accomplish this,either intermaxillary elastics must be used or in some few cases the first molars extracted..The incisors are now repositioned still maintaining the space distal to the canine which Bull referred to as the'strategic space'.Upper premolars are now extracted and the upper canines retractedto completely close the extraction space.Now upper and lower full arches are used along with class 11 mechanics to retract the upper incisors and to move the mandibular molars and premolars forward to establish a class 1 relationship.Both upper and lower arches incorporate Bull loops and tie back stops.

Since Bull relies on tooth movement and accomplishes it within the confines of the arch width ,arch length and jaw relationships of the original malocclusion then extractions are necessary.

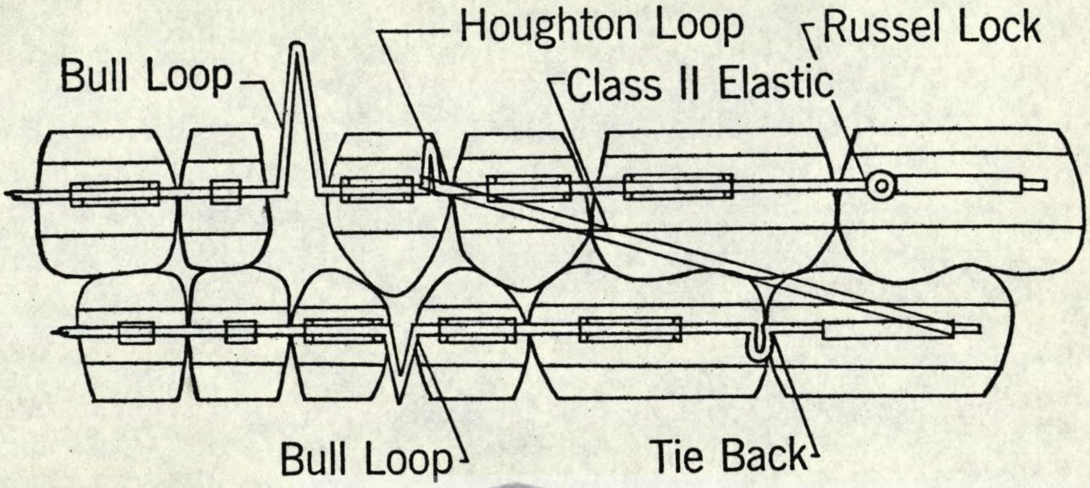


FIG. 594. Edgewise appliance as constructed for the Bull technic. (Harry L. Bull)

<u>Bull compared to Tweed</u>

Tweed uprights the teeth and tips them distally for anchorage preparation and retracts the mandibular incisors and canines until the space s are closed.

Bull uprights the posterior teeth and then moves them forward to a class 1 position.

Tweed uses the mandibular arch as anchorage while Bull depends on intramandibular stability as the buccal segments are moved anteriorly and the maxillary teeth are moved posteriorly.

THE UNIVERSAL APPLIANCE

The Universal Appliance

This was designed mainly by Atkinson according to Yudelson.It is a light wire appliance which uses a double channel,double action bracket.

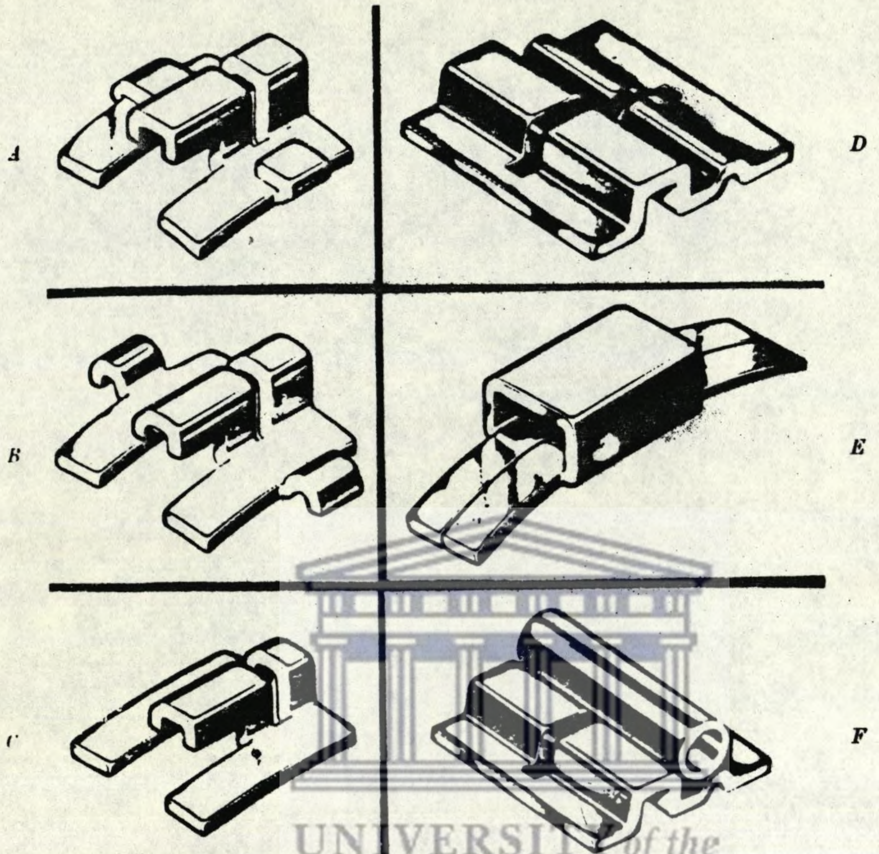


Fig. 2. The different types of Universal bracket. *A,* "Double-action" type; *B,* "root-torque" type; *C,* "curve" type; *D,* double buccal long-channel lug; *E,* horizontal type of lingual sheath; *F,* double buccal long channel with round tube to accommodate extraoral appliances. (Courtesy of Unitek Corporation.)

This design of bracket allowed the orthodontist ,for the first time to use either a ribbonarch or a round wire singularly or together,or a round wire in each channel .The wires are held in by means of a lock pin.When the wires are locked in the occlusal wire will be brought to bear against the top surfaces of the wings of the brackets as well as the base of the occlusal slot,while the gingival wire will be against the underside of the wings and the top of the gingival slot.

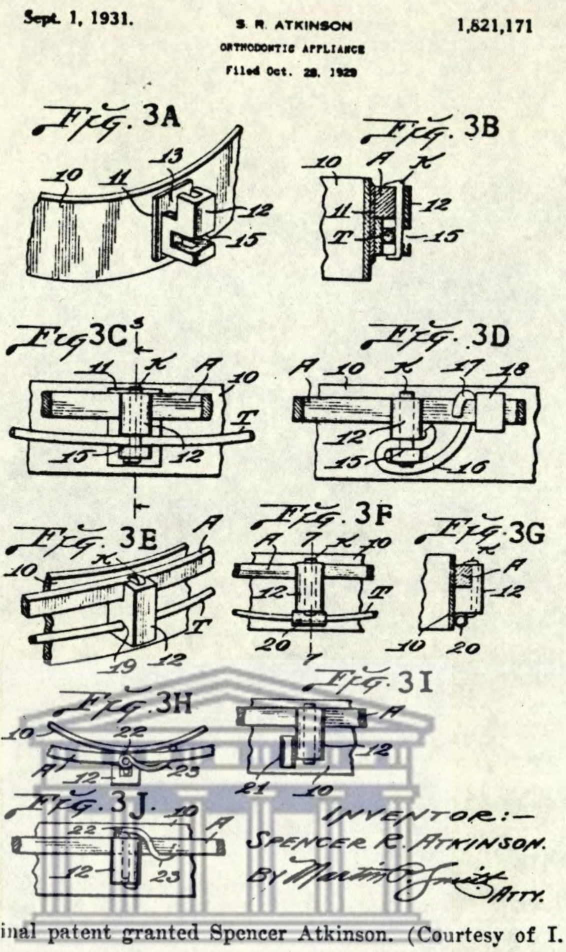


Fig. 3. Copy of original patent granted Spencer Atkinson. (Courtesy of I. Eugene Gould.)

Fig. 4. *A,* The bent end of the lock-pin engages occlusal wire, pulling it against the occlus aspect of the bracket's wings. The pin then passes labially or buccally to the gingival wir as in *B.* The end is cut off and burnished along the bracket, "locking in" the wires in us

When an occlusal wire is used alone it acts against a surface from the most mesial tip of the mesial wing to the most distal part of the distal wing of the bracket on each tooth. When a gingival wire is used along with this occlusal wire the surface against which it bears (bearing surface) is effectively doubled.This distance can be increased by using the root torquing double action bracket which has wings that turn out from the centre thus increasing the bearing surface.Because of this action and with both wires acting in concert the universal bracket becomes a four dimensional appliance allowing tooth movement in a mesiodistal and a buccolingual direction ,rotation on its axis and movement in a vertical plane.If the ribbon arch is torqued a further dimension in tooth movement is available,that of moving the tooth away from its vertical position.

On the lingual surface of the mandibular molars are welded lingual sheaths each with a distal indent known as the 'Dillon dimple' after its innovator C.F.Stenson Dillon. This dimple or indent acts as a lock to hold the lingual arch. This lingual arch is used primarily as anchorage and is so designed that it touches the lingual surface of the second premolars(if they are in an ideal arch position) and the lingual aspect of the cingulum of the four incisors.It must not touch the lingual of the canines since this is the anchorage unit against which the canines are to be retracted.

The lingual arch also guards against rotation of the molars during canine retraction.

A maxillary anterior bite plate may be used to open the bite,to relieve any mechanical locking of the maxillary first permanent molars to their antagonists if class 11 mechanics is applied,and to prevent mesial drift of the remaining premolars by adding a spur to their mesial surfaces.

Basic Technique with the Universal Appliance.

1.Alignement of the posterior segments

At this stage the case has only the buccal segments banded,up to the canines. An 0.012 inch round wire ,recurrent on itself is placed in all four quadrants.This wire passes through the gingival and occlusal slots of the double action brackets.These wires are replaced every three weeks,graduating to an 0.014 inch round wire as the teeth assume their correct positions.

2.Retraction of the Canines

The canines are retracted using single contraction coil springs to move the teeth bodily along an arch wire..With this appliance 2 ounces of force are all that are considered necessary.The levelling wire here is still sectional but is now made from 0.008 x 0.028 inch wire doubled back on itself at the molar region and is inserted into the occlusal slot of the bracket.

The coil spring is the Nagamoto design which is held in place by the locking pin of thecanine passing througha portion of the coil turned at right angles to the rest of the coil. Distally the coil is unwound and the wire burned.It is then threaded through the gingival slot of the second premolars where the locking pin will secure it,and on through the gingival channel of the first molars .The coil is activated by gripping it distally and pulling it through the bracket of the first premolar until activated by 1mm.The wire is then wrapped around the distal extension of the levelling wire.

3.Retraction of theAnterior Segments

This is effected in much the same way as the canine retraction i.e.by means of Nagamoto contraction coils.The levelling wire used at this stage ,now that the anteriors are banded,is usually 0.012 inch. The retraction coils are set distally to the laterals.

As levelling proceeds a multiple wire arch may be inserted This is usually two 0.010 inch wires in the occlusal slots. (These wires are soldered together at their ends.)

When all the spaces are just about closed the arch wires used depend on the remaining correction necessary,but a typical arch would be 0.012 x 0.028 inch ribbon arch in the occlusal slots and a round wire arch (0.014) is placed in the gingival slots.

4.Retention

The choice of retainers depends on the operator , but before they are placed the band space must be gathered up. All bands are removed except canines and molar bands.The last used ribbon arch is placed and the spaces closed using contraction coil springs

THE JOHNSON TWIN WIRE APPLIANCE

The Johnson Twin Wire Appliance

This technique was presented as one that could provide continuous,gentle and automatic tooth movement.Some of the advantages of this appliance over the heavier wire appliances are;a fine guage wire is more resilientand can return to their normal shape thus moving the teeth,bodily movement of the anterior teeth is facilitated by the sliding movement allowed by this appliance.Torquing of the anteriors is not easy to accomplish with this appliance.

The twin wire arch çonsists of a doubled stainless steel wire of 0.010 or 0.011 inch which fits into stainless steel end tubes.The end tubes must be differentiated from the buccal tubes which are to be found on the molars.The twin wire arch fits into the 0.022 inch end tube which in turn fits into the 0.036 buccal tube.

At the beginning of treatment only the four incisors and the first permanent molars are banded.

The wire arch is attached to the bands by one of at least four types of anterior bands .These are shown in the diagram below.

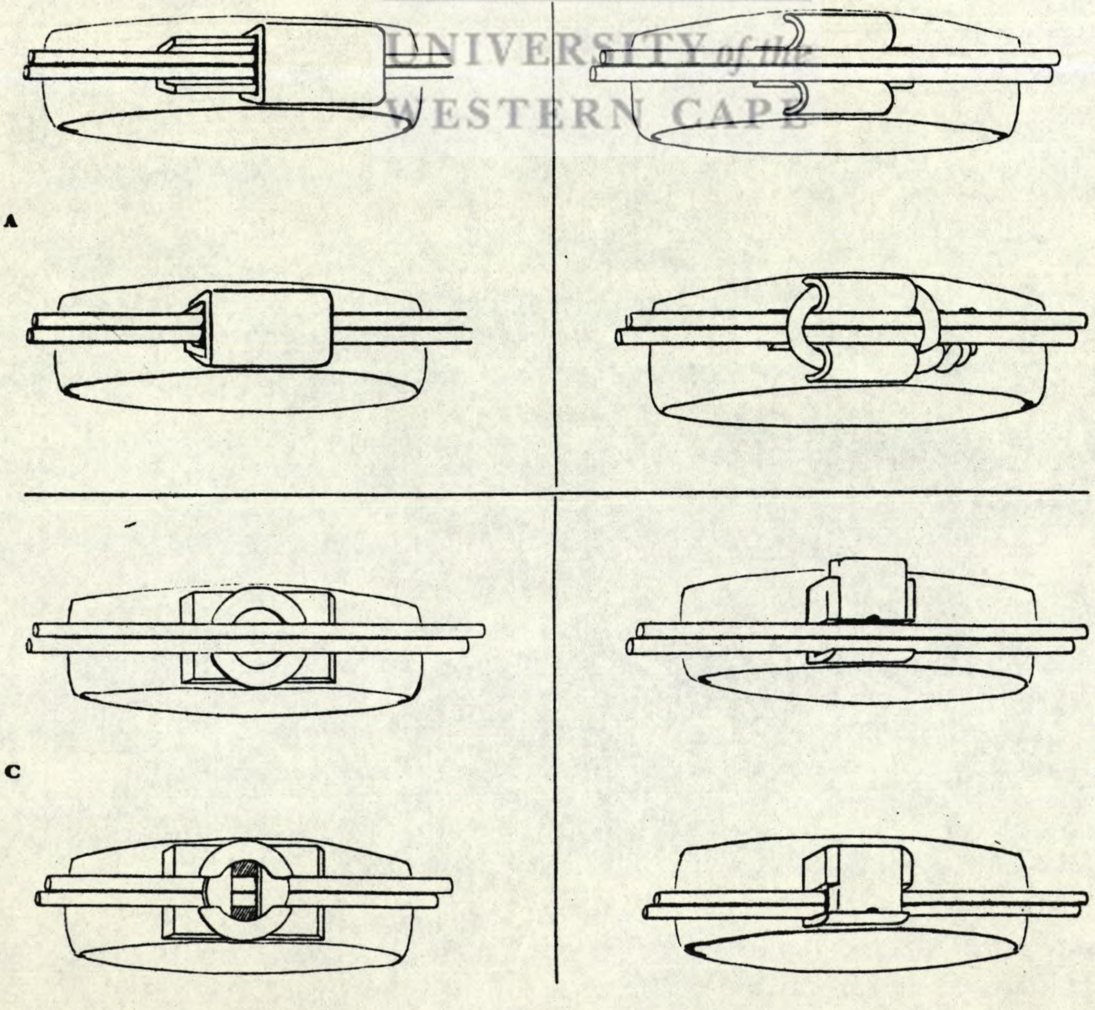


Figure 87. A, Diagram of original Johnson friction cap. **B,** Twin-tie channel bracket. **C,** Ford type lock. **D,** Sliding "gate" lock.

The twin wire arch is fabricated as in the diagram and consists of two end sections covered by the end tubes ,and a central section of twin wire

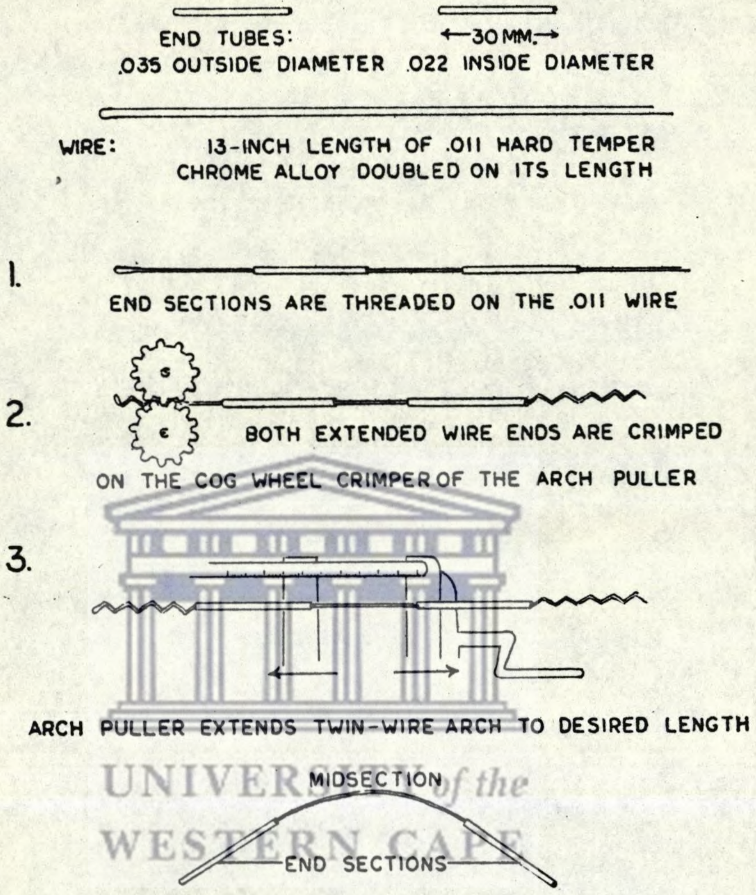
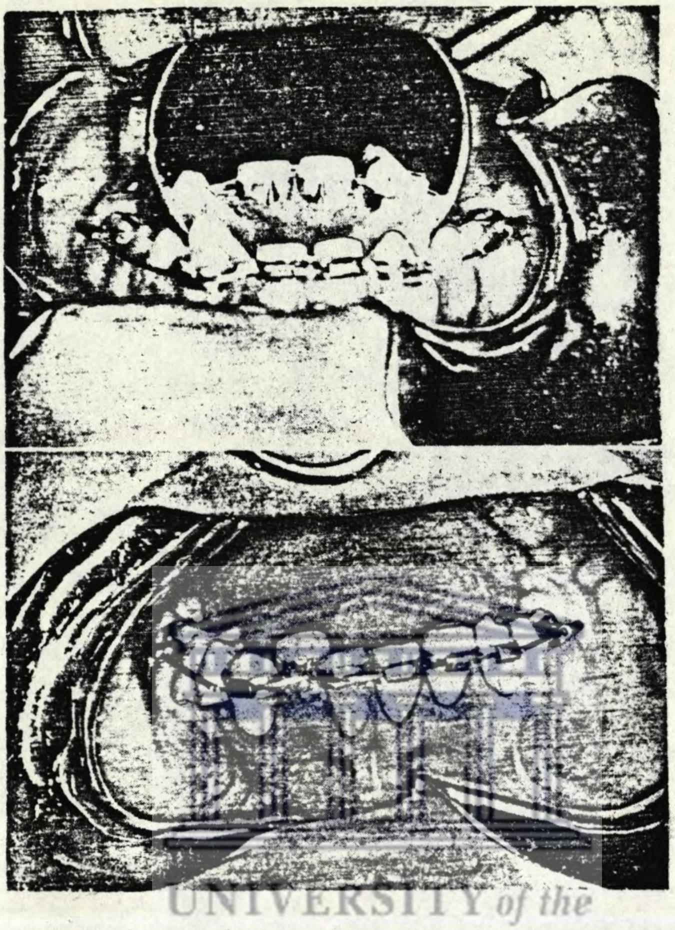


Figure 117. Twin-wire labial arch construction.

The end tubes have hooks soldered onto them if elastic traction is to be used in the treatment.Also coil springs can be added to the archwire before the last end tube is fitted to move teeth mesially or distally.
When fitting the twin wire arch ,especially the initial arch, care must be taken to avoid excessive force which would lead to pain thus the arch is crimped around gross tooth irregularities ,the crimps are gradually elimnated as the anterior teeth become more regularly aligned.Alternatively ,

one of the methods of partial seating may be used .



Appliance Mechanics

The end tubes are placed in the buccal tubes oftthe molars, this allows the anterior segment of the arch to assume a normal dental arch shape without bending or manipulating. (Salzmann and Johnson (1966). When the wire is sprung into position on the malposed teeth and locked, the resiliency of the twin wires makes possible the automatic movement of the teeth until the wire returns to its original shape. Although the wires fit accurately in the channel of the lock , there is enough play to allow a sliding movement of the tooth along the wire in a mesial or distal direction. Shepherd (1961) considers the twin wire appliance capable of moving the crowns and roots of the teeth in labial, buccal, lingual, mesial, distal, occlusal and gingival directions automatically.

When there is excessive eruption or extrusion of anterior teeth

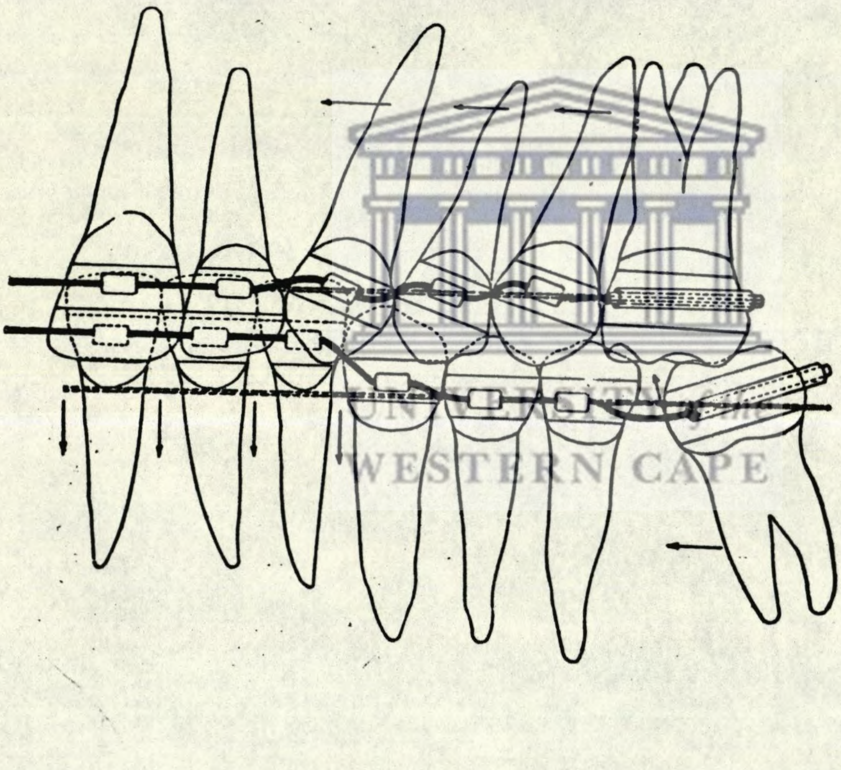


FIG. 547. Method of using the twin-wire arch to bring canines and premolars into perpendicular position, straightening tipped molars, closing space due to loss of tooth in the mandibular arch and to depress mandibular incisors. The dotted lines indicate the position of the twin arch wires at the completion of tooth movement.

they can be depressed if the twin wires are made to lie gingivally and then are sprung into the brackets.

In moving molars distally coil springs are placed over the 0.036 inch end tubes so that when the arch is locked into the anterior teeth the coils are compressed against the molars.

Coil springs are also used in this appliance to close diastemata and move incisors labially where necessary.

The lingual arch may also be used with the twin wire appliance to stabilize the molars and act as a framework for auxiliary springs if necessary.The maxillary lingual arch is not extended farther forward than a line joining the mesial surfaces of the canines.This arch may be used for expansion of the molars.

The mandibular lingual arch can be reinforced by soldering a labial extension which passes distal to each canine.This provides additional anchorage.

To correct crossbites the upper lingual arch is used along with cross elastics.

Open bites are treated with up and down elastics from loop spurs soldered onto the lock caps.

Molar rotation is corrected by the lingual arch.

A flat wire arch may be used when treating any malocclusion which requires bodily movement of teeth.This wire is usually 0.010 x0.020 inches and has less tendency to tip anterior teeth outwards during lingual and labial movement.

With the twin wire appliance elastics are worn practically at all times during treatment of all malocclusions.

THE BEGG TECHNIQUE

B

Begg Technique

According to Begg,his technique causes no discomfort to the patients,no loosening of the teeth and no damage to the periodontium,while at the same time the teeth are moved rapidly and the forces exerted are easily controlled.The technique is based on the principle that in moving anterior teeth with relatively small root area ,relatively light archwires and light elastic ligature force are required to produce the most rapid movement with the least disturbance of the tooth investing tissues.

Begg recommends the use of the narrow ribbon arch bracket since it produces a minimum of frictional binding and facilitates tipping of the teeth.The narrow bracket also allows greater interbracket distance thereby permitting greater resiliency with less force. It allows one point contact.

Bands are placed on incisors,canines and first permanent molars. The premolars are banded as space closure nears completion.

Archwire

Tip back bends are placed in the molar area,and the canine to canine distance is increased by opening the interbracket loops to the desired distance in order to align the anterior teeth. These interbracket loops allow the force to be of longer duration and reduced in degree.The amount of loop opening is determined by the crowding component.

Everything required in moving and rotating teeth is bent into the archwire.This includes intermaxillary hooks,vertical loops and tip back bends.An uprighting coil spring is used to parallel and upright the incisor,canine and premolar roots and an auxiliary 0.014 inch torquing arch is used for the anterior teeth.The main arch wires are made from 0.016 inch wire. The wire used in the formation of these arches must be Australian orthodontic wire which is very resilient,tough and strong.Begg considers that his technique could not have been developed and cannot be employed without this type of wire.

The tip back bends in the molar area of the archwire are intended to move the teeth,open the bite and at the same time move the ante rior teeth distally into the extraction spaces without

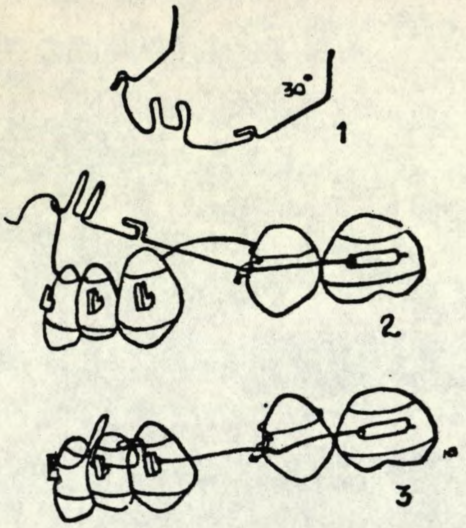


FIG. 597C. First stage. (1) Arch designed to move upper left central incisor lingually. Note 30° tip-back bend placed in distal arms of arch. (2) Anterior segment of arch lies in mucobuccal fold when arch is placed in molar tubes. (3) Arch pinned in brackets and ligated to premolar.

depressing or tipping the molars.The bends should not be strong enough to tip the first molars distally but should be sufficient to prevent these teeth from coming forward. The arch slides through the buccal tubes and carries the anterior segment distally ,closing the extraction spaces.This is aided by light elastic force,thus distal movement of the maxillary anteriors is obtained while the molars are kept stable.

Extra-oral Anchorage

According to Begg and Kesling (1971) the introduction of the light round archwire technique has eliminated the need for extra oral anchorage.With this technique ,all teeth except the anchor molars are subjected to only simple free tipping of their crowns throughout the treatment until the last stage of treatment.In this last stage when their axial inclinatio are being corrected ,very light root torquing and root tipping forces are used.These forces are so light that tooth roots move quickly through the bone without building up high resistance to their movement.It is this low resistance to tooth movement coupled with the high reaistance to movement of the anchor molars which accounts for the reduction of the tendebcy of the dental arches to move forward and which therefore also allows us to dispense with extra oral anchorage.

The Three Stages of Treatment with the Begg Technique

These three stages are distinct and must not be allowed to overlap.It is chiefly to prevent anchorage failure that this technique uses three stages.All tooth movements in all stages are carried out simultaneously.

First Stage

The tooth movements to be effected in this stage are,the correction of crowding and irregularity and the teeth are brought beyond regular alignement into positions of over movement by simple tipping of their crowns.The spaces between anterior teeth are closed and rotations are overcorrected.Deep anterior overbites are overcorrected to open bites and the anterior teeth are brought to an edge to edge relationship, unless there is an existing anterior open bite ,in which case the teeth are brought to normal or even deeper overbites when the original openbite was very pronounced.
Anteroposterior relations of the crowns of all teeth are over correctedand crossbites are corrected at this stage.
The crowns of the anterior teeth are allowed to tip in any direction in response to archwire and elastic force..The contours of upper and lower dental arches are coordinated in form and occlusion and at this time the extraction spaces are reducing.
Finally the axial inclinations of the anchor teeth are corrected.
anchorage in this technique comes from the molars.

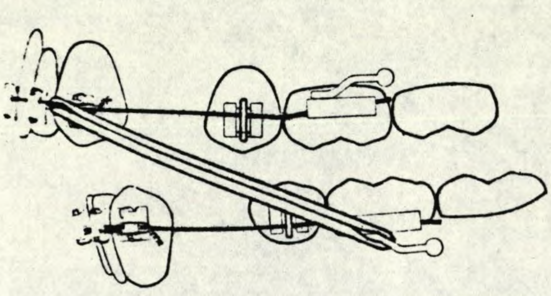


Figure 194. All appliances, including Class II intermaxillary elastics, are placed in position on the first day at the start of treatment. This set-up is typical for start of the first stage of treatment of Class I and Class II malocclusions.

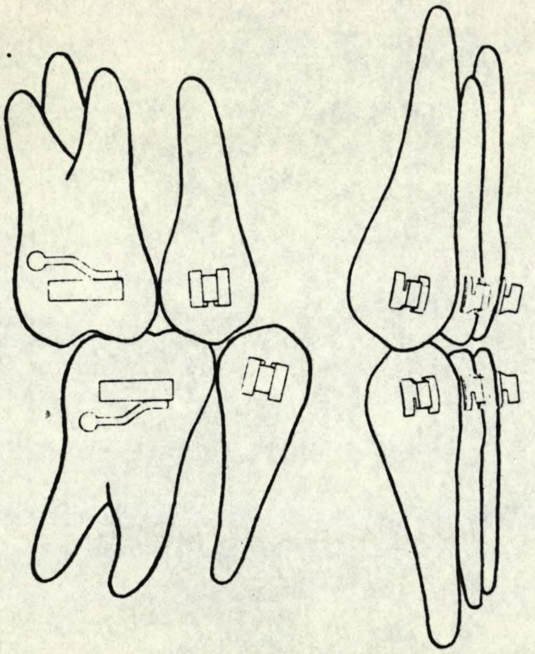


Figure 200. Positions of the teeth at the end of first stage of treatment.

Second Stage

Before proceeding to this stage the first stage of treatment must be completely finished,it is not permissible to continue with the next stage in just one arch.

In this stage the extraction spaces are completely closed and the crowns of upper and lower anterior teeth become tipped further back than at the end of the first stage.All tooth movements accomplished in the first stage must be maintained The closure of extraction spaces is done in a separate stage to ensure that the anchorage is not strained allowing mesial movement of the molars and resulting in insufficient space for retraction of the anteriors.

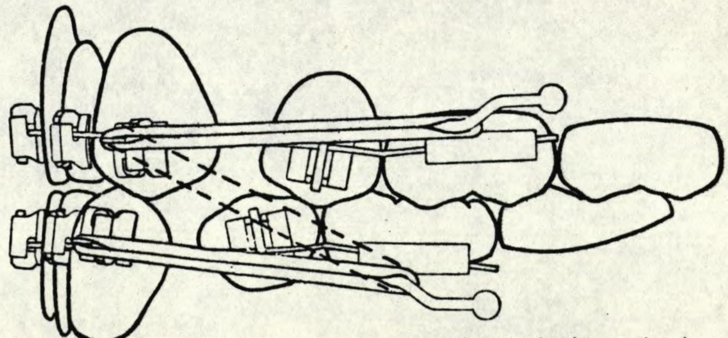


Figure 203. Space-closing elastics and Class II intermaxillary elastics applied at start of second stage of treatment.

========= As required to maintain desired molar relationship

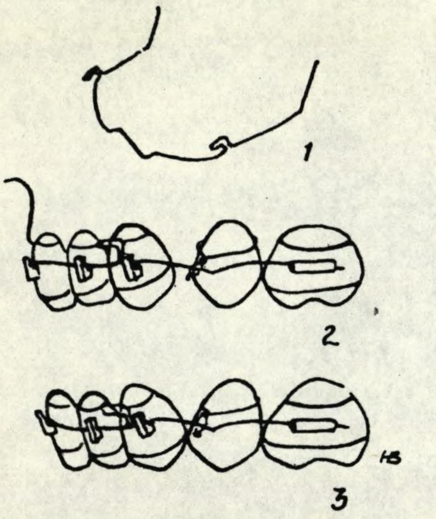


FIG. 598. Second-stage arches. (1) Stage 2 arches with bayonet bend replacing loops. (2) Stage 2 arch pinned to brackets and ligated to premolar. (3) Extraction space completely closed with horizontal elastics. The canines and incisors are well tipped back.

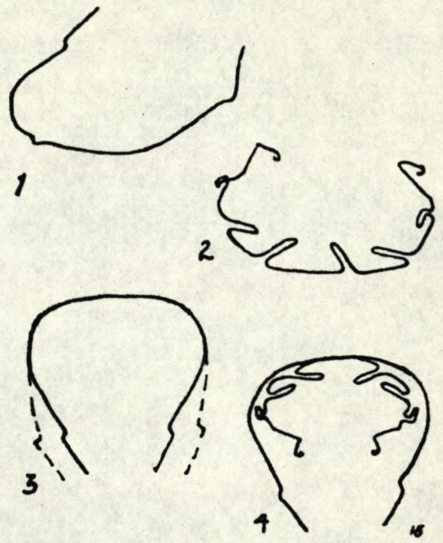


FIG. 599A. Third-stage arches. (1) Main arch with bend to mark midline, molar offset, and tip-back bends. Bayonet bends are placed to replace loops. (2) Anterior root torqueing auxiliary arch. (3) Overcontouring of main arch to offset buccal flaring forces of torqueing arch. (4) Relationship of torqueing arch to main arch.

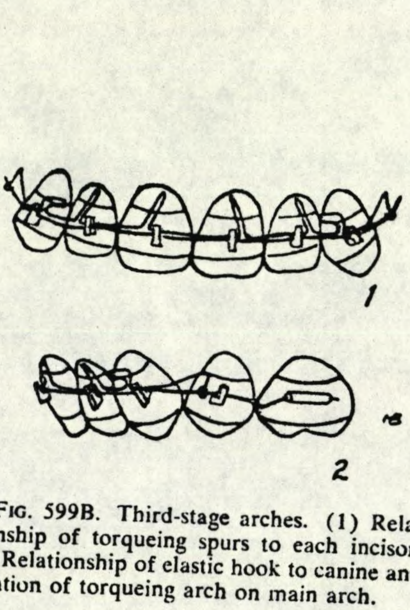


FIG. 599B. Third-stage arches. (1) Relationship of torqueing spurs to each incisor. (2) Relationship of elastic hook to canine and fixation of torqueing arch on main arch.

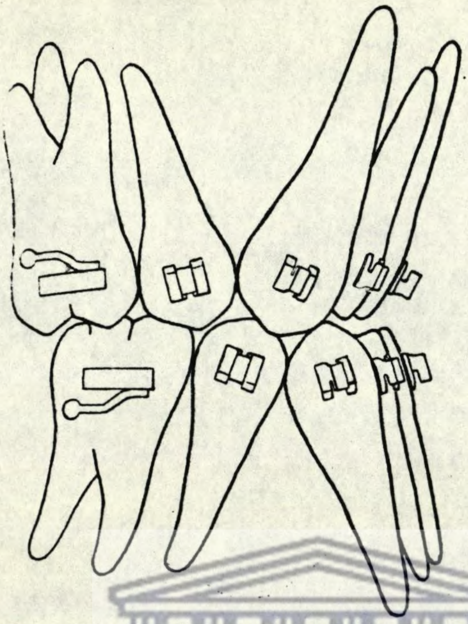


Figure 206. Positions of teeth at end of second stage of treatment.

Third Stage

The axial relations ,labiolingual,buccolingual and mesiodistal are simultaneously overcorrected in this final stage.This stage chiefly comprises movement of the roots. Root movement is acheived in this technique by the use of root torquing springs and uprighting springs,these move the roots in buccolingual and mesiodistal directions respectively.

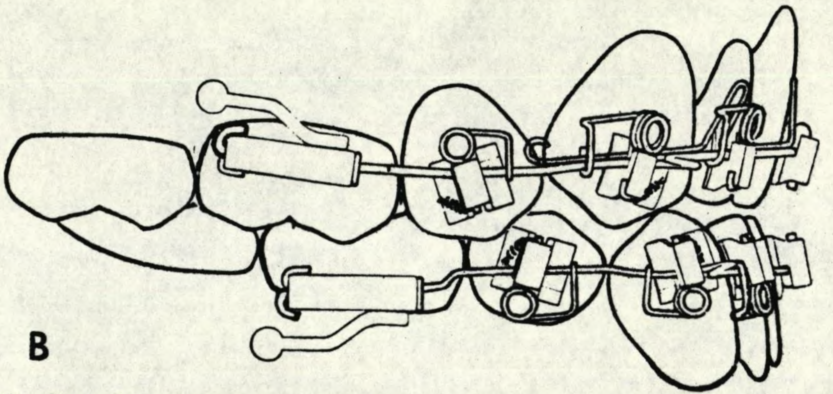


Figure 207A. Start of third stage of treatment. At this time an upper auxiliary arch wire was placed to torque roots of all upper incisors lingually. Springs were placed on upper lateral incisors and on all canines to tip their roots distally and on all second premolars to tip their roots mesially. **B.** Typical arrangement of [illegible] and Stage 3 appliances at the beginning of Stage 3.

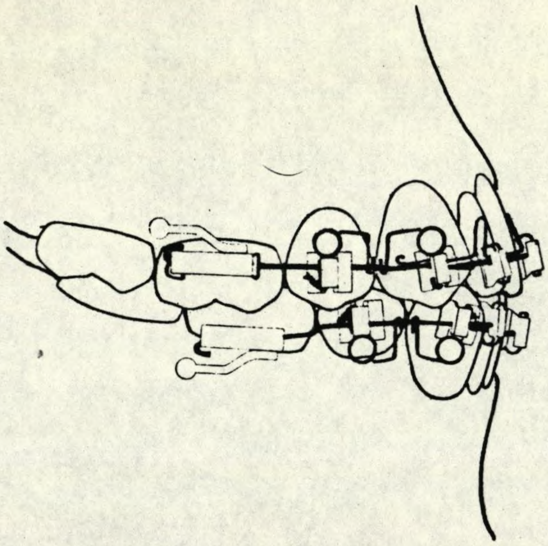


Figure 209. Appliances in position at the end of active treatment. The root-tipping springs and upper root-torqueing auxiliary have corrected axial relations of tooth roots.

Retention in the Begg technique uses an upper acrylic plate shown below

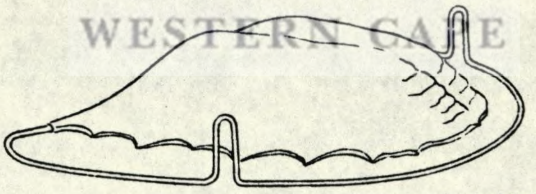


Figure 216. The form of upper retention plate used by P. R. Begg. No lower retention plate is used.

The advantage of this appliance over the Hawley applaince is that its wire does not tend to keep the crowns of upper premolars and canines apart and it can be used to tip the crowns of the canines,premolars and molars slightly lingually if required.
No retention is used in the lower jaw.Begg and Kesling (1971) consider that as deep overbites are eliminated by depressing teeth in their sockets and as rotated teeth are overcorrected

in this light wire technique there is such a high degree of posttreatment stability that is is seldom if ever necessary.

Final tooth position is usually established with a positioner.

Advantages of Removable Appliances

1. Generally simple in construction
2. Require little surgery time for fitting and adjustment
3. Can be easily repaired.
4. If the activating mechanism is disturbed the plate can be left out of the mouth before there is any signifiant damage.
5. The plate can be removed for cleaning which also facilitates cleaning of the teeth
6. With careful designing the appliance need not be displeasing in appearance.

Disadvantages of Removable Appliances

1. Active cooperation of the patient is required if the appliance is to be worn properly.
2. Tend to be bulky
3. Only a limited range of tooth movements are possible.

Advantages of Fixed Appliances

1. They do not rely on patient cooperation as heavily as removables.
2. Multiple tooth movement may be carried out with the same appliance.
3. Less bulky
4. More precise in their action.
5. They may reduce the length of active treatment.

Disadvantages of Fixed Appliances

1. Multi-banded appliances require considerable surgery time for fitting and adjustment.
2. Repairs may be time consuming.
3. If they become distorted they may have an untoward effect on the dentition before the patient can return for treatment.
4. They cannot be removed to facilitate the cleaning of the teeth or the appliance.
5. Expensive.

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