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Jaw movements engraved in solid plastic for articulator Controls. Part II. Transfer apparatus*

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Part I of this article described a new method and apparatus for recording jaw motions (Fig. 1).† Although the information recorded from the patient can be used in its original form for research purposes, the information must be transferred into another form when it is to be used in an articulator.

Part II describes a mechanical device for transferring the recorded jaw movement information into a set of articulator controls. This pair of transferred record-ings constitutes the total information needed to guide and control the movements of an articulator for duplicating the patient's jaw movements. No computations are necessary on the part of the operator and, although the information transfer may be performed by a dentist, it is a purely mechanical procedure which may be performed equally as well by a trained technician.

TRANFER APPARATUS AND PROCEDURES

The upper transfer frame. The upper frame is a flat T-shaped metal structure which is a substitute for the maxillocranial part of the patient's head (Fig. 2). It has two keyways and dowel pins for locating a pair of plastic blocks which will re-ceive the transferred jaw movements (motion analogues). The two analogues will become the articulator controls. The analogue blocks are generally cubical in shape but rounded on the posterior side in order to more readily accept the transfer information and also to conveniently allow for the opening and closing action of the articulator. Each of the two plastic blocks is supported in a separate metal holder. The location of the hinge axis is indicated by a small dimple on the outer wall of each metal holder. The pair of analogue blocks, when fastened to this frame, have a fixed lateral separation distance of 110 mm. to their centers. The frame has a centric relation indicator pin midway between the two analogue blocks for centering it with a lower transfer frame.

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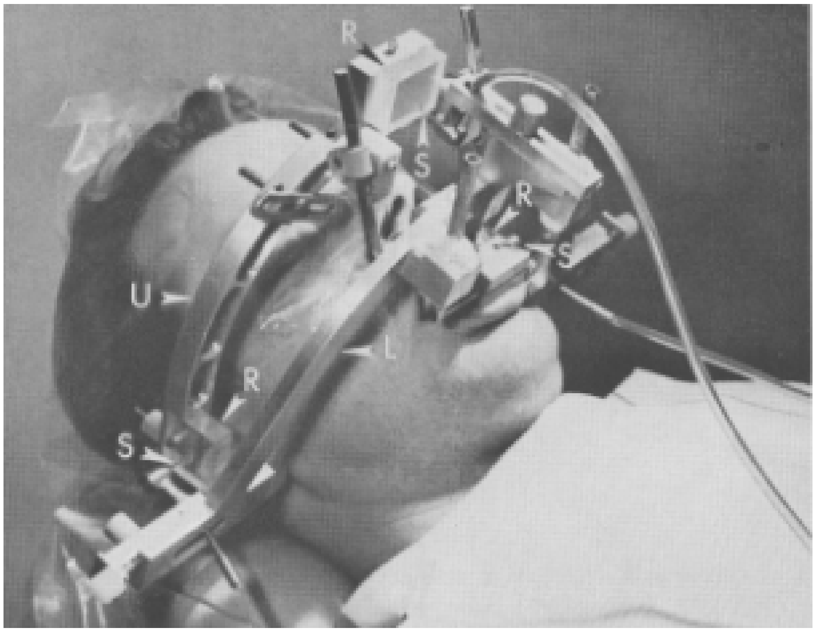

Fig. 1. The upper recording bow (U) holds three plastic recording blocks (R) in fixed spatial relationships to each other and to the orbital axis plane of the patient's head. The lower recording bow (L) supports three recording styluses (S) (air turbine drills) in fixed spatial relationships to each other and also to the mandible. The jaw motions are engraved in three dimensions in the three recording blocks by the styluses.

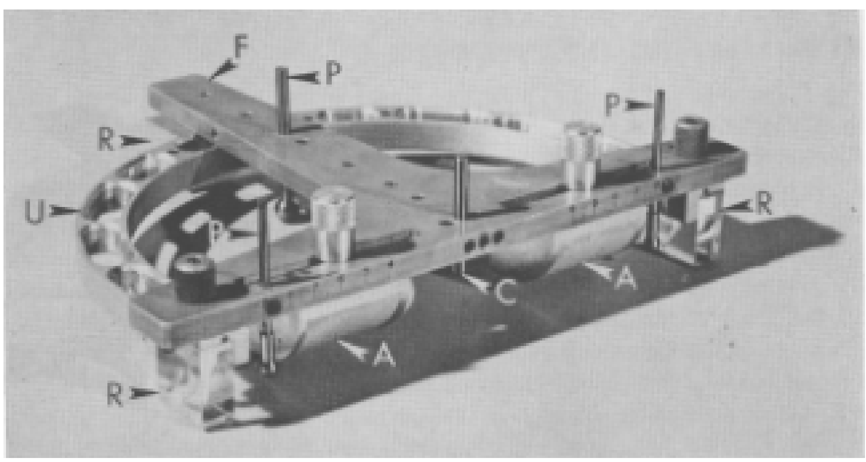

Fig. 2. The upper transfer frame (F) is joined to the upper recording bow (U) in preparation for transferring the recorded information (R) to form the articulator analogues (A). Note the three support-pins (P) and the centric indicator pin (C) which are used during the transfer to establish the position for the centric relation openings in the analogue books.

There are three adjustable vertical support pins, one on each of the three arms of the transfer frame. These three pins are used in connection with the static relation (centric relation) transfer when the initial openings are cut into the analogue blocks. Calibrations on the posterior side of the transfer frame are used for research purposes but are not required in the normal use of the transfer procedure.

The upper transfer frame is attached to the maxillary recording bow by a thumb screw on the outer end of each arm of the frame directly above the corresponding axis record block (Fig. 2). The union of the upper transfer frame to the maxillary face-bow produces what is referred to as the upper transfer assembly. The patient's recordings are attached to the upper face-bow so that the records of protrusive movement are facing outwardly. The protrusive guide slot block is attached to the upper bow to guide the anterior stylus.

The lower transfer frame. The lower frame is a substitute for the mandible (Fig. 3). It is also a flat T-shaped metal structure and is essentially the same size and shape as the upper transfer frame. It supports two vertical ball-nosed end mills, ¼ inch in diameter. The radius centers of the hemispherical ends of these two mills precisely locate the axis of the lower frame. These two mills fit into key-ways in the transfer frame so that they can be moved laterally to various positions indicated by calibrations on the frame. These various locations are sued for research purposes only, and in the normal transfer procedure each mill has a fixed position of exactly 55 mm. from the center of the frame, making a total of 110 mm. between the two.

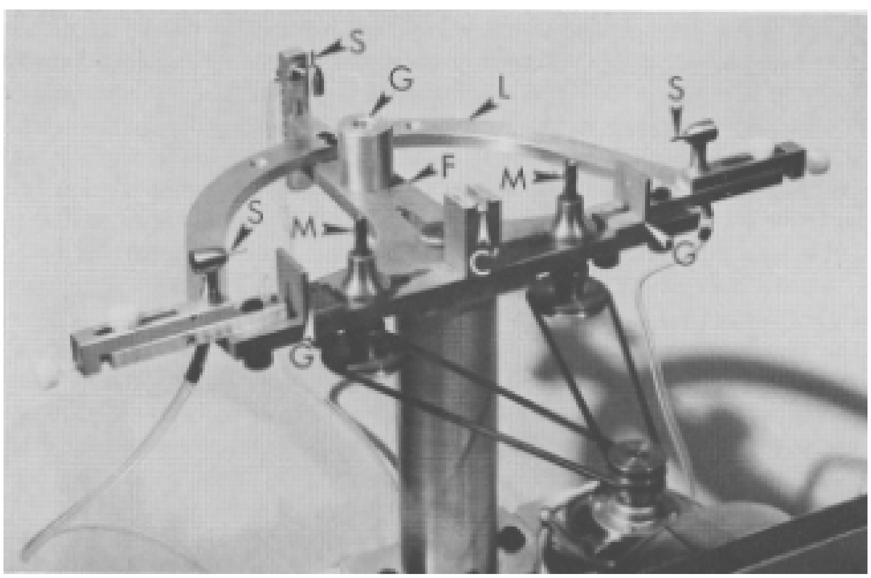

Fig. 3. The lower recording bow (L) is joined to the lower transfer frame (F) in preparation for transferring the information recorded from the patient by three styluses (S) to the two analogue mills (M). Note that the long axis of the hinge axis styluses (S) passes through the centers of the hemispherical ends of the two vertical transfer mills (M). The centric key-way (C") and the three support-pin guides (G) will be used during the transfer to establish the position of the centric relation openings in the articulator analogue blocks.

The lower transfer frame has in its center a raised post with a key-way which is used to engage the lower end of the centric relation indicator pin of the upper transfer frame. The lower frame remains on its support stand which also supports a variable speed motor for milling the analogue recordings. Each of the two transfer mills is coupled with a pulley and stretch belt to the motor which drives them. There are three support-pin guides which correspond to the three support-pins on the upper transfer frame. The anterior pin guide is in the form of a well, which acts as a socket for the ball end of the anterior support-pin. The socket is adjustable in the horizontal plane to engage the anterior support-pin.

The lower face-bow is joined to the lower transfer frame by two dowel thumb screws which precisely align it so that the common axis of the two axis styluses is aligned with the axis formed by the radius centers of the two transfer mills (Fig. 3). The combination of the lower face-bow to the transfer frame forms what is referred to as the “lower transfer assembly.” The recording drills are removed from the three air turbines on the lower bow, and smooth styluses of the same length and diameter are substituted for them. The length of the styluses protruding from the air turbines is precisely controlled by a depth-setting gauge. The smooth styluses have hemispherical ends like the recording drills so that they are able to track the recorded grooves without damaging the recordings.

Static information transfer (centric relation). The two analogue blocks are removed from the upper transfer frame. The upper transfer assembly (upper transfer frame and face-bow) is joined to the lower transfer assembly (lower transfer frame and face-bow) by engaging the three transfer styluses with the centric relation portion of the protrusive recordings (the most posterior parts). The stylus carriages are set on the same reference marks that they occupied during the patient-recording phase. The upper transfer assembly is positioned above the lower assembly so that the centric relation indicator pin is fully engaged with the centric relation key-way of the lower frame. The weight of the upper transfer assembly rests on the tripod formed by the three transfer styluses. The components of the apparatus now have one common axis which is colinear with the hinge axis recordings representing centric relation.

The three support-pins on the upper transfer frame are lowered so that they rest on their counterparts (guides) on the lower transfer frame. The support-pins are locked in these positions. The transfer styluses are now retracted, thus leaving the upper transfer assembly in centric relation while being supported by the three support-pins (tripod). The upper transfer assembly is lifted from the lower assembly and the two blank analogue blocks are reattached to the upper frame.

The anterior support-pin which acts also as a pivot point is seated in its counterpart (socket) on the lower frame. The posterior part of the upper assembly is lowered over the two rotating transfer mills which cut openings in their associated analogue blocks. The medial surfaces of the two posterior guides control the downward movement of the two posterior support-pins. The lower ends of the two posterior pins stop the downward movement of the upper transfer assembly so that each transfer mill forms a centric relation opening to the proper depth in its respective analogue block (fig 4). The tripod consisting of the three support-pins causes the upper assembly to be precisely relocated at the centric relation position indicated by the protrusive recordings. The three transfer styluses are now re-engaged with the centric relation parts of their respective protrusive recordings. The depth stop and calibration scales insure that the stylus carriages are positioned precisely as they were during the recording of the patient’s jaw movement.

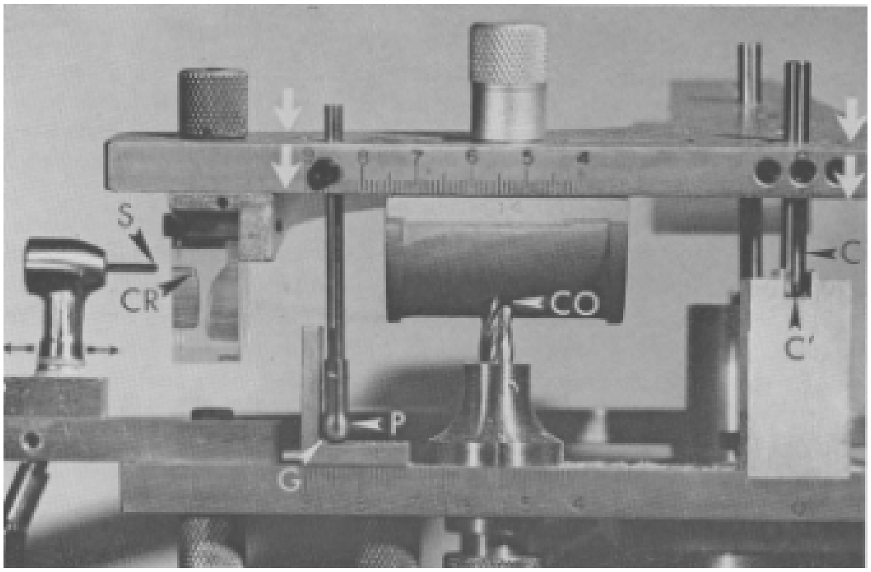

Fig 4. This picture shows the left side of the transfer device and the centric opening (CO) that has been cut into the left analogue block. Note that the support-pin (P) has come to rest on its guide (G) and that the axis stylus (S) can now be returned to centric relation (CR) which is the most posterior part of the protrusive record. The centric indicator pin (C) is fully engaged with the centric key-way (C'). The large arrows on the upper frame represent the direction of motion of the upper assembly when the centric openings are being cut.

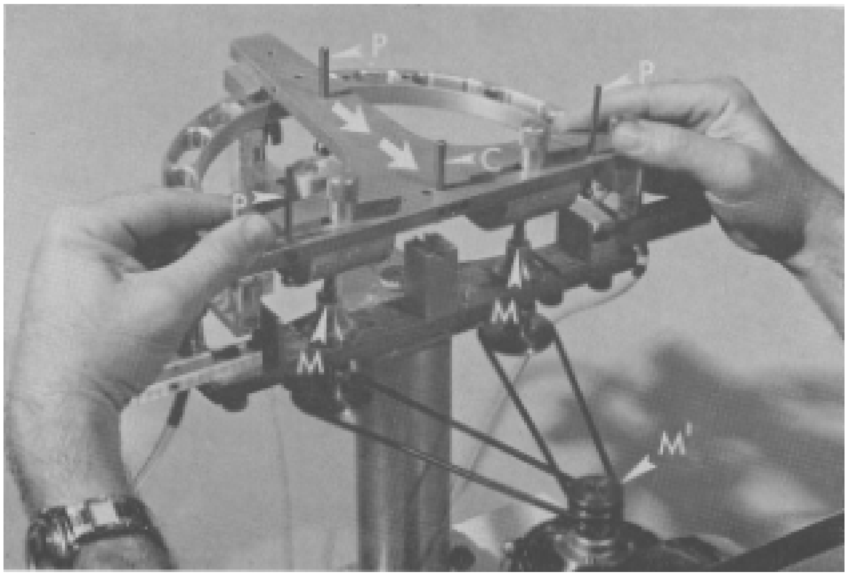

Fig. 5. A transfer of the protrusive movement record is being made. Note that the transfer mills (M) are being powered by the motor (M') while the upper assembly is manually moved rearward as shown by the two large arrows. Not that the three support-pins (P) and the centric indicator pin (C) have been raised and locked so that all of the motion is controlled by the recordings made on the patient.

Dynamic information transfer (protrusive and lateral). The centric relation indicator pin as well as the three support-pins are raised and locked so that they cannot interfere with the movements made during the transfer. The patent's records are lubricated with silicone spray and the upper assembly is then moved manually rearward while being guided and controlled by the three styluses in their respective protrusive recordings. Simultaneously, the two vertical transfer mills are activated and engrave a set of motion analogues in the two plastic blocks which surround them (Fig 5). As soon as the ends of the protrusive recordings are reached, the transfer mills are stopped. The two axis recording blocks are removed from the upper facebow and they re reattached to the bow with the right and left lateral movement recordings facing the styluses. The protrusive guide block on the anterior part of the upper bow is replaced by the record blocks that contain the recordings of the lateral movements. The three transfer styluses are re-engaged with the recordings of the lateral movements. The transfer mills are activated and the upper assembly is moved manually in the lateral movement recordings while the transfer mills add these pathways to the two analogue blocks (Fig. 6). The transfer of the lateral movements is completed when the ends of the recording grooves are reached. The addition of the lateral movement information does not destroy the essential guiding parts of the protrusive information because the pathways of the two movements are divergent. The three transfer styluses are retracted from the recordings of lateral movement and the analogue blocks are removed from the upper transfer frame for placing on the articulator.

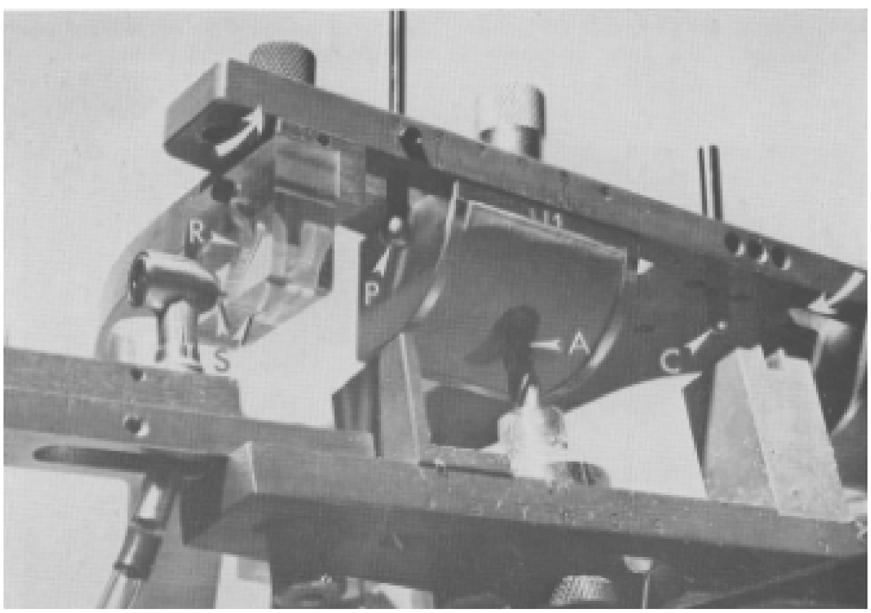

Fig. 6 The left side of the transfer device is shown during a transfer of the right lateral jaw movement. The left transfer stylus (S) is obliged to follow its recorded groove (R) in the recording blocks while the other two styluses of the face-bow (not shown) must simultaneously follow their respective recordings of right lateral motion. The left articulator analogue is shown being engraved at (A). Note that the support-pins (P) and the centric relation pin (C) have been raised and locked so they cannot interfere with the transfer. The motion of the upper assembly is indicated by the two large arrows to the right and left of the upper frame.

THE ARTICULATOR

The engraved motion analogues are secured to the upper frame of the articulator which has key-ways and dowel pins which locate the analogues in the same relative positions which they occupied during transfer. The articulator is essentially a tripod in which the two analogues with their respective styluses on the lower frame provide two points of support. The third and anterior point of support is provided either by the incisal pin or by the casts of the teeth. The articulator functions equally as well whether it is resting on the upper or the lower frame. An advantage of resting on the upper frame is that the lower part moves like the mandible of the patient and also allows for easy visibility of the occlusal surfaces of the upper teeth.

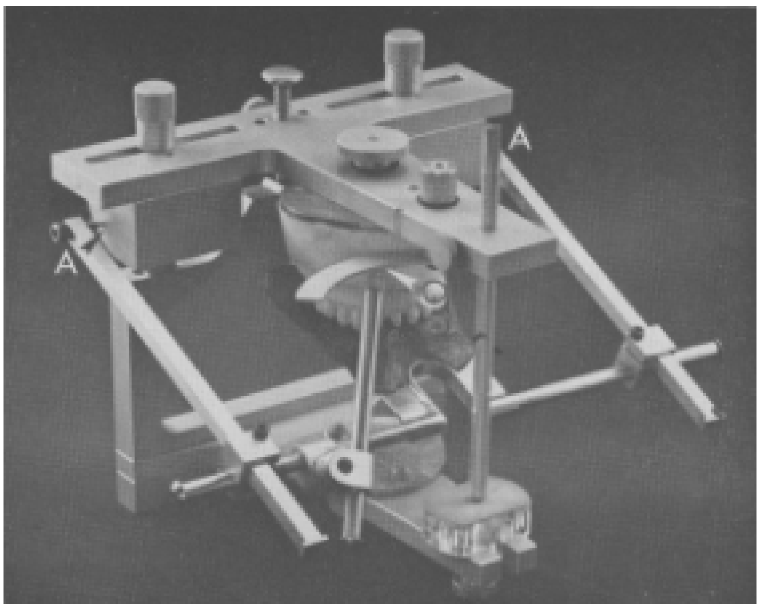

Fig. 7. A maxillary cast is being mounted to the upper frame of the articulator by means of an orbital axis transfer face-bow. Note the use of the axis dimple (A) and the orbital flag (O) to establish the horizontal plane of reference indicated by three tattoo spots on the patient's head.

MOUNTING CASTS

Preliminary preparations for transferring the patient's casts to the articulator include the following items: (1) Maxillary and mandibular casts of the patient's teeth are made. (2) An interocclusal record is made for relating the maxillary cast to the mandibular cast in centric relation. (3) A face-bow fork registration is made on a transfer face-bow that has three adjustable points (tripod) to match the respective orbital axis tattoos (static reference plane) on the patient's head.

The two dowel pins which space the analogue blocks are raised and the blocks are moved equal distances along a calibrated scale so that the axis dimples in the outer walls match the face width of the patient at the tattoo marks. A transfer face-bow that has three points of adjustment to match the three static reference points on the patient is used to transfer the maxillary cast to the upper frame of the articulator. The axis points of the transfer face-bow are engaged with the axis dimples on the analogues blocks. The lower surface of the orbital flag of the upper frame of the articulator is in the same horizontal plane as the axis dimples. This flag rests on the orbital pointer of the transfer face-bow, thus completing the static relation of the transfer bow to the orbital-axis plane of the patient. The maxillary case of the patient's mouth is placed in the impression the face-bow fork of the transfer bow, and it is joined with plaster to the mounting plate on the upper frame of the articulator (Fig. 7).

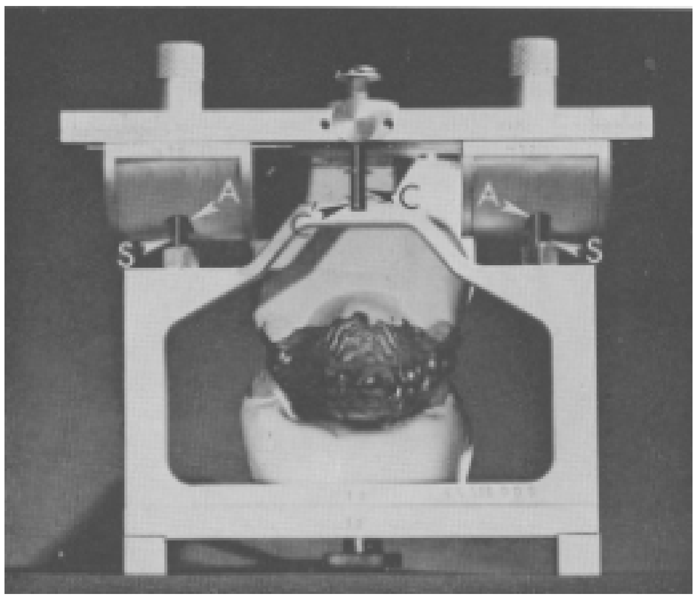

Fig. 8. A posterior view of the articulator with a set of working casts mounted on it. When the centric relation indicator pin (C) is engaged with the centric relation key-way (C'), the two articulator styluses (S) will remain the centric relation portion of the two analogues (A). When the centric relation pin (C) is released, a spring raises it and the articulator can be moved in the lateral direction. Note the access and visibility to the casts through the rear of the instrument.

CENTRIC RELATION MOUNTING

After the maxillary cast of the patient has been mounted, the transfer bow is removed, and the analogue blocks are returned to the doweled transfer position for mounting the mandibular cast in centric relation. The analogues must always remain in this fixed position for the centric relation transfer of the mandibular cast, as well as for all replay procedures after the casts have been mounted. The upper frame of the articulator is placed upside down, and the centric relation index previously taken from the patient is placed on the occlusal surface of the maxillary cast. The mandibular cast is placed on the centric relation index in preparation for joining it to the lower frame of the articulator.

The lower frame of the articulator supports two spherical styluses, ¼ inch in diameter, which are spaced precisely 110 mm apart to correspond the spacing of the motion analogues on the upper frame of the articulator. The lower frame of the articulator is placed over the mandibular cast so that the two styluses rest in their associated motion analogues. The exact centric relation position of the two styluses within the analogues is indicated by a centric indicator pin in the center of the upper frame and a key-way in the center of the lower frame. When these two centric components are fully engaged with each other the twoframes of the articulator are related to each other exactly as the two frames of the transfer apparatus were during the transfer phase. The incisal pin is set on the incisal rest pad to space the two frames of the articulator parallel to each other. The nandibular cast is joined with plaster to the mounting plate on the lower frame of the articulator, thus completing the transfer of the casts to the centric relation position of the analogues (Fig 8).

CENTRIC RELATION INDICATOR PIN

The centric relation indicator pin can be locked in either the up or down position or used with the palm of the hand for quick connecting or disconnecting with the key-way on the lower frame. When the centric indicator pin is raised, the articulator can be moved in the lateral directions. When the indicator pin is seated in the key-way the instrument will remain in centric relation. The articulator can be opened and closed about the hinge axis and will remain in centric relation when the pin is in the down position.

DISCUSSION

The tripod of original recorded information from the patient is of paramount importance because it relates the three-dimensional recorded movements to the axis-orbital plane of reference at any instant. In the usual Cartesian coordinate procedures of setting articulators, the dentist is obliged to separate the mandibular movements into their three linear coordinate components, by means of the projection of any point of the tracing to the three planes of space on six recording plates, then to adjust and hand grind the articulator controls to follow the six tracings for each movement recorded. The method described in this article integrates all the data at the same time through the mechanical transfer device.*

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*In essence this apparatus may be referred to as a special-purpose mechanical analogue computer. This procedure is described in greater detail in U. S. Patent No. 3,452,439.

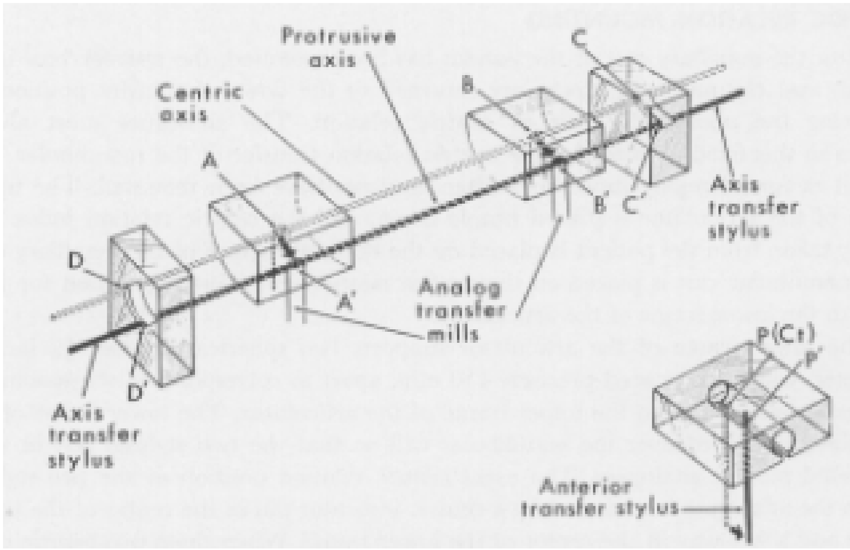

Fig. 9. A diagram showing the relationship of a protrusive recording to the transferred motion analogues. Points (A), (B), (C), and (D) represent the position of the hinge axis in centric relation, and points (A'), (B'), (C'), and (D') represent a hinge axis position with the mandible protruded. The paths of points (A) to (A') and (B) to (B') are represented by engravings in the plastic articulator blocks. The anterior stylus is guided from centric relation (P[Ct]) to protrusive movement (P').

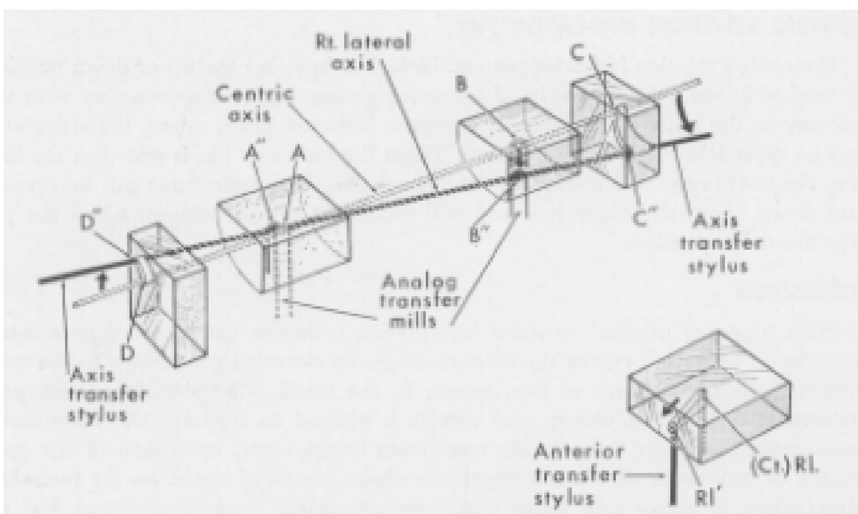

Fig. 10. A diagram showing the relationship of the right lateral recording to the transferred motion analogues. Points (A), (B), (C), (D) and (R*l*[Ct] are identical to those in Fig. 9 and represent the jaws in centric relation. Points (A"), (B"), (C") and (Rl') represent a jaw position during the right lateral mandibular movement transfer. The paths of points (A) to (A") and (B") are represented by engraved pathways in the plastic articulator blocks.

In the past, mandibular movements have been transferred from an analysis of their different components. This method proceeds from a synthesis of the movements as a whole (Figs 9 and 10).

The nature of the mechanical transfer prohibits the dentist from injecting unrecorded information into the analogues. He merely supplies the manual power which moves the transfer frames relative to each other while they are timed and controlled in three-dimensional movements by the styluses in the recorded grooves. There is no portion of the information that is disregarded or thrown away, and therefore, the motion analogues completely represent all of the movements recorded.

The use of an arbitrary separation distance of 12 mm for the transfer mills and styluses on the articulator seems to conflict with commonly held "centers of rotation" theory[2]. However, during this research effort, many tests were made with the use of sliding pointers (Fig. 11) to ascertain whether the translated hinge axis line in lateral border movement actually intersects the centric relation hinge axis line (which condition would be necessary to have a center of rotation). In many patients' records tested, the translated axis line did not intersect the centric relation axis line. In some of those tested, the translated axis line did intersect the centric axis line at some point. Occasionally this point was found to be outside the dimensions of the patient's head.

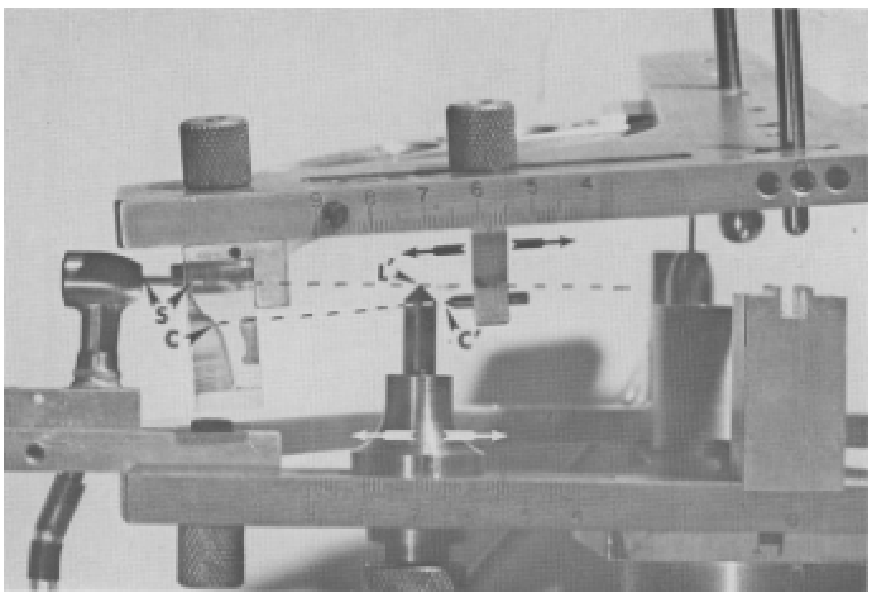

Fig. 11. A sliding point (C') represents the position of the hinge axis when the jaws are in centric relation and the point moves on the same line as the centric opening in the recording block (C). A sling point (L') represents the translated hinge axis line when the mandible is in a left lateral position. The point (L') moves on the hinge axis line with the recording stylus (S). In many of the recordings tested, there was no intersection of the translated hinge axis line in lateral movement with the hinge axis line in centric relation. In this situation, there can be no "center of rotation" for the axis.

Tests were made by transferring the same patient's recorded information to various separation distances of the transfer mills ranging from 80 to 160 mm. The transfer mills were replaced with smooth styluses of the articulator to allow the two frames to be guided and controlled by the analogues rather than by the grooves in the record blocks used on the patient. Recording drills were placed in the three air turbines and recordings of the movements were made in new record blocks. In all of the patients' records tested, the recordings were observed visibly to be the same as those made directly on the patient, regardless of the separation distance at which the transfer analogues were made.

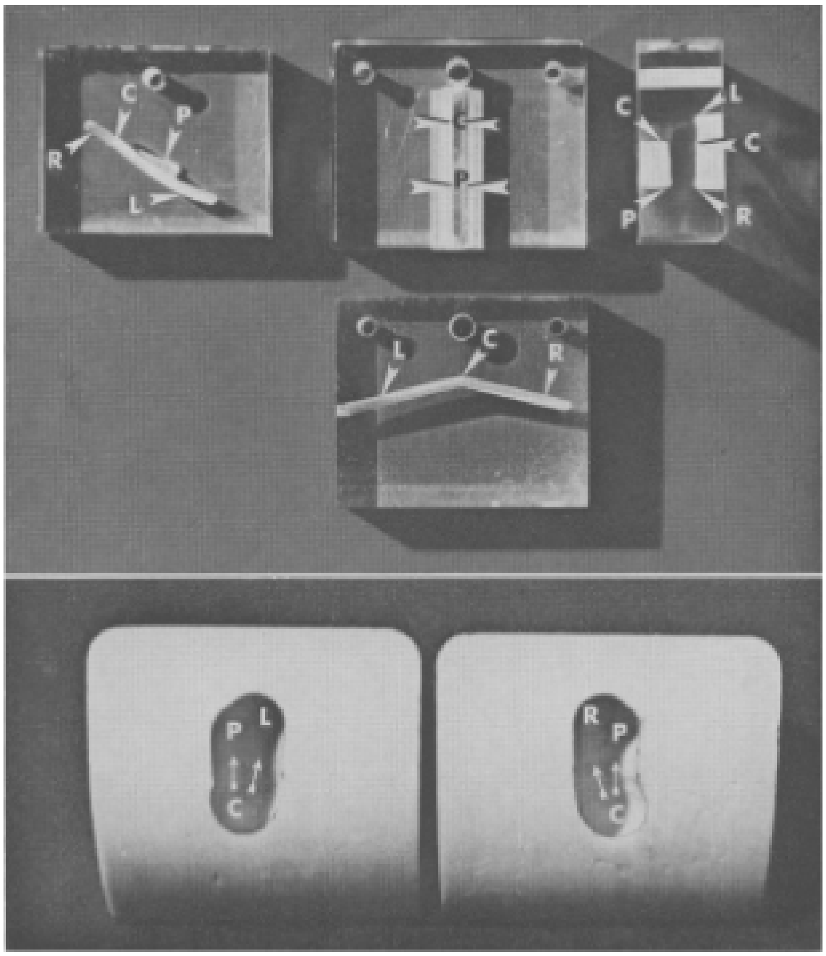

Fig. 12. The set of jaw movements records A, produced the configuration for the articulator controls shown in fig. 12, B. (C) represents the jaws in centric relation, (P) represents the mandible in protrusive movement, (L) represents left lateral movement of the mandible, (R) represents right lateral movement of the mandible. In B, the articulator styluses are in centric relation at (C) and move to protrusive (P) or right lateral (R) or left lateral (L). Compare this set of articulator controls to the set in Fig. 13.

The engraved pathways in the analogue blocks show changing magnitudes depending upon how far apart the engraving mills were located during the transfer procedures. Our conclusion is that since the guidance pathways for the articulator styluses are all in the analogues of axis motion, the separation distance for the transfer mills need only be large enough to form a stable tripod outside the dimensions of the casts to be mounted on the articulator. If, for example, a separation distance of two inches were used for the transfer mills and the articulator styluses, the casts mounted on the articulator would fall outside the 2 inch dimension and one would have an unstable guidance system for reproducing recorded motions. If a distance of 12 inches were used for another example, one would have a very stable tripod which would fall outside the limits of dental casts to be mounted. However, an instrument of this size would be awkward to handle in the laboratory as an articulator.

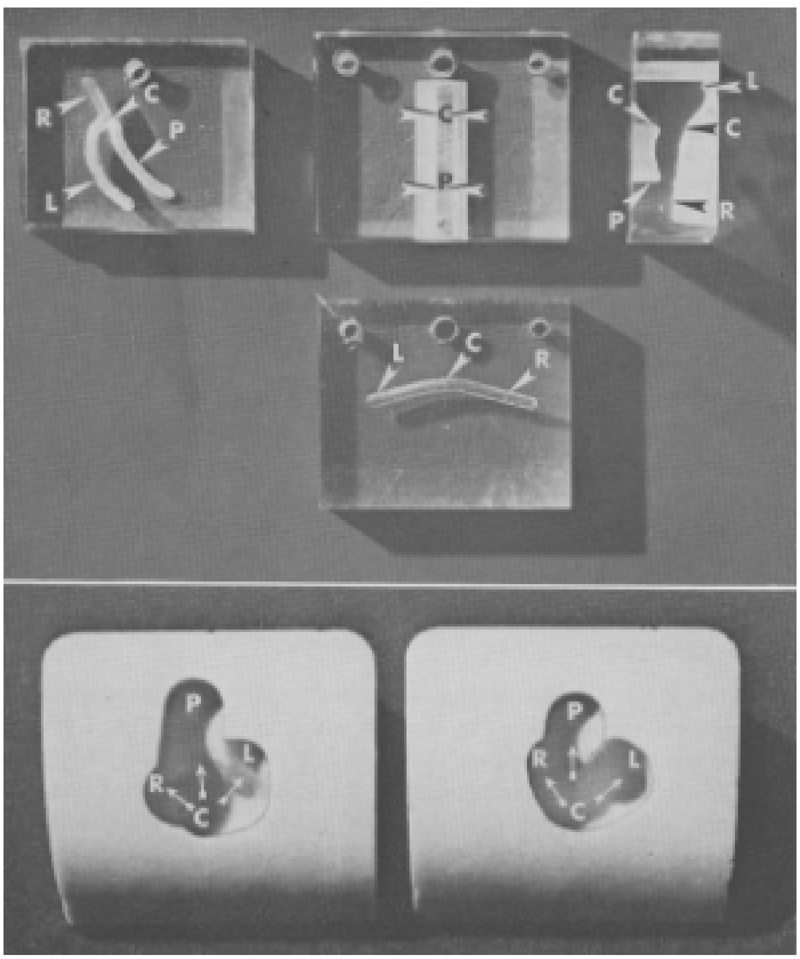

Fig. 13. The set of jaw movement records in (A) gave the configuration for articulator controls for the patient as shown in (B), (C) represents the position of the jaws in centric relation, (P) represents the mandible in protrusive movement, (L) represents the mandible in left lateral movement, (R) represents the mandible in right lateral movement. In Fig. 13, B, the articulator styluses are in centric relation at (C) and move to protrusive (P) or right lateral (R) or left lateral (L). Compare this set of articulator controls to the set in Fig. 12.

Some important considerations in the method of transferring the recorded information are: (1) The protrusive movement is used to transfer both the static and dynamic information directly to the analogue block. This is possible because the extreme posterior limit positions of the protrusive recording clearly represent the hinge axis in centric relation. (2) Recordings of the right and left lateral movements and a protrusive movement can be stored in the same pair of analogue blocks because the respective pathways coincide only at centric relation and then become divergent. Therefore, the articulator styluses will follow whichever set of pathways the dentist chooses to use. (3) The two analogues are *not duplications* of anatomic shapes. They are configurations in the form of motion analogues which are produced by the paths of points on the hinge axis (Figs 12 and 13). (4) The same relative motion is produced either from the primary recordings of the patient or from the transferred analogue recordings on the articulator.

Articulator controls of the type described in this article are of practical value to dentists and laboratory technicians because there are no calibrations or adjustments that need to be considered in order to reproduce the patient's movements. Once a set of analogues has been obtained and the casts have been mounted for that specific patient, all that is necessary is to have the analogues on the articulator when work is being done for that patient, the controls are available. The three recording blocks used to record the patient's jaw movements are also identified and stored so that new analogues may be made in case the first set is lost or destroyed.

RECORDING CENTERS

The utilization of dentist-operated recording centers to provide recording and other diagnostic services for referring dentists was suggested in Part I of this article. It may not be too bold to anticipate that in a few years there may be another field in dentistry which specializes in services such as locating and marking the hinge axis of patients, making records of the patient's jaw movements, transferring recorded jaw movements to articulators, mounting of patient's casts in centric relation, and other special laboratory procedures.

SUMMARY

A new apparatus and method was described for transferring jaw movements through a mechanical engraving device directly into a pair of plastic blocks to form an individual set of articulator controls for each patient.* This pair of engraved recordings constitutes the total information needed to guide and control the movements of an articulator for duplicating the patient's jaw movements.

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