14075

THE JOURNAL

—OF THE—

National Dental Association

VOL. 3

MAY, 1916

No. 2

ORIGINAL COMMUNICATIONS.

SOME BASIC PRINCIPLES AND METHODS IN THE REPRODUCTION OF MANDIBULAR MOVEMENTS.

By Dayton Dunbar Campbell, D. D. S., Kansas City, Mo.

(Read before the National Dental Association.)

IN THIS paper it is the purpose of the writer to show how all movements of the human jaw that are of importance to us as Prosthetists, may be used as guides to reproduce like movements on a variable or adjustable mechanical contrivance, termed an Articulator.

Eleven pairs of muscles are attached to the mandible and by the action of one-half pair, or more, of muscles, a certain definite movement is described along some path of the jaw. The return-to-rest position or distal occlusion is accomplished by the other half of this same set of muscles or may be so modified by the action of the other pairs or groups of muscles as to cause its return by a more circuitous route.

In securing the different tracings of the mandible in its varied movements,

we are to concern ourselves with that portion only of the tracing that is nearest the position of rest. We consider this portion and neglect the rest of the tracing because the wide-open jaw, great protrusion, and extreme lateral movements are of no importance in masticatory effort.

As astronomers, after a few hours' observation of some satellite, are enabled to compute correctly the diameter of its orbit by simply referring to the arc of the circle described by the eye piece of the telescope, so we, having established a tooth plane, (as herein described) are enabled to compute the angle of inclination formed by the condyle path, the lateral condyle path, and the incisal path, in conjunction with this plane, thru simply consulting a portion of the tracing

produced by the mandible in some one of its movements.

The most extraordinary feature of this whole procedure is that the centers from which these paths are reproduced have no tangible location in the individual but are purely imaginary. However, these centers do have on the Gysi Adaptable Articulator a definite position and on it are easily located. The Gysi Adaptable Articulator is a practical as well as a scientific instrument and one that enables the student to arrive at a knowledge of the various movements of the mandible so that this information may be used to construct eminently sat-

Figure 1.

isfactory dentures upon the Gysi Symplex—an articulator that is not adjustable but having an average condyle path, lateral condyle path, oscillating or rotating points, and an Incisal guide.

The Gysi Adaptable is for the student and teacher, and your essayist is constrained to believe that it will never become popular with the majority of the profession. The ideal articulator, of course, would be the mandible and maxillae of each individual patient and there are some in the profession who obtain excellent results by placing all the teeth in their respective positions on the contour or bite plates while in the mouth. A modification of this rule is advisable and in all instances is essential where the Gysi Adaptable is not used.

Let us here point out the fact that Anatomical Occlusion is not a panacea for all the denture ills to which the Prosthe-

tist is heir. Anatomical Occlusion is but one factor in the process of the construction of a proper masticatory apparatus for the edentulous mouth. By Anatomical Occlusion we mean the proper distribution of leverage in the arrangement of the teeth so that in the incisal or masticatory effort of the jaw, the dentures may be balanced or prevented from tipping. This may be simply illustrated by attempting to balance a hoop or U shaped piece of any material on two points; it may be done, but with three, four, five, or more points of suspension, it becomes less difficult. Let us say, then, "three or more points of contact."

It would seem then, on first thought, that Anatomical Occlusion was of no importance until the teeth were in contact—or occlusion—and that, up to this point, the retention of the denture was purely a question of adaptation in the upper or of weight in the lower. But in constructing the dentures, we place the teeth so that, approximately, a line drawn from the crest of the upper to the lower will pass thru the long axis of the tooth and at right angles to the base planes of the plates, in this way (Fig. 1) satisfying the two physical laws of force controlling the leverage with which we are concerned, i. e. first, Force moves in a straight line and at right angles to the surface from which it emanates; second, The combined direction of two or more forces is their resultant. It is now apparent that the phrase Anatomical Occlusion is, in a measure, a misnomer; for in many instances it would be the height of folly to set the teeth anatomically correct as they are set in the mouth which has a full complement of teeth in good occlusion.

Here each tooth sets rigid in its respective alveolus while the same tooth on the plate is on a moveable base. The upper has absorbed up and in and is smaller; the lower, down and out and is larger. The teeth must be smaller and should

be sharper than a normal tooth so as to more easily comminute the food and lessen the stress upon the easily irritated membranes under the bases. Figures 2-A, 2-B, 2-C, from the Dental Digest show

Figure 2-A.

diagrammatically the cutting power and action of wedges—cusps. (Fig. 2-A).

"I—Upper and lower teeth set to straight up and down movement only may be diagrammatically illustrated by the two wedges here shown. It required much force to push them thru the food shown as "F." This is illustrated to

Figure 2-B.

every man who shaves, by the fact that a straight downward movement of the razor across the little hairs "pulls" while a slight sideways movement, does not.

A sideways movement of the teeth may be here diagrammatically represented by two wedges and the food by the round body between them. If the wedges

are forced thru vertically great pressure will be required. (Fig. 2-B).

If the wedges be put in the position B. and moved in a direction shown by the arrows very much less force will be required. The reason is that the cutting form of the wedge is changed. With this motion the form of the wedge is not the triangle formed by the lines A, D, E, but the much sharper angle which is drawn inside each triangle and lettered A, A-1, and A-2, and B, B-1, and B-2, and exactly reproduced in the position C. (Fig. 2-C).

Figure 2-C.

This greater biting power can be seen by comparing the triangles in position C with those in position A. The triangles A, A-1, and A-2, and B, B-1, and B-2 have about three times the biting power of the triangle A, D, and E."

It is absolutely essential to the construction of a perfect set of teeth, that the foundation trial plate of the denture be of some rigid construction that will not warp, spring or give when heated to body temperature by placing in the mouth; and deviation from this rule will be paid for later by loss of time, oft' times by loss of temper, and in no small number of cases, by loss of the patient. One of the trial-plate materials on the market is very brittle, thru an excess of

shellac; another is elastic enough to creep away from the cast when apparently cold, therefore, this one is treacherous; another, and by far the best, contains a goodly amount of gutta percha.

By placing a piece of this trial plate over the cast, and warming it gently and evenly with the brush flame of a blow pipe, it will conform to the cast with a

ion models or trial plates, the base is vulcanite.

After the bases are sandpapered they are poured with plaster of paris, and the occlusion models prepared, by kneading a sheet of pink paraffine wax over a flame until the grain of the wax disappears and it becomes a homogeneous mass; this is rolled out to the thickness of the little finger, one end held in the flame and the dripping wax conveyed to the crest of the ridge of the base plate; the roll of wax is now conformed to the ridge and given

Figure 3.

very little assistance of moistened fingers.

Your essayist prefers the vulcanized base advocated by Dr. George H. Wilson, in his Double Vulcanization Method. It takes very little more time to construct, and possesses two distinct advantages. First, in the event of a faulty impression or if for some other reason the trial base is not a perfect adaptation, the time and labor of constructing the entire denture anew is saved. Second, the vulcanized base may be mounted on the Gysi Adaptable Articulator and after the dentures are completed, returned to the articulator to prove the occlusion. In this article where reference is made to occlus-

Figure 4

the general shape of the universal base plate gauge, made of sheet steel, patterned by Dr. Gysi and shown in Fig. 3. By using this gauge as a guide, the upper and lower occlusion models assume the same definite shape and form, and when the patient arrives, much time is saved at the chair. (Anyone desiring one of these gauges need but send a few cents postage to the writer when it will be mailed free). Both occlusion models are made larger than necessary so they may be trimmed to the proper length and contour. This is decidedly better than having them too small and attempting to add to them at the chair.

The crest of the ridge of each occlusion model is now pressed against some smooth surface and made flat. Insert the upper model and try the adaptation; if satisfactory trim the wax down to a

sixteenth of an inch below the lip line when at rest, and from the medium line to the heels, so that the resulting surface of the ridge will correspond to the original tooth plane.

This tooth plane is the starting point in the scientific arrangement of artificial teeth for edentulous mouths. We will constantly refer to it, measure in almost every direction from it, and come back to it repeatedly; in fact, every movement of the jaw and every tooth on the base, is given its particular position with ref-

barely touches it like the lateral in front, while the third molar has stepped away quite a bit and that the incisal edge of the central is slightly below. This holds good in nearly every instance and every student of anatomical articulation is urged to verify this for himself either by his patients or from casts practically normal in occlusion.

Now with this "knitting needle tooth plane" in mind, we proceed to trim the lower border of the upper occlusion model to it; by placing a foot ruler along the

Figure 5.

erence to this plane. Its correct location is of more importance by far than that of the median line, still it is no more difficult to locate. If we were to take almost any adult mouth containing a full complement of teeth (Fig. 4) and in fairly good occlusion, and grind off the sharp cusp of one of the bicuspid; then place a knitting needle against the ground cusp and run it back thru the sulci of the two bicuspid and first molar, we should find the remaining portion of the needle out of the mouth to be on a horizontal line, parallel with a line drawn from the base of the nose to the external opening of the ear. So this knitting needle then, is the tooth plane (Fig. 5) and if we could look thru the patient's cheek, we should see that the first molar

Figure 6.

side of the face, we may draw a line on the face from the base of the nose to the external opening of the ear, however, one soon becomes proficient with a ruler and a small case knife and it is seldom necessary to mark the face. The blade of the case knife is held tightly against the occlusion surface of the model with the left hand, the right hand holding the ruler; by sighting along the ruler and noting the position of that portion of the knife out of the mouth, the changes to be made in the wax are indicated. (Fig. 6). A tendency in the projections of the two lines made by the ruler and knife respectively, to meet in front, means that the wax model is too long in the molar region—which is often the case; the reverse of this, a tendency in

the projections of these two lines to further diverge, is evidence that more wax must be added in the molar region rather than that the anterior part, which has already been trimmed to meet requirements of the lip line, should be cut away.

In this process of conforming the base of the upper occlusion model of the tooth plane, it is oftentimes advantageous to sprinkle the maxillary surface of the base with powdered gum tragacanth; this will literally stick the plate up to place, and while assisting the operator, will lend confidence to the patient.

The lower occlusion model is now inserted and trimmed to the approximate length and contact, removed, and its surface heated from heel to heel lengthwise with a sizzling hot spatula; this heating is continued until the surface, except for its borders, is liquid. The advantage of heating the surface lengthwise may now be readily seen, since to draw the hot spatula crosswise would be to invite the melted wax to flow off of the model. The lower occlusion model is returned to the mouth and the patient instructed to close easily, but firmly, until the lips assume a natural position of rest, easy and not protruding. Protruding lips may be caused by the occlusion model being too large or shutting too close together. This latter condition, especially in the "biscuit bite" is the bugaboo of the dental laboratories, who, by the way, construct dentures that are marvels in adaptation and workmanship—when you take into consideration the impressions, "bites" and meager instructions they receive.

The lower model is now removed and the excess wax cut away and returned to the mouth to get the relation of the two models with the jaw at rest, i. e. in distal occlusion. Every dentist has his favorite "method" of "getting the bite"—so it will be sufficient here to note that when the proper relation of the occlusion model is obtained, the anterior ramifications of the temporal muscles may be left to stand out distinctly under

biting stress, a muscular contraction that cannot be created by any other position of the mandible. With the occlusion models in their correct relative positions, the medium, high, and low lip lines, are indicated and all other marking and contouring done; the models are removed separately and placed in cold water.

The location of the condyles may be ascertained by placing the index finger about one quarter of an inch in front of the tragus of the ear and on a line drawn to the outer canthus of the eye. As a matter of convenience, this point may be marked with a pencil or a bit of black court plaster. At this juncture if the Gysi Simplex is to be used instead of the Adaptable, the prongs of the fork of the Snow face-bow are now heated and forced into the body of the upper

Figure 7.

wax occlusion model; an attempt is usually made to get it in the median line, and parallel with the tooth plane, altho neither position is imperative; the end of the fork may stick out of the corner of the mouth at an angle of a Bowery tough's cigar. If it be securely fastened in the wax model, it will, on account of the universal joint of the face—bow proper, answer the purpose for which it is designed, and that is, to obtain the relation of the maxilla to the condyles. In other words, the face-bow is the dentist's divider or caliper for producing the correct distance from the condyle of the jaw to the cutting edge of the upper incisors and a means by which this individual Bonwill equilateral triangle may be transferred correctly to the articulator. This is its sole function and should in no wise be confused with the operation commonly known as "taking a bite."

Here (Fig. 7) we have a set of teeth mounted on an occluding frame where no

face-bow is used. This same set of teeth is placed in the mouth with the result shown in Fig. 8; the distance from the condyle to the incisors is shorter when placed in the mouth, than the distance from the hinge of the articulator to the incisors. In other words, in opening and closing the articulator the cutting edge of the lower incisors describes an arc of a larger circle than will be described by the same point when placed in the mouth, consequently, the molars touch first. There can be no guess work about this; in every mouth the alveolar process of the maxilla bears a certain relation to the condyles of that particular jaw. With this distance properly registered, the "bite" can be raised and lowered with impunity, should the occasion demand it. This accounts for the action of the teeth on the old plain line occluding frame—when we tried them in the mouth they did not act so well at first, fact is, not until the wax became warm and the teeth bit into position unwittingly and to our satisfaction. Had we finished them then, without trying them again on the occluding frame, all would have been well—but no, we noticed a space between the upper and lower molars, and so we "fixed it."

With the prongs of the fork securely fastened in the upper occlusion model, it is returned to the mouth with the lower and the jaw closed in distal occlusion. The universal joint on the bow is slipped over the tail of the fork now protruding from the mouth, with the set-screw beneath the bow. The screw is set up tight and then loosened just enough to allow for proper adjustments. This is better than having the set-screw loose and depending on the patient to tighten it. It also gives the operator an opportunity to step away from his patient to make better observations. The ends of the condyle bars are set over the marks which indicate the tubercles of the condyles of the jaw, slightly touching the face, while care is taken to see that they

are at equal distances from their respective lock-nuts thru which they run. This is done by counting the sections on the bar from the inner end of the bar lock-nut and adjusting the bow at the universal joint until the sections number the same on both sides. The universal joint is then set right, for this position must be maintained until securely mounted on the articulator. It is never necessary to set the lock-nuts up securely on the condyle bars while the bow is on the face.

With the face-bow adjusted, the lips are parted and the models securely united with two Bristol steel belt staples. These staples should be warmed in a

Figure 8.

flame by holding in the fingers and out of the patient's sight; then pushed firmly into the occlusion models in that region between the cuspids and first molar. When they are held in the flame with a pair of pliers, they get too hot, melt the wax and defeat the purpose for which they are intended; then, too, the patient is afraid of being burned, and oft' times shifts the jaw to some position that is not desired. After removing the occlusion models and face-bow intact, the casts are placed in the former and held in place by sealing their borders with sticky wax. The condyle bars of the face-bow are pushed all the way in and tightened, they must now be sprung over the extension pins of the Simplex Articulator. The occlusion surface of the occlusion model must now be on a parallel line with the lower bow of the articulator. This is imperative because the relation of the occlusion surface of

the model to the hinge of the articulator must correspond to the relation which the tooth plane bears to the condyle of the mandible. (Fig. 9). The Simplex Articulator has no adjustable condyle path and in the light of our present knowledge, it is not of so much importance as it was once thought to be—then too, the old method of securing the pitch or slant of the eminentia articularis by the protrusive bite and transferring this measurement to the articulator, was always approached with apprehension and, when finally secured, there was a vague

Figure 9.

sense of uneasiness lest the results were not what we should like to obtain—this was especially true when a great discrepancy was known to exist between the two eminentia.

Dr. Gysi cites one instance where there was a difference of 39 degrees and the writer recently noted a case where there was a difference of 48 degrees in the two eminentia—the discrepancy was so glaring as to indicate some error—but all doubt was eliminated with the knowledge that the lower occlusion model was held securely in position by two Gilmore clasps and that the condyle path register never varied in its markings. For the general practitioner the writer believes that the average condyle path of the Simplex with the additional improvement over the former so-called

Anatomical Articulator of an average lateral condyle path and an average incisal path, will give more gratifying results than any articulator that has come to his observation—excepting, of course, the Gysi Adaptable—and insists that the former be used in conjunction always with the face-bow.

An adjustable condyle slot articulator would be sufficient if in masticatory effort we moved the jaw in and out, open and shut, like an elephant or alligator. But we don't masticate our food in this manner, we open the mouth slightly, laterally, while the bolus of food is thrust between the teeth with the tongue, and as the teeth are brought into antagonization, the liquid in the bolus is squeezed out and the final returning to occlusion lateral movements comminute or grind the food. A diagrammatic scheme of this movement is shown in Figure. 10.

A. Showing the cusp action (in section) of either a normal natural denture or properly constructed artificial dentures. On the masticating side, the mandible is obliquely depressed, moved over to that side by the pterygoid muscles, carried upward by the masticating muscles (temporal and masseter) until the cusp-to-cusp position is established, penetrating the food and partly expressing the juices from the bolus. The lower jaw is then drawn obliquely towards the median line until the lower buccal cusp rests in the upper masticatory groove as shown here in B, crushing the food and forcing it between the cusps. This process is repeated a sufficient number of times, thoroughly comminuting and insalivating the food when deglutition follows. The diagrammatic scheme C. gives us an idea of the vertical and lateral movements of the mandible in masticatory movements of the mandible in masticatory efforts. Beginning at A, the position of rest with buccal cusps of the lowers in the masticatory groove of

the uppers the jaw is depressed and subsequently drawn further towards the masticating side and at the same time, the tongue thrusts the bolus of food between the teeth. Then the masticating muscles draw the separated teeth to the cusp-to-cusp position, condensing the food and expressing the juices and in the balance of the movement, B, the cusps slide back home to the rest position as in B, performing

There is no articulator on the market, save the Gysi Adaptable, that gives us a desirable rotation point for each individual patient. The Simplex with its fixed average lateral condyle and oscillation or rotation point, comes nearest it.

The drawing (Fig. 11) discloses correct and incorrect theories regarding the movement of the mandible at the condyle during the lateral movement to which reference has already been made. It

Figure 10.

their grinding and masticating function. Thus we see how impossible it is for the New Century and similar articulators to mimic this movement of the jaw. Another feature of the lateral condyle path is, that it provides for more nearly proper intercuspation of the teeth, thereby maintaining and insuring better retention of the dentures.

In each individual case there is a particular individual lateral path thru which every cusp of every tooth in the jaw passes in the lateral movement; but this particular individual path is contingent upon the correct location of the oscillation or rotation point upon which the mandible swings.

has been supposed that when the jaw was swinging on the masticating side, that it was simply swinging in a rotary movement with the opposite condyle as a center. Prof. Gysi has shown that this is incorrect and that in the lateral masticatory movement, the whole mandible moves inward laterally as well as forward while on the other side the condyle, instead of merely rotating, (as shown in the incorrect drawing) moves slightly outward as in the correct drawing. These rotation points should not be confounded with the articulator portion of the condyles in their relation to the glenoid cavities. As we have previously stated, these do not exist in the

natural jaw, but are imaginary points founded upon deductions made from measurements taken of the mandible in its lateral excursions. They are real points, however, on the mechanical articulator, and represent the mechanical center out of which this lateral movement can best be reproduced.

The Simplex Articulator has its rotation points inside of, below, and behind the heads of the condyles; and in the lateral excursion the lower incisors pass sideways and forward under the upper

teeth to the "curve of Spee" of the mandible; and while it is exemplary to follow nature in every possible way in arranging artificial teeth, there are problems and conditions that exist in the edentulous mouth, such as retention, easily irritated membranes, kicking muscles, etc., that can best be taken care of by applying a knowledge of physics and some principles well known to mechanics. The working out in the wax of a compensation curve is, in many instances, not necessary nor advisable in constructing den-

Figure 11.

incisors—more nearly mimicking nature than the articulator which is constructed with the rotation points *in* the condyles and which, as a result, forces the lower incisors more directly forward.

A distinct improvement is the incisor Guide Incline, which is, in fact, a reversed lingual aspect of the incisors. A Guide Pin keeps the casts from being forced together in manipulation, and thus lowering the bite. Consequently all of these improvements give us an articulator which will permit the grinding of the artificial teeth to forms that will be more efficient when placed in the mouth.

There is a method of trimming the wax occlusion models just before arranging the teeth, to a "compensating curve," corresponding in artificial den-

tures on either of the Gysi Articulators, and especially in the exaggerated cases, a positive detriment to the dentures. In those cases where there is a marked discrepancy in the width of the upper and lower jaws, the following cross bite is used advantageously. (Fig. 12). The first and second right upper molars are placed in the positions usually occupied by the first and second left molars, the latter occupying the position of the former, the remaining upper and lower molars are criss-crossed likewise, while buccal cusps of the now upper molars are placed to occlude between the buccal and lingual cusps of the now lower molars. This scheme, aside from giving more freedom to the tongue, brings the masticatory groove over the crest of the ridge, and

within the line of force exerted in masticatory effort.

The Gysi Adaptable Articulator. (Fig 13).

We will now return to the occlusion models that were placed in the bowl of water, remove the lower and press into its occlusion surface, the horse-shoe plate so that the two pins that are to receive the condyle path register are on either side of the median line. There are four rather long pointed pins upon this horse-shoe, which, when pressed firmly into the wax, hold the plate se-

the side of the horse-shoe plate. This plate thus serves the two-fold purpose, of pressure gauge, and of an outline from which to trim the wax on the upper occlusion model so that there may be no obstruction on its surface which would prevent free movement of the mandible.

To facilitate the gliding of one occlusion model upon the other, the surfaces of each are lubricated with warm cocoa butter. The condyle path register is now slipped over the pins made to receive it. Its weight and proportions are

Figure 12.

Figure 13.

curely. (Fig. 14). This is obviously essential since any movement here would give a false tracing at the pencil point. The lower occlusion model with the affixed horse-shoe plate is now placed in the patient's mouth. The added thickness of the horse shoe plate would, of course, raise the bite; to avoid this, the upper occlusion model is heated with a hot spatula from heel to heel by drawing the spatula lengthwise until the surface is a pool of wax. When the wax is congealed sufficiently, it is placed in the patient's mouth again with a request to close firmly. This will allow the occlusion models to assume the desired relations and at the same time will press the wax thru the V shaped segments on

so evenly distributed and balanced as to require nothing else to hold it in position on the jaw.

As a matter of convenience, the lateral condyle path tracings are made first by placing the points of the vertical pencils opposite the outer tubercle of the condyle—the point previously marked on the cheek with a pencil or a bit of court plaster. (Fig. 15). The lateral condyle path register is now placed over the patient's head (see illustration) with the ground glasses resting lightly upon the vertical plane or an average condyle path. The register is balanced on the finger and the glasses are pressed firmly against the head. The patient is now instructed to "make side movements," to use Dr. Gysi's own expression, and be-

fore the patient makes these satisfactorily, viz: without opening the mouth or moving the head, a certain amount of coaching is often necessary. The lateral register is now laid aside until the measurements are to be transferred to the articulator.

The pencil holders are now turned around and adjusted to point directly at the outer tubercles of the condyles. (Fig. 16). A card is placed between one of the pencils and the face, with the straight edge base of the card parallel with the

bles the one opposite, especially in degrees of inclination to the occlusal plane. The tracings following an opening movement of the jaw are usually definite and well defined, while the return-to-rest movement often traces a circuitous route. The reverse end of the card is held in a like manner against the other side of the face and the tracing made for this side by the same method. The card is now placed aside with the lateral condyle path register for future use. The condyle path register is

Figure 14.

occlusal plane, represented here by the broad, horizontal plates of the condyle path register. The pencil is moved up against the card, by means of the rack and pinion provided for this purpose, until the spring behind the pencil is sufficiently compressed to mark upon the card. The patient is now instructed to open and close or to make lateral movements; the tracings thus secured are intensely interesting and a few moments study here, will do more to teach one something of the movements of the mandible, than a complete set of text books on the matter. The tracings are as varied as the faces we meet on the street and while the tracings of all condyles have the same general form, it is a rare thing indeed, that the tracing of one condyle resem-

removed from the horse-shoe plate, care being taken not to alter the position of the pencil points since this condyle path register is to serve the purpose of the face-bow in mounting the casts on the articulator.

It is the practice of the writer at this time, to remove the bite plates, wash them off in cold water and give the patient a rest while mounting the incisor path register and blackening the anterior portion of the horse-shoe plate to receive the tracings of the steel point of the former.

The incisal path register (Fig. 17) is designed to trace the lateral movements of the jaw upon the blackened anterior portion of the horse-shoe plate in order to give us a template or guide for the cor-

rect location of the rotation point. The anterior pointed part of this tracing is the forward point of the individual Bonwill triangle of this particular patient. The steel point of the incisal path register, is placed in the median line of the upper occlusion model and high enough that the point while tracing may be seen by the operator.

The anterior portion of the horse-shoe

Figure 15.

plate is given a thin coating of inlay wax to which has been added a quantity of carbon, collected from an acetylene jet or obtained by burning a pledget of cotton dipped in oil of cloves. The black wax on which the teeth come will not do as it is too soft. The occlusal models are now returned to the mouth and the steel point of the incisal path register is released from the horizontal slot which has, until now, held it up out of the way, and let down into position.

The patient is instructed to move the jaw from side to side and this exercise

is repeated until the blackened wax presents a broken and irregular triangular

Figure 16.

field with well defined borders, coming up to a sharp point in front. There is

Figure 17.

absolutely no guess work about this tracing. When the steel point rests in the

anterior point of the triangle, the mandible is in distal occlusion—the steel point cannot rest in this anterior portion of the triangle with the jaw in any other position.

The occlusion models are now securely fastened together with the Bristol steel belt staples.

The lateral condyle path register (Fig. 18) is now laid upon some flat, preferably white, surface so the tracings may be readily seen. A ruler is laid across the

Figure 18.

two ground glass plates and a base line drawn thru the two rest points of the tracing. From each of these rest points, a vertical line is erected at right angles to the base by means of a little square like those used in mechanical drawing. The square is used to extend the tracings to the edge of the ground glass, the degree plate is slipped under the glass and its point, on the rest point of the tracing, and the nought degree base on the vertical line—the extended line of the tracing will indicate on the degree plate the proper inclination. The degree of inclination is marked on the ground glass with a lead pencil as a matter of convenience. The operation is repeated on the other ground glass. The

lateral path set-screws upon both sides of the articulator are loosened and set to correspond with the degree indicated on the ground glass. The card with the condyle path tracings, (Fig. 19) is now

Figure 19.

laid flat and a line drawn thru the "working portion" or parallel to it. The other tracing is treated likewise, the base of the degree plate is held against the base of the card and the point of the extended tracing where it leaves the card—where the other end of this line passes thru the circumference of the degree plate—will be noted the number of degrees of inclination the *ementia articularis* is inclined from the occlusal plane.

The little pin is removed from the low-

Figure 20.

er end of the incisor guide pin, (Fig. 20), and the screw that secures the condyle degree plate on the articulator is loosened and the indicator placed to corre-

spond with the tracings on the card, and the screw tightened again.

The casts are now placed in the occlusion models and sealed in place with sticky wax; the horse-shoe plate is again pushed into the holes in the condyle path register and this in turn, fastened to the goose neck on the iron stand which is designed to support the condyle path register while the casts are being

the oscillating or rotating points so that the teeth will, when placed in the patient's mouth, inter-cusate properly.

The Bristol steel belt staples are removed and the steel pin in the incisor register liberated. The oscillating points are in or out, as the case may be, so that the radius between this point and the steel point in the incisal path will be the proper distance to permit the steel

Figure 21.

luted to the articulator. The straight incisor guide pin is exchanged for the curved incisor guide pin, so that the incisor path register may be placed in the median line of the articulator and the ends of the pencils placed at the heads of the condyles. The pencils may be moved in or out with impunity, provided the incisor guide register is in the median line.

After the casts are luted to the articulator, (Fig. 21) the condyle path register and its supporting goose neck are removed from the horse-shoe plate and the final adjustment made—that of setting

point in the incisal path register to exactly retrace the outer border of the triangle in the wax on the horse-shoe plate. The oscillating or rotating points are fixed, the incisal path register and horse-shoe plate removed and the straight incisor guide pin replaced. The thickness of the horse-shoe plate is replaced by a few drops of wax in the molar region; markings on the occlusion models are transferred to the upper cast for future reference; the wax is cut away the length of one side of the occlusal model, and the teeth arranged beginning at the median line.

*Discussions.**Dr. J. F. Stephan.*

I haven't had the pleasure of meeting Dr. Campbell, but have had the pleasure of reading his paper. To say that I liked it is expressing it mildly. The paper has been very instructive to me. The essayist has gone very thoroly into detail, and consequently anything I might say would be repetition and unnecessary. There are just a few points, however, I should like to speak of. It seems that the occlusal plane is the key to the entire situation, and anything that makes it more easy to get that is quite an addition. It is evident to all of us that the more scientific the instrument with which we can rebuild the lost dental organs, the better service we can render our patients. There is a device known as the Dabney Occlusal Plane Gage which will simplify the taking of the occlusal plane and make it a little more accurate than by the method of drawing a line with a ruler and watching that. In other words, you can manage your models, and pay less attention to the drawing of the line of the face.

It has been interesting to me to note the progress of the articulator, it having been invented about the year 1805. It has taken a century to develop this machine. It took about half a century for Dr. Bonwell to give us the Bonwell triangles. It took about a quarter of a century more to get a change in articulators that would give us a more truly anatomical articulation. I remember when I attended school in 1890, Dr. C. S. Case asked us to cut the old plane line articulator in the upper portion, the portion that held the upper casts, and to cut a slot a quarter of an inch in length, in order to get something on the order of the present condyle path as we know it, and to file off the sides of that portion that fitted between the lower part of the articulator. This gave us the possibility of the side and lateral motion

of the condyle path, and by placing a piece of soft rubber between the wire that held these portions together, and the upper portions of the articulator, we were able to reproduce in a nice way something of anatomical articulation. It was in 1895 that my brother added to this, and that was the first time, I think, that the condyle path and the Bonwell triangles were united in one instrument. I have never, however, seen credit given to him for that advance. His parents on that were recorded. That antedates any other advance along these lines, even in the Bonwell articulator, the uniting of the inclined condyle path and the Bonwell articulator in one instrument. I think credit should be given Dr. Case for his advance in 1890, and to my brother for his advance in 1895.

It is true, as the Doctor has brought to our attention, that the rotation points are not found in the condyles, and that the location of the rotation points is a most important factor. We know that during life the klenoid fossa, which is sometimes one-sided may be greatly out of position. I remember making a denture as a substitute for teeth for a patient eighty years old, and who had been without those teeth 37 years. I made three dentures, and I had to carry the lower jaw a quarter of an inch back of its protruded condition. The articular point had been changed. We will find that in many cases, and if we use an instrument that will enable us to scientifically and correctly locate the rotation point, so as to reproduce the lost organs correctly, then we are doing scientific work. In the Gysi articulator there seems to be one important change that should be made, and that is in the incisal plane. I think that should be made adjustable, because if the over-bite is short, and the rotation points are between the condyles, then with the present articulator we cannot reproduce that as well as we should. If the over-bite is long, where the rotation points are

outside of the condyles, it is more nearly correct. True, the difference in rotation is not much in degrees, but if we are to do scientific work and be correct, then those points should be made adjustable, as the condyle path is.

Dr. Campbell's paper has been so exhaustive that it would require considerable study for all of us to thoroly comprehend all his points. I wish to thank him for writing the paper, and the Committee for asking me to do what little I might do of service on this program. (Applause.)

Dr. Charles A. Hawley, Washington, D. C.

I feel somewhat embarrassed in attempting to discuss this paper, because I had not the privilege of seeing it before it was read. I am therefore in the position of an extemporaneous speaker. In addition to that, this work that has been presented is entirely outside of my field of work. I presume the President of the Association, when he asked me to discuss the paper, thought I might contribute something to the subject in the way of study of the tempero-maxillary articulation from the standpoint of an orthodontist. It is probable that the orthodontists in the last ten years have observed as closely and have studied as carefully this articulation, as any other class of dentists. I will only present this view of the problem. We know that it is rare to find a denture in anything like normal occlusion. You rarely find a set of teeth where there have been normal mandibular movements during life. You are not seeing the jaws of people who have been treated by orthodontists, or perhaps that would not be true. So you have people in whom the condyle path is abnormal. In children and in people who have been fortunate to develop a somewhat perfect mandibular movement, you have a normal tempero-maxillary articulation. Now you are attempting to place in a skull, where this articulation is abnormal, and

adapted to a purely artificial motion of the teeth, governed by their occlusion and by the number of teeth they have lost, a denture which must be moved along perfect paths, and you of course will have some difficulties along that line. As far as the observations that have been made as to this tempero-maxillary articulation go, we know it changes at all times of life. Bone grows and changes constantly, according to the pressure not only of the hard and soft tissues, but according to the movements of the muscles. The question entered my mind as to how much it would be possible for you to take account of that fact. We have in the skulls of people places where this articulation is entirely different, where it is adapted to different positions of the teeth. Recently I saw a remarkable skull in which the condyle had established articulation actually on the temporal bone; on account of loss of teeth, the mandible had moved forward and to one side, and established articulation in that place. We find many which have established almost a fixed articulation on one side and a sliding on the other. I wonder what occurs when you insert in that jaw a denture that is articulated according to this method. (Applause.)

Dr. Alsosfar.

The essayist has imparted so much information upon the subject in hand, and that information is so scientific, that he leaves little for me to do save to call attention to some details and principles which could not be included in his paper without making it too long.

The first of these details is the character of the series of movements by which the mouth is opened and closed in the taking and mastication of food.

The first part of the opening movement is straight downward, and that when a certain degree of opening is reached the movement leaves the straight line and deflects to the right or

left, to the side engaging in mastication. The upward movement is nearly vertical until the teeth come into contact in lateral occlusion. Thru the movement in which the upper and lower teeth articulate, the mandible returns to the position of central occlusion.

The distance which the jaw habitually moves laterally when masticating without consciousness of that movement, has never been determined, but it is believed to be very short in most patients. I have had many patients in whom the condition of the wear in the teeth indicated the presence of rather wide lateral movements. The extent of this movement doubtless differs with different people.

I believe, however, that we should not confine the lateral movements of our articulators to the distance actually traveled by the jaw in this unconscious lateral movement, because it would not then be possible to so place the teeth that the dentures might not be dislodged by wider movements of the mandible. A wider range in articulators enables us to arrange teeth better. This is merely an application of the principle to which Dr. Gysi has often called attention, that our appliances should be scientific and accurate, but that they need not be exact duplicates of the human masticatory apparatus.

The essayist has called attention to the fact that an astronomer can plot the entire path of a heavenly body from a relatively small portion of its arc, and I shall use this most happy illustration to show that when the human teeth have all been lost, we can plot the habitual movements of the patient's jaw, and from them determine the arrangement of artificial teeth which will harmonize with those movements, as I specialize more and more in anatomical articulation, I come to appreciate more and more highly the efficiency and value of the jaw movements as established by the natural teeth and to desire more and

more to harmonize my work with them rather than to arrange teeth without regard to them, and with the strong probability of destroying them. Perhaps you may care to know the reason for this belief.

The movements habitual to the mandible of the patient were undoubtedly the results of the articulation of the patient's natural teeth. The condyles are in opposite position before the teeth are, and the movements of the jaw upon whatever form of condyles exists, guide the newly erupted teeth to place in the arch. But when those teeth reach a position where what we call "Anatomical Articulation" exists, that is when the teeth properly oppose and support and lock each other, the sliding of the teeth, uppers and lowers, determines the movements of the mandible, and the forms of the articulating surfaces in fossae and condyles, and doubtless the muscular action and perhaps even the muscular formation, are determined by the articulation of the teeth. It is very probable that when all the teeth are in what we call correct positions, the movements of both sides of the jaw are either identical or closely similar.

But with the loss of the teeth in the irregular manner, which is common, the movements of the jaw become deranged from the symmetry they may formerly have presented, and the movements of the two sides of the mandible become unlike, in one or more particulars and in greater or less degree. Sometimes the unlikeness of movement is very marked, as the essayist has pointed out.

But whether the movements of the two sides are like or unlike, they are usually more or less efficient, and whether more efficient or less, **THEY ARE THE MOST EFFICIENT MOVEMENTS THE PATIENT IS LIKELY EVER TO HAVE**, at least so far as my observation goes. And believing this, I regard it as of great importance to determine as exactly as possible what those movements are, and

to arrange the artificial teeth in such way as to preserve them and enable the patient to profit by their efficiency.

The reasons why I believe the movements established by the natural teeth to be the most efficient the patient will ever have are found in the fact that artificial dentures are rarely if ever sufficiently stable in position to be able to guide the jaw with the certainty and regularity necessary to the formation of new bony articulating surfaces and new muscular actions which shall approach in efficiency those which the natural teeth established. Even when only a few healthy natural teeth remain scattered about the mouth, they are much more firmly established than the best of artificial dentures. And, if they cannot prevent changes in the movements and in the bony formations and muscular actions, how much less can dentures mounted on movable bases prevent such changes, unless they are articulated in harmony with the established movements. I must say that this explanation of the causes occurred to me as a means of accounting for what I saw in practice. Experience with a large number of denture patients, many of whom have had from five to twenty sets of artificial dentures each, and many of whom keep these dentures in boxes rather than in the mouth, has convinced me that it is quite impossible for dentures to establish new and efficient masticatory movements, and that our success in making dentures with which the patients can masticate efficiently is absolutely conditioned upon the nearness with which they are arranged to facilitate the movements habitual to the patient. In cases where no intelligent attempt is made to preserve these movements, one of the most common effects of denture wearing is to destroy all definite and efficient movements of the mandible and indeed to lose all intelligent control over the movement so that the jaw flies about without control by the patient. It is

hardly necessary to say that under these conditions the efficiency of mastication is reduced to a minimum.

The essayist has ascribed as fully as his time permitted, two very important improvements which have lately been made in articulators and which make possible the recording and reproduction of the patient's jaw movements. They are the Incisor Guide Incline and the movable rotation points. In concluding this discussion, it may be profitable to endeavor to make the importance and application of these two improvements clear.

An Incisor Guide Incline and the pin working on it are necessary in an articulator, because the upper jaw is there the movable part, and, unless it be supported in the anterior part during the lateral movements, it tends to fall upon the lower jaw, and cause wrong relations of the upper and lower anterior teeth. This is exactly the opposite to what occurs in a natural jaw, which tends to fall away from the upper teeth.

The influence of the Incisor Guide Incline on the positions of the teeth is much greater than is generally appreciated, and this influence once recognized makes this improvement an important part of an articulator. The following slide (Figure A) (from page 157 P. A. showing the influence of the Incisor Guide Incline) illustrates on the left (A) an Incisor Guide Incline which inclines 20° to the occlusal plane, associated with a forward condyle path of 45° . The position of the first molars just above the picture of the incline show that the inclination of the working bite to the occlusal plane is 10° . If now we look to the right, (B) we find an Incisor Guide Incline which slopes at an angle of 40° to the occlusal plane. The inclination of the working bite of the first molars is now 18° , tho the forward path of the condyle is inclined to the occlusal plane only 20° .

When, however, we compare the

depths of the working bites in the second molars, we see that the more steeply inclined the condyle path the more the buccal cusps of the upper second molar are elevated from the occlusal plane.

It is apparent, therefore, that the inclination of the Incisor Guide Incline exerts an important influence on the positions of the teeth back to and including the first molars, but the influence of

difficult regions to articulate, and one where wrong contact frequently results in dislodgement of the dentures.

Figure B shows three horizontal locations of the rotation points, and the paths of the upper first bicuspid which are necessitated by these locations.

When the rotation point is at R 1 the upper first bicuspid follows the path with the same mark (R 1—show it). When it is at R m, the path is as shown

Figure A.

the condyle movements is dominant in the second molars.

Dr. Campbell has shown us diagrams illustrating the influence of the different horizontal locations of the rotation point on the movement of the teeth. He has shown that the teeth move in one direction when the rotation points are located outside the condyles, and in quite another direction when the rotation points are inside the condyles, and has explained that wide variations in these locations often occur on different sides of the same mouth and necessitate different arrangements or grinding of the teeth.

I may be permitted to extend and emphasize what he has said by applying the differences in these movements to the upper and lower cuspid regions of the dentures, always one of the most

with the same marking as the rotation point, R m. When it is at R a it follows the path marked R a.

It is at once apparent that these paths are quite different in direction and that they may very possibly require different adaptations of the teeth.

A moment's study of the small figures on the right of the slide shows how true is the fact that the teeth require different arrangements to be able to follow these paths, and a very important detail, heretofore generally unnoticed, results therefrom. It is that the width of the upper six anterior artificial teeth, as related to the width of the six lowers is materially modified by these several locations of the rotation points.

When the rotation point is at R 1 the relations of the upper teeth must be as

shown in the figure marked "D" in which the tips of the upper cuspids come a little posterior to the distal angles of the lower cuspids. This permits the tip of the upper cuspids to pass in right relations to the lowers—a most important matter.

When the rotation point is at the location marked "R m" the relative widths of the upper and lower anteriors must be as shown in the figure marked "E," in

clever exposition of the possibilities in his own practice, but in these interesting and instructive explanations to others.

DR. GEORGE HENRY WILSON, Cleveland, O.

This subject is certainly one that we are deeply interested in, it is a valuable one, and one method has been well presented today. The trouble is that it is a complicated subject, and it has not

Figure B.

which the tips of the upper cuspids come just above the distal angle of the lower cuspids.

When the rotation point is at the location marked R a, the relative widths of the upper and lower anteriors must be as shown in the figures marked "F," where the tips of the upper cuspids are a little anterior to the distal angles of the lower cuspids.

These several considerations which I have been compelled to briefly touch upon, and others of equal importance which cannot be dealt with for lack of time, indicate the importance of knowing and reproducing the mandibular movements when arranging teeth for those patients who are sufficiently intelligent and appreciative to permit it. The essayist is doing much good, not only by his own

reached perfection as yet. We need to follow along with the different subjects as they come up. Every little while a journal will publish a new method of producing these results, and some point will be brought out; then a little later there will be something else.

Dr. Stephan spoke of Dr. Case bringing out an improvement in 1890. That same point was the foundation of the original anatomical articulator brought out by Dr. Evans in 1840, eighteen years before Dr. Bonwell brought out his triangle.

As far as the equilateral triangle is concerned, I think most of us have read the article by Dr. Frowne's, of Denver, in which he says in his experience at least ninety per cent of his cases are of scalene triangles, that is, with none of

the sides equal. What shall we do? One of the professors of prosthetic dentistry in one of our colleges says ninety per cent are scalene. Just before that article appeared I had the pleasure of making measurements of some three hundred mandibles in the Smithsonian Institution at Washington. I found but nineteen (6%) that were equilateral triangles; 187 (64%) cases of isosceles triangles, in which two sides were equal, in some cases the base and one side, but in a large majority the two sides were equal. Then the other one-third were scalene, no two sides equal. We know there are many influences changing the form of the face, the loss of the teeth and so on, so that one side is developed more than the other. The formation of the face is largely due to the development of the teeth. If a molar is lost on one side, we cannot expect that side to be developed as the other is. When we have an instrument that is based entirely upon an equilateral triangle, then we are wrong in depending upon it. There is the foundation. We study that, and then when there are variations we must develop those afterwards. How shall we get along with those different ideas? We go according to the scientific method as best we can, and then we refer to the never-failing articulator, the human anatomical articulator. The case must be taken to the mouth and adjusted there. The only trouble is in controlling the patient. But that is the only method we can really depend upon. So don't depend on mechanical devices altogether, but on what Nature has given us. (Applause.)

DR. PROTHERO, Chicago, Ill.

In the first place, I want to compliment the essayist on the very valuable paper presented. He has brought out many facts of value and many facts that are absolutely correct. There are some points about his paper with which I would like to take issue, if we had time, but I am not going to take up the time

of the meeting for that. I want to second one point Dr. Wilson brought out, and that is with regard to the variation of the mandible and mandibular movements, and that we must test everything in the mouth. For many years we have been using articulators, or klenoid frames, the rotation centers of which were four inches apart, based upon the average distance between centers of the human condyles, and we still get very good results by using that, by afterward going back to the human apparatus and testing out the dentures on that appliance with carbon paper, grinding down the points of interference and making new contacts to conform to what we find in the particular individual. That is what Dr. Gysi has to do. He must finally test out by means of carbon paper, having the patient subject the mandible to lateral movements, and grind down the high points, then reproducing the points of contact.

I do not believe the Simplex Articular is a scientific appliance. The essayist says that Dr. Gysi has found 39 degrees between the two condyle paths, and he has found one of 45 or 48. Then how can an anatomical articulator with the condyle path set at 35 degrees prove a scientific instrument in that case? There must be a lot of "fixing," as Dr. Campbell says, done for such cases. We find variations in the condyle paths of our patients every day and variations in the rotation centers of the mandible, and there is no mechanical appliance made at present that will exactly reproduce the mandible movements, and if we know how to correct those variations as they come, we will be able to render our patients a class of service they have never been able to get in the past.

I have had only a limited experience in setting the lower molars outside of the upper molars, and reversing them when the molar is set outside and the normal mandibular movement is outward. When that happens, that throws

the teeth in an incorrect relation to either receive or crush, and that movement is abnormal, and I don't believe it will answer in the normal case. Judging from general anatomical movements, that doesn't appeal to me. The extent of bodily lateral movement, side movement of the mandible is brought out very prominently in the Gysi system. While there is no doubt but there is a bodily lateral movement, the extent of that side movement, and the slight movement necessary to bring the teeth in closer relation to each other is so slight as to be almost imperceptible, less than $\frac{1}{2}$ mm. in the average case, the side movement, according to the measurements which I have made. When the mandible is swung way to one side, then you get a much greater movement, but I have registered a number of cases where there is no actual bodily side movement. I can swing my own mandible almost an eighth of an inch, but I find in studying the movements of my jaw in mastication of meats, that I do not use the side movement to any great extent, merely a protrusive movement on one side, the other side remaining practically at rest. The rotation centers in my own mandibles are not exactly on the heads of the condyles. They are, in certain cases. Some lie outside and some inside, and there is no reason why they shouldn't lie in the condyle itself. There are cases where the condyle itself is the true center in the movement. I do not believe there is a better and I do not believe any appliance constructed at the present time that is as scientific in its movements or capable of producing as good results, if all the details are correctly followed and accurately followed, as the Gysi Adaptable appliance. If it is studied and the instructions carried out carefully, that is very good, but that is not infallible. I do not sanction the use of the Gysi Simplex, either from the standpoint of the

teacher or for use in the profession in general. (Applause.)

DR. CAMPBELL: Having known Dr. Prothero, of Illinois, for several years, following closely his teachings, I am, of course, familiar with his instrument for securing the occlusal plane. I am constrained to believe that in most instances the occlusal plane may be secured in less time with the knife and ruler than would be required to mount Dr. Prothero's instrument.

Among the many things noteworthy of the men who are inventing articulators, or making new appliances for the anatomical occlusion of the teeth, is the fact that the more correct they are in the reproduction of mandibular movements the more like the Gysi Adaptable Articulator they make their new mechanism. This is particularly gratifying to the Gysi adherance and enthusiasts.

The lateral path was mentioned by Dr. Prothero and the movement of one-half mm. That is not the condition found in my own mouth and in observing the masticatory movements of my patients. I say three mm. or the width of a lower incisor.

The condyle may follow paths which, altho irregular, are nevertheless habitual movements. The last few teeth before disappearing were enough to establish movements differing widely from what might be regarded as normal. The Gysi Measuring Instruments simply copy these movements, regular or irregular, and enable the prosthetist to arrange the teeth on the Adaptable Articulator in conformity with the habitual movements.

I regard it as a high honor to present my paper in the presence of Dr. Wilson and Dr. Prothero. To me they have been "daddies" in Prosthetic Dentistry and when in doubt I shall continue to look to them for help.

Some one said that the Simplex is not a scientific instrument. I agree with

him. Still, with the exception of the Gysi Adaptable, I regard the Simplex as the best. The person who raised this objection based it upon the old belief that the rotation point and temporo-maxillary joint had a common center. We must insist that that belief is no longer tenable. The theoretical points of rotation in the actual masticatory movements sometimes fall as much as

an inch and a half outside of the jaw. On the Articulator we must give all points tangible locations. Whether the triangle, Bonwill's equilateral or anybody's scalene, isosceles, or any other triangle, we get the rotation points, reproduce them on the Adaptable and obtain dentures which may be placed in the mouth without gloomy forebodings of subsequent alterations.