# United States Patent [19]

**Derda et al.**

[11] **3,908,271**

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## [54] DENTAL ARTICULATOR


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[52] **U.S. Cl.** ..... **32/32**

[51] **Int. Cl.²** ..... **A61C 11/00**

[58] **Field of Search** ..... 32/12, 22, 32



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*Primary Examiner*—Robert Peshock

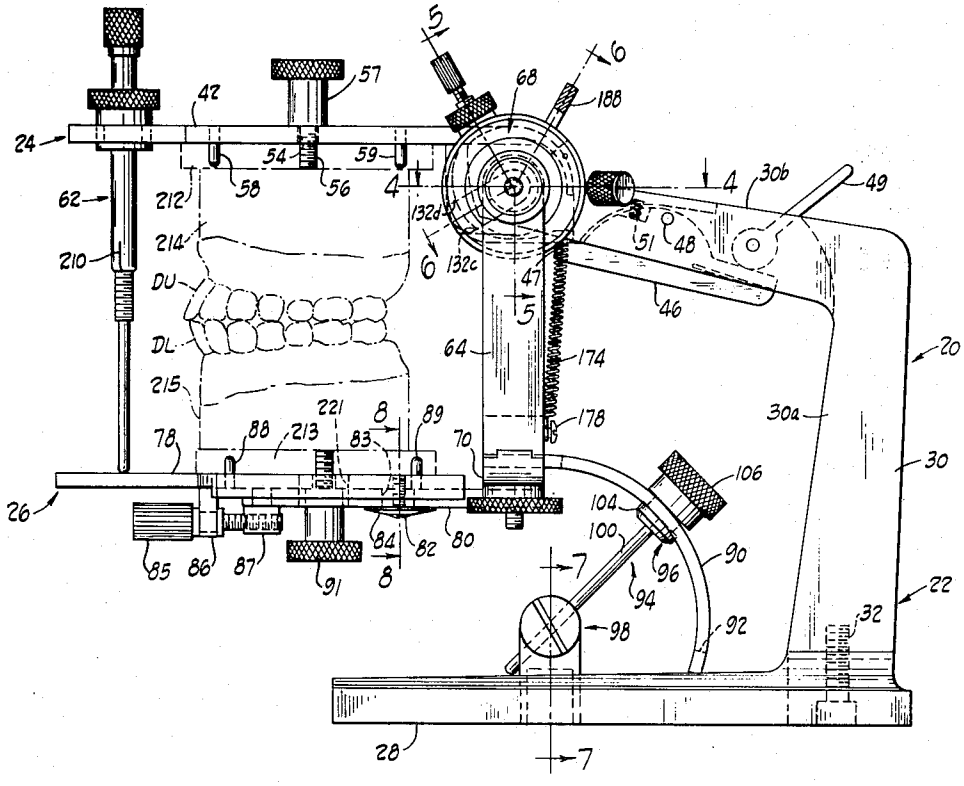
*Attorney, Agent, or Firm*—Watts, Hoffmann, Fisher & Heinke Co.



[57] **ABSTRACT**

A dental articulator that simulates jaw movements in the same directions as the natural jaw. A lower jaw element is suspended from a fixed base by two pivots movable relative to the frame along restricted paths. An upper jaw element is pivotally supported by the base about a fixed axis coincident with one position of the movable pivots. Each jaw element forms a support for a dental arch cast. Each pivot can be individually locked in a fixed location and the lower jaw element can be released from the pivots for limited relative translational and rotational movement and adjusted to a new relationship with the pivots. Adjustable cam surfaces on the frame control lateral movement of the lower jaw element. A rigid link pivotally and releasably connected between the frame and lower jaw element restrains movement and establishes a chewing-type pivoted action. A plate on the lower jaw element is movable rectilinearly so that the anterior-posterior closed position of the teeth can be adjusted without changing the pivot axis. Plates with peripheral sponge-like wall portions forming enclosures for plaster are adapted to be secured to the supporting jaw elements. The wall of each plate serves to support a dental arch cast and acts both as a plaster dam and as a compressive spring when opposed plates and dental arch casts are pressed in opposition on a bite registration to secure the cast to the articulator. An adjustable stop is secured to one support element for contact with the other support element to limit proximity of the jaw elements and is removable without changing its effective length.


**52 Claims, 14 Drawing Figures**



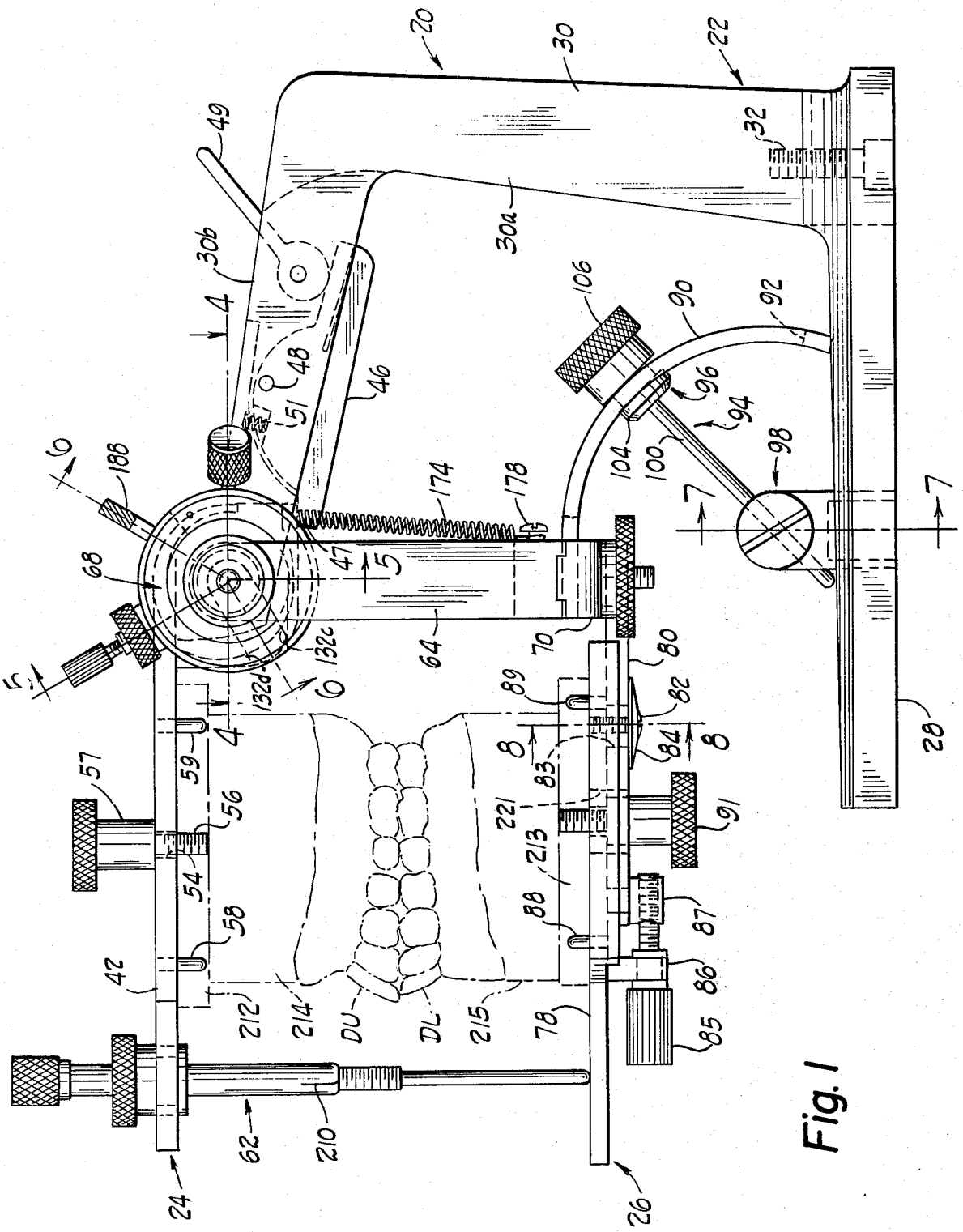

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Fig. 1

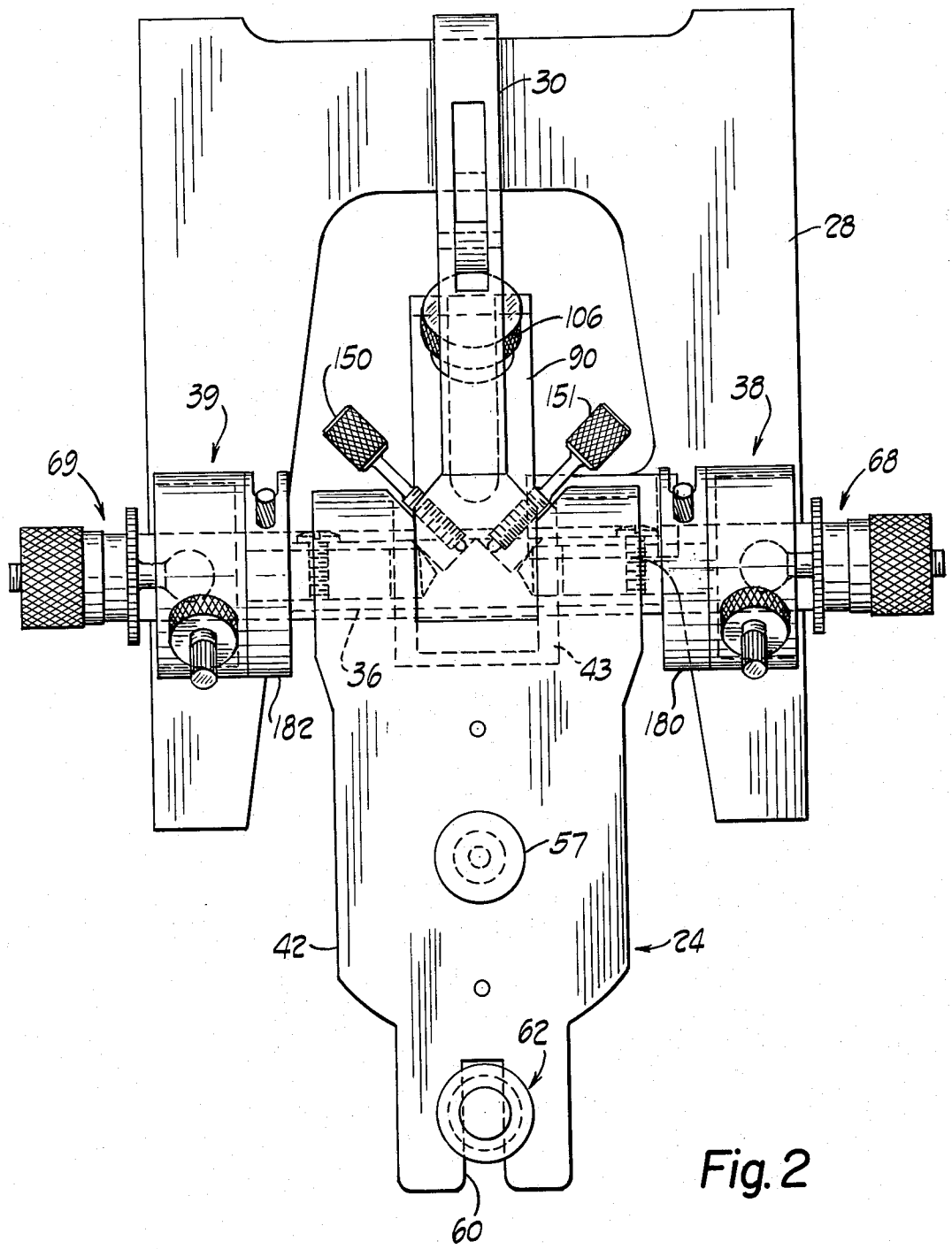



Fig. 2

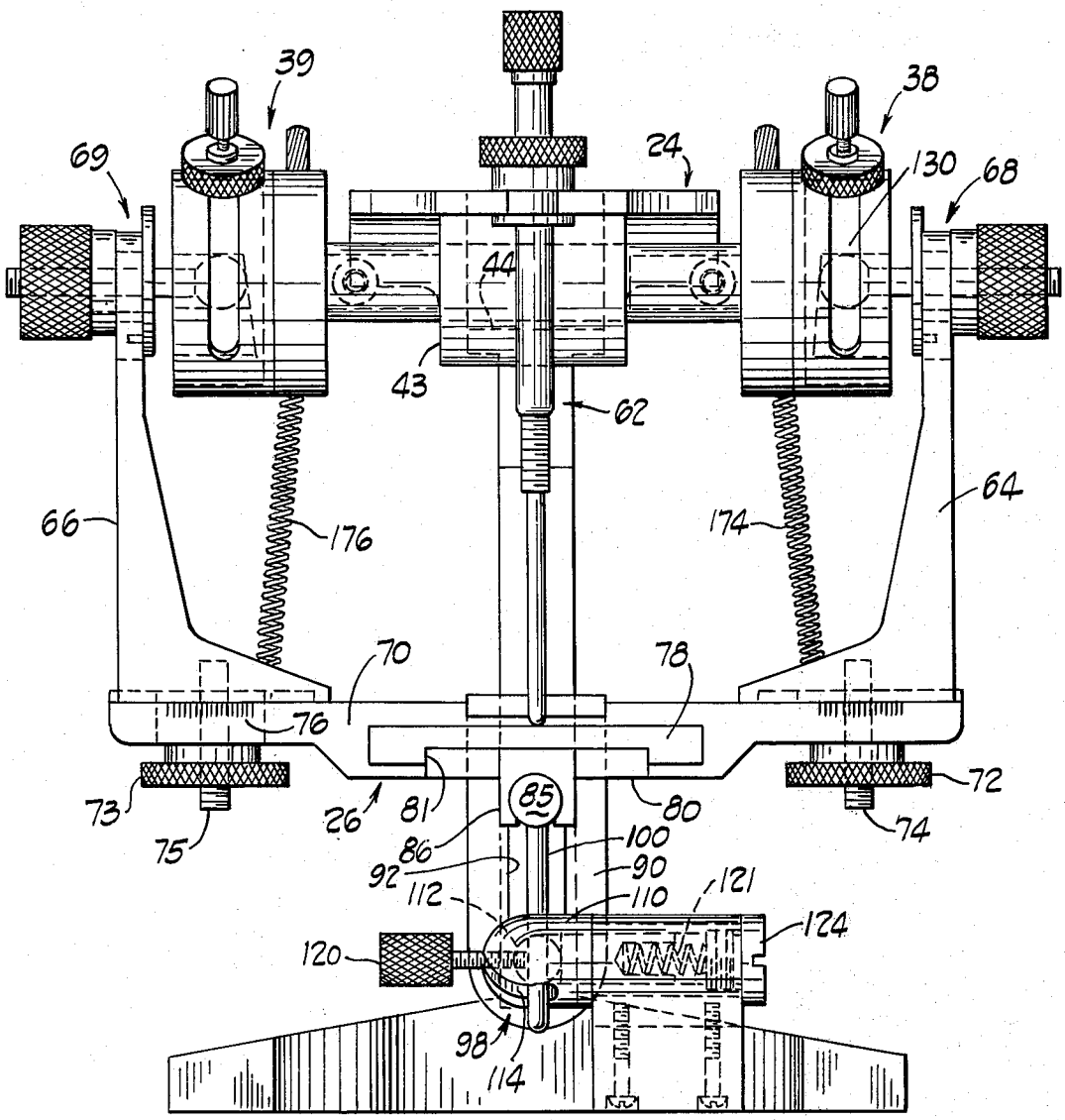

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Fig. 3

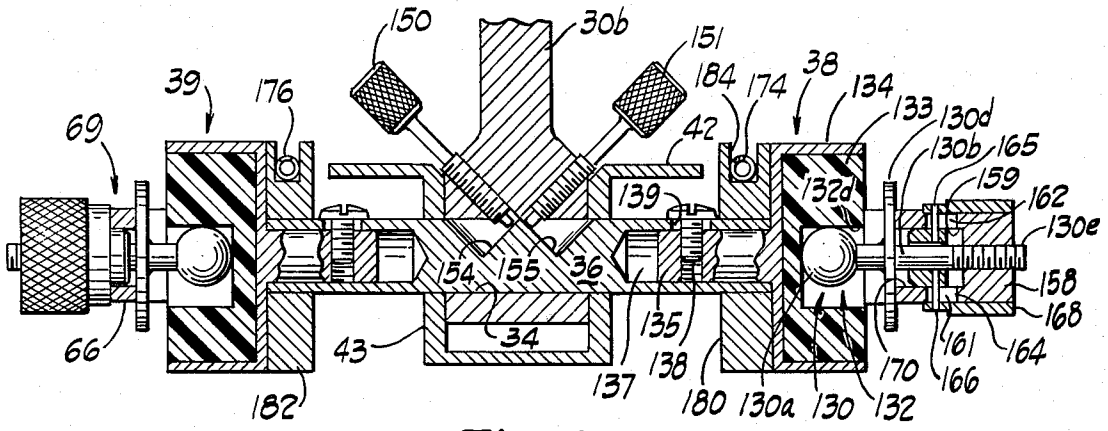



Fig. 4

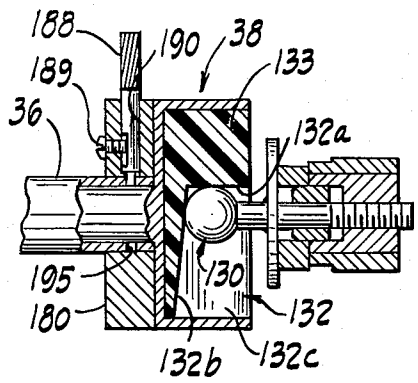



Fig. 6

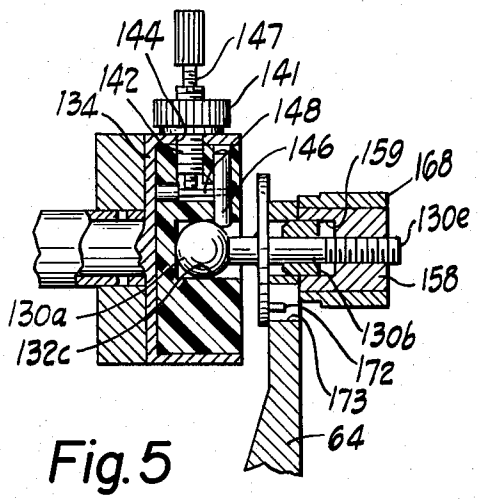



Fig. 5

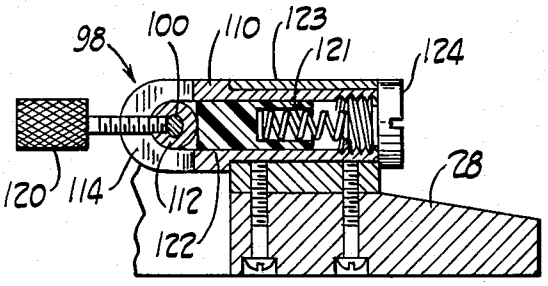



Fig. 7

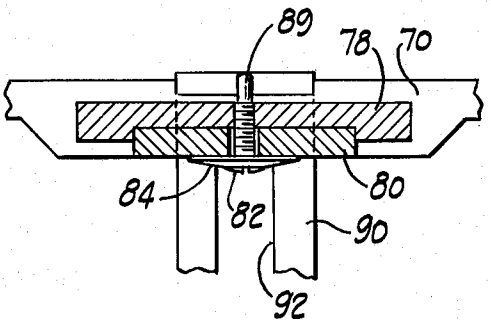



Fig. 8

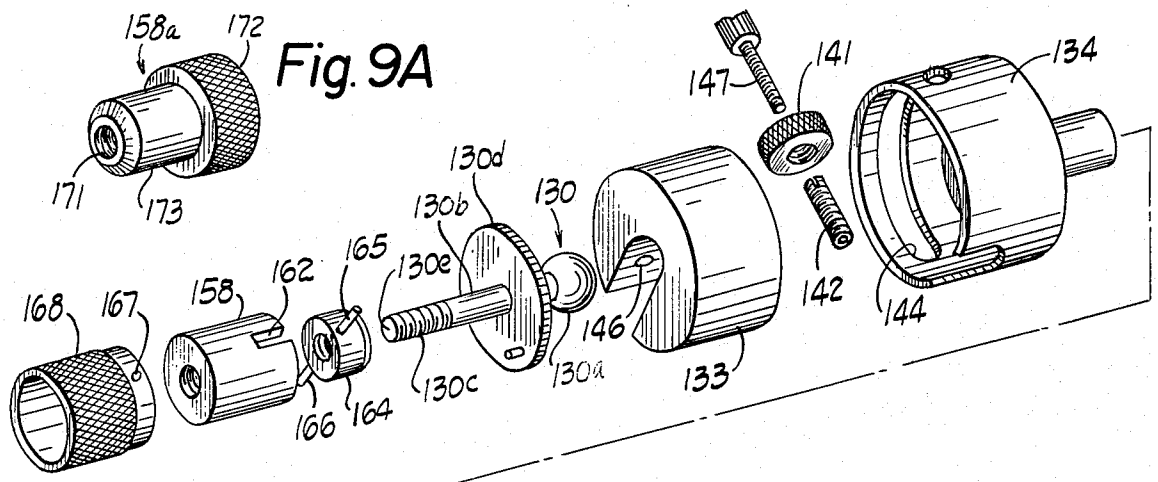



Fig. 9A

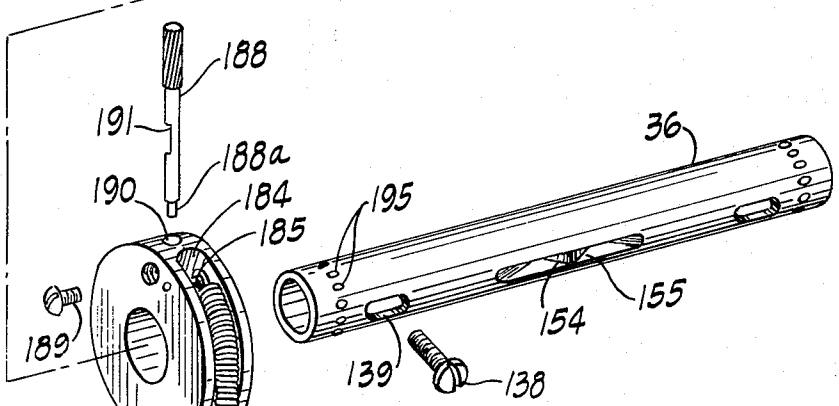



Fig. 9

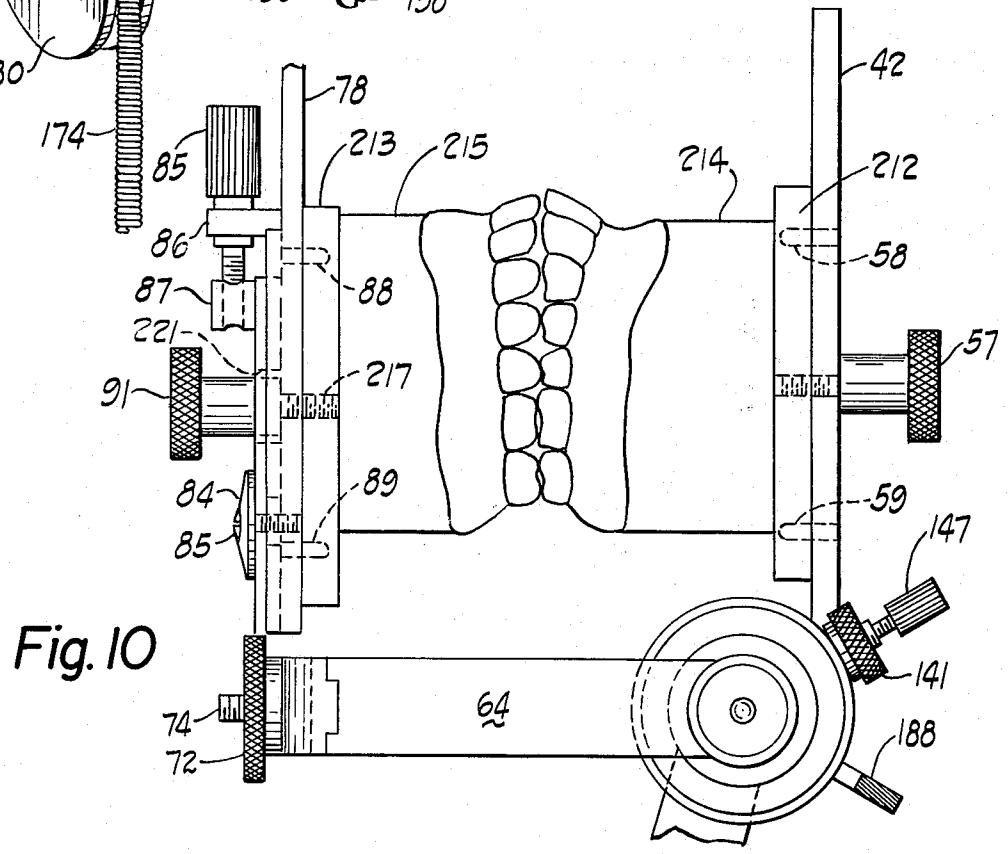



Fig. 10

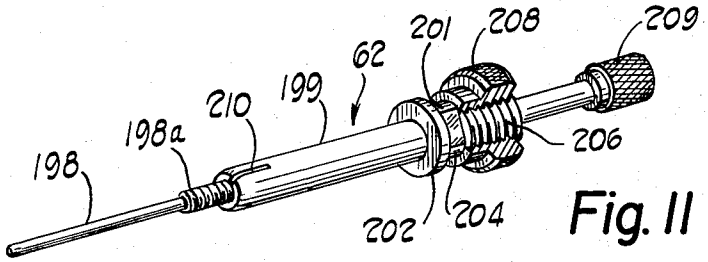



Fig. 11

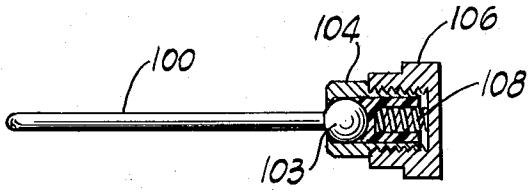



Fig. 12

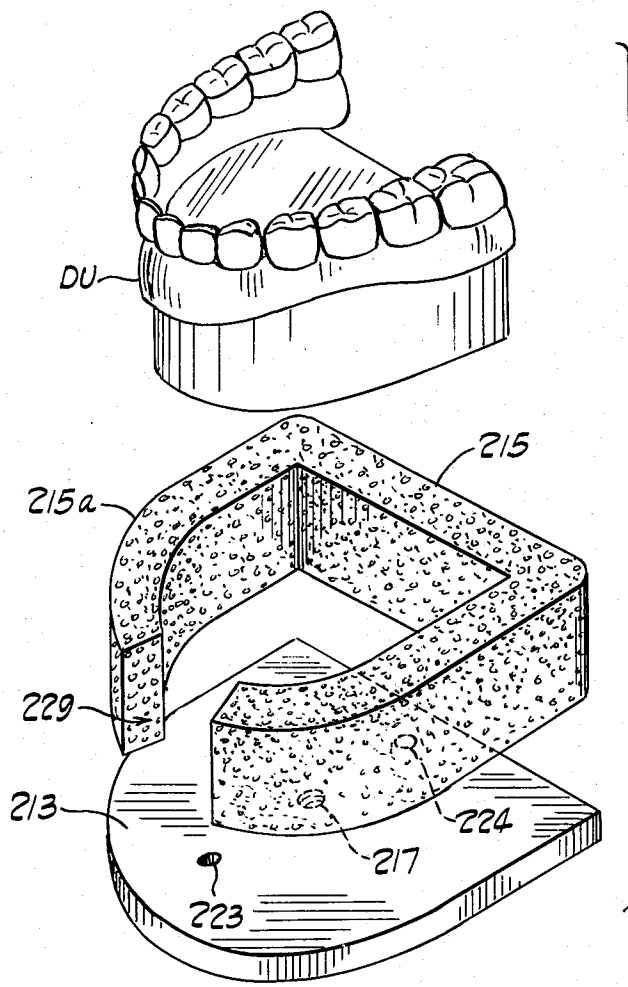



Fig. 13

# DENTAL ARTICULATOR

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to dental articulators.

2. Prior art

The general purpose of an articulator mechanism is to move cast replicas of dental arches relative to one another through the intercuspal range and to their closed position. The movements and closed positions attainable on an articulator are important in attaining a functional restoration of teeth. An articulator, along with a compatible face bow system, aids a dentist in diagnosing the articulation and occlusion of a particular patient and aids him in constructing restorations outside of the mouth.

Good articulation and occlusion are important for oral health, comfort and aesthetics, and in the case of denture wearers, are important to maintain the periodontal structures, denture stability, chewing efficiency, and comfort. In cases of improper tooth arrangement and contour, forces can be generated during articulation and occlusion that traumatize the tooth-supporting structures, thereby weakening tooth support, increasing tooth mobility and increasing the likelihood of periodontal infection. In some instances improper tooth-to-tooth contact causes forces at the temporomandibular joints that result in a muscle spasm — pain syndrome.

The process of dental restoration is long and involved. An articulator, when used with a face bow, in effect puts the patients head on the workbench where lengthy construction procedures can be made without discomfort or hazard to the patient. Moreover, functional jaw movements required to design and evaluate restorations are difficult to generate consciously in the mouth. In practice, mechanically reproducible movements based on preconscious functional recordings of jaw movements are preferable.

The articulator is typically used with a face bow measuring system that relates the particular patient's temporomandibular joints to his dental arches, and a bite registration to relate the dental arches, one to the other, so that the dental arches can be properly positioned on the articulator.

The face bow insures the accuracy of the bite registration by indicating with pointers that the jaw is in the desired position while the impressionable material on the bite registration records the imprints of the cusp tips. Among other functions it also serves to approximately locate the particular patient's temporomandibular joints with respect to his dental arches. The bite registration is preferably thin and typically includes an impressionable material. When affixed to the face bow and clamped between the teeth of the patient, it records a relationship between the teeth and the temporomandibular joint, that can be transferred to the articulator.

The complex movements of the jaw have been recognized for some time. See, for example, the article published in **1908** by N.G. Bennett entitled "A Contribution to the Study of the Movement of the Mandible" ["Proceedings of the Royal Society of Medicine" (Odont. Sect.) Vol. I (3)]. A great many articulators have been designed for dental use. According to a thesis by James E. House ("The Design and Use of Dental Articulators in the United States from **1840** to **1970**" — Master's Thesis, School of Dentistry, Indiana University, **1970**) **235** dental articulators were patented in the United States during the period **1840** to **1970.** Typically, early articulators were of the so-called hinge type in which two superposed support plates were used, one fixed and one supported for simple pivotal movement toward and away from the other. Also, see U.S. Pat. No. **1,574** issued Apr. **30, 1940** and purportedly the first patent to be issued on an articulator. More sophisticated articulators hinge the upper plate for translational and rotational movement, sometimes through the use of adjustable shafts, to simulate the temporomandibular joint. Movement of the hinged plate is controlled by the joint construction, which may include condylar elements in condylar guide housings. Typically, a pin would be provided on the pivoted jaw member and an incisal guidance table provided on the fixed frame to guide the movable jaw in chewing movement. In contrast, an articulator using only a hinge movement lacks chewing closure movement.



Articulation with pivoted upper plates have resulted in a reversal of movements from that of the normal jaw. Also, attempts to provide the variety of necessary movements and adjustments to accommodate differences in measurements for patients has resulted in complex arrangements that have practical limitations and are difficult to use. Yet, for the modern practitioner, the dental articulator must provide many different jaw positions and perform many movements through different mechanisms. The ease and simplicity with which an articulator can be adjusted to provide the needed positions and perform the needed movements accurately and precisely, largely determine its usefulness.

## SUMMARY OF THE INVENTION

The present invention provides a dental articulator that incorporates the necessary adjustments and movements to produce the necessary flexibility and motions to attain the needed positions and movements for diagnosing articulation and occlusion and to aid in constructing restorations. At the same time, the articulator embodying the present invention is of simplified construction readily adjustable without the need for tools, and will perform the different movements required accurately and precisely. It has the particular advantage of simulating the natural movements of a lower jaw in the normal relationship to the upper jaw by utilizing a jaw element connected to a frame in an orientation analogous to the natural position of the jaw in the skull.

Most desirably, an articulator must be capable of closely duplicating jaw chewing movement; i.e., the so-called working condyle of the articulator, corresponding to the condyle on the pressure applying side of an actual jaw, should move medially or sideways while the non-working condyle moves along a constraining path analogous to the temporo-mandibular fossa and controls the extent of the medial movement of the working condyle. The movement of the front, i.e., tooth area, of the movable articulator jaw must also be suitably constrained along a desired approach angle to the fixed jaw. The articulator embodying the present invention attains this capability through a minimum of adjustments and constraints to assure the necessary flexibility and movements without undue mechanical complexity. An instantaneous screw axis analysis of actual jaw movement and of the present articulator movement

shows that the movable articulator jaw moves through essentially the same instant axes as an aactual jaw, during typical chewing movement.

Basically, the present invention is comprised of two relatively movable jaw elements for supporting dental arch casts, and specific adjustments and constraints for the jaw elements. A lower jaw element is adjustably supported, e.g. by a support frame, for complex translational and rotational movement, to simulate chewing jaw movement and to facilitate tooth gliding. The upper jaw element is supported, as by the same frame, for simple pivoting about a single axis to provide access to the dental arch casts and for establishing maximum intercuspal position, i.e., closed position. The device is constructed to locate dental arch casts supported by the jaw elements in a forward location relative to the supporting portions of the apparatus frame, accessible for work and view without interference from the frame, pivot structure or constraints associated with the pivoted jaw member.

Movement of the lower jaw element is controlled by two joint constraints above a dental arch cast support portion and a prime link constraint between the jaw element and frame. The link constrains one degree of freedom of the jaw element movement, helps define the approach of the lower jaw element relative to the upper element, and in addition establishes functional chewing movement. The link is adjustable in its effective length and angle between the support frame and jaw element to vary the angle and range of movement of the jaw element. It is also releasable to permit hinge type pivoting and tooth gliding movement of the lower element, or the use of an incisal table for controlling jaw element movement. Pivot mechanisms include a number of adjustments for releasing the repositioning the lower jaw element and for permitting sideward movement and guided sliding movement, analogous to that of the condyles of the jaw on the fossae of the skull. The pivot mechanisms are adjustable for different dimensions that may be required when working on dental casts for different individuals. The adjustments are useful to indicate the difference between a position determined from a bite registration mounting and the existing (acquired) closed position as determined by the teeth and further permit the quick remounting of dental casts to any bite registration or the comparison of a number of bite registrations with the cementing position of the dental arch casts to thereby compare the bite registrations one with another. In this manner, the device serves the same function as the known split-cast technique, but provides greater speed and indicates the amount of any discrepancy. The adjustments include, in particular, the independent setting of the slope of the structures analogous to the fossae and the setting of a desired intercondylar distance. A side shift of the pivots is provided to increase the effective lateral movement which is useful for developing clearances of posterior teeth and lateral movements as well as to develop a sideward freedom of movement at the closed position.

Each pivot mechanism provides a first lock for adjustably positioning the angle of the condyle-guiding structure analogous to the fossa slope, and a second lock for separately and selectively restraining or releasing each condyle pivot of the lower jaw to prevent or allow movement of either or both along the guiding fossae slopes. When both condyle pivots are restrained by the second lock, the lower jaw pivots about a single fixed axis. As a further feature of the pivot mechanisms, each condyle pivot can be released relative to the lower jaw and the jaw freely moved and/or adjusted with respect to the condyle elements in two degrees of freedom.

Adjustable spring tension mechanisms are provided for the lower jaw mechanism to adjust the closing force of the lower jaw to the desired feel, or to completely release spring tension as when the condyle pivots of the jaw are released relative to the jaw in determining the existing or acquired closed position applicable to the supported dental arch casts.

A mechanism comprising a rectilinearly adjustable slide surface is carried by the lower jaw to accurately correct for overretrusion of the jaw by bringing the jaw straightforward from a retruded position rather than down the fossae slopes, and to develop anterior-posterior clearance between the dental arch casts.

The upper jaw hinge movement is selectively controlled by a lock mechanism that is positive in action and cam controlled, to selectively permit pivoting movement. The upper jaw mechanism carries an anterior stop and incisal pin constructed so that the pin can be removed without changing its setting. The pin controls the distance between the upper and lower jaw elements and can be adjusted to open the bite to compensate for thickness of articulating papers and to change the freeway space. It can also be used as a cam follower on an incisal table and can be used to make jaw movement tracings.

A novel mounting plate is provided for use with each jaw element to facilitate support of the dental arch casts. Each mounting plate includes a rigid back member and a peripheral sponge-like wall portion forming a peripheral surface against which the back surface of the dental arch cast rests and further forming an enclosure for plaster. By virtue of the sponge-like construction of the peripheral wall, a nearly constant and uniform holding pressure can be exerted against opposed casts, to maintain the casts in a desired relationship as plaster is poured between the casts and supporting plate, and within the peripheral wall. With this arrangement, both casts can be mounted concurrently and the plaster is to t the area desired. The construction of the support frame facilitates orienting the jaw elements vertically so that plaster can be easily supplied to the zones defined by the peripheral sponge walls.

It will be apparent from the above that a general object of this invention is to provide an improved dental articulator that supports dental arch casts in a natural relationship and in a position relative to the frame that facilitates working and viewing without obstruction, that mechanically reproduces jaw movement and jaw position as they occur functionally in the mouth, and that can be conveniently and easily adjusted to relate the dental arch casts to a particular patient's temporomandibular joints. More specific objects as well as other features and advantages of the invention will become apparent from the detailed description that follows, when considered in connection with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of an articulator embodying the present invention;

FIG. 2 is a top plan view of the articulator of FIG. 1;

FIG. 3 is a front elevational view of the articulator of FIG. 1;

FIG. 4 is a partial sectional view taken along the line 4—4 of FIG. 1;

FIG. 5 is a partial sectional view taken along the line 5—5 of FIG. 1;

FIG. 6 is a partial sectional view taken along the line 6—6 of FIG. 1;

FIG. 7 is a partial sectional view taken along the line 7—7 of FIG. 1;

FIG. 8 is a partial sectional view taken along the line 8—8 of FIG. 1;

FIG. 9 is an exploded perspective view of the shaft and one condyle pivot assembly of FIG. 4;

FIG. 9A is a perspective view of a modified embodiment of one part of the condyle pivot assembly of FIG. 9;

FIG. 10 is a partial side elevational view of the apparatus of FIG. 1 oriented with the jaw elements vertical to facilitate cementing of the dental arch casts to the articulator;

FIG. 11 is a perspective view, with parts broken away and parts in section, of the incisal pin that forms a part of the articulator;

FIG. 12 is an elevational view with parts in section of a link pin that forms a part of the articulator; and

FIG. 13 is an exploded perspective view of a mounting plate and sponge wall used to support a dental arch cast in accordance with a preferred embodiment.

## DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

A dental articulator embodying the present invention is indicated generally by reference number **20** in the drawings, and basically comprises a stand **22,** a maxillary or upper jaw member **24,** and a mandibular or lower jaw member **26,** which members are constructed to hold upper and lower dental arch casts DU and DL in a natural, opposed relationship, as illustrated in phantom in FIG. **1.** The stand is constructed to orient the jaw members in two directions, one in which they extend substantially horizontally as shown in FIG. **1,** and a second position in which the stand is placed on its back, with the jaw members in a substantially vertical direction as shown in FIG. **10,** especially useful for initially mounting the dental arches. Both jaw members **24, 26** are pivoted to the stand **22** to facilitate access to the dental arches and to permit articulation of the lower jaw, for chewing and gliding movements, relative to the upper jaw member.

The stand **22** is constructed to support the articulator on a flat horizontal surface, and for that purpose is provided with a U-shaped base **28,** from which an L-shaped upright member **30** extends, one leg **30***a* of which extends vertically from the back of the base and another leg **30***b* of which extends forwardly over the base to support the jaw members **24, 26** in cantilever fashion. In the embodiment shown, the leg **30***b* is received in a slot of the base **28** and is secured by a screw **32.** A through bore **34** (FIG. **4**) is formed in the distal end portion of the leg **30***b* to receive a cylindrical shank **36** that extends transversely of the leg **30***a* and parallel to the plane of the U-shaped base **28.** Two joint area socket-like pivot structures indicated generally at **38** and **39** are carried by the shaft **36,** one at each end, and cooperate with ball-like pivot structures of the lower jaw element to articulate the lower jaw element relative to the stand in a manner generally analogous to the manner in which the fossae and condyles of the temporomandibular joint pivot the human jaw.

The upper jaw member **24** is comprised of a plate **42** with a hinge structure **43** at the back end, that receives the end of the leg **30***b* that journals the shaft **36.** A transverse surface **44** of the hinge structure **43** (see FIG. **3**) abuts the lower surface of the leg **30***b*, to prevent the plate **42** from pivoting toward the lower jaw element beyond a horizontal position parallel to the base of the stand. Upward pivoting of the plate **42** to a position slightly beyond or behind a vertical position is permitted by the hinge structure. When the plate **42** is in a horizontal position, as shown in FIG. **1,** a latch **46** pivotally carried by pin **48** on the leg **30***b* can be engaged through a lever **49** with a notch **47** of the hinge structure **43** to retain the plate in a lowered or horizontal position. A compression spring **51** biases the latching lever **46** toward a non-latching position. A central aperture **54** is provided in the plate for receiving a screw **56** having a knurled knob **57** above the plate, for attaching a dental arch cast. Depending locating pins **58, 59,** are located on diametrically opposite sides from the aperture **54,** to locate and prevent rotational movement of a dental arch cast. A front slot **60** (FIG. **2**) is provided in the plate **42,** perpendicular to the hinge access, for receiving an incisal guide pin **62.**

The lower jaw element **26** is comprised of two parallel support arms **64, 66** (see FIGS. **1** and **3**) that pivotably depend from the pivot structures **38, 39** through condyle pivot assemblies **68, 69,** at upper ends of the support arms, which are in part received in the pivot structures **38, 39.** A crosspiece **70** connects lower ends of the two arms **64, 66,** through a tongue and groove junction that provides for adjustment of the distance between the two arms **64, 66.** The position of each arm is secured by a knurled nut **72, 73,** on a threaded post **74, 75,** that extends from each arm through a longitudinal slot in the cross piece **70.** Calibrations **76** are provided for each arm to facilitate centering or otherwise positioning the cross piece and indicate the distance between the arms.

A mandibular plate **78** extends forwardly from the cross piece **70,** supported on a tongue **80** that is partially recessed into a lower groove **81** of the plate. The plate is secured to the tongue by a screw **82** that is threaded in an aperture of the plate and that extends through a slot **83** of the tongue. A spring washer **84** beneath the tongue yieldably biases the plate to the tongue for relative sliding movement. The plate is also secured to the tongue by an adjustment screw **85** rotatably secured to the plate **78** at a fixed location by a yoke **86.** A fixed projection **87** receives the screw **85** in a threaded bore, so that rotation of the screw slides the plate **78** rectilinearly toward and away from the cross piece **70,** relative to the tongue **80.** Locating pins, **88,** 89 and a knob **91** similar to the knob **57** locate and secure a dental arch cast to the plate **78.**

For purposes of providing a restraint to motion of the lower jaw element **26,** a curved finger **90** extends rearwardly from the cross piece **70,** in an opposite direction from the tongue **80,** and downwardly toward the base of the stand. The finger has a central elongated slot **92.** In the preferred construction, the curvature of the finger is of approximately but not exactly a uniform radius.

A restraining linkage **94** connects the lower jaw member **26** through the finger **90** to the stand **22** to limit the freedom of movement of the lower jaw element relative to the upper jaw element in a manner that will produce a range of final closing movements of the jaw element as occur during chewing, and which is constructed to be easily released to facilitate tooth gliding and to adjust for the thickness of a bite registration. The linkage provides a degree of restraint to movement of the lower jaw member **26** by fixing the distance of a point on the jaw from a point on the stand. This linkage holds jaw movement to a desired path and, unlike an incisal pin and table, there can be no movement beyond that permitted by the link, whereas an incisal pin can be inadvertently lifted from the guide table.

The linkage **94** is comprised of a universal joint **96** movable along the slot **92** to change the angle at which the link extends relative to a plane passing through the point of connection of the link to the stand and the pivots of the lower jaw member, a universal joint **98** fixed to the stand and located generally centrally of the curvature of the finger **90,** and a rigid link **100** connected to the universal joints in a manner to facilitate adjustment of the effective length of the link. Alternatively to facilitating length adjustment, the location of one of the joints **96** or **98** could be movable to facilitate a change in angle and the length of the link maintained constant.

As best shown in FIGS. **1, 3, 7** and **12** the link **100** is in the form of a pin with an integral ball **103** at one end that forms a part of the universal joint **96.** The ball **103** is received in a ball housing **104** that rides in guided relationship within the slot **92** of the finger **90.** A knob **106** is threadedly secured to the ball housing **104** and serves to clamp the ball housing in a fixed position along the slot **92** when the knob is tightened against the finger **90.** In addition, the knob retains a compression spring **108** that spring loads a plastic bearing against the ball **103** in a direction that biases the pin outwardly of the housing.

A slotted housing **110** rotatable about a horizontal axis transverse to the link **100** supports a ball **112** of the universal joint **98.** The housing **110** is slotted at **114,** so that the ball **112** lies in the path of the slot. The ball **112** has two cylindrical apertures along radii at right angles, one of the apertures extending diametrically through the ball and receiving the link **100,** and the other aperture extending at right angles thereto, communicating therewith and threaded to receive a set screw **120.** The ball **112** is spring-biased against the housing **110** by a compression spring **121** and slidable bearing block **122** within a support bracket **123** in which the slotted housing is rotatable. A screw **124** retains the spring under compression against the ball.

The pivot structures **38, 39** and condyle pivot assemblies **68, 69** together serve to connect the ends of the parallel jaw supports **64, 66** to the stand **22** for movement with three degrees of freedom, and are constructed to (a) serve as condyle range finders to indicate the difference in mounting position at the condylar element and along the condylar axes, between the acquired and ideal positions of the jaw, (b) act as pivots that allow restrained jaw movement simulating chewing motions of the teeth, and (c) permit release and reattachment of the jaw element to ball pivots that act as condylar elements to adjust to a bite registration or to otherwise change the relationship between dental arch casts secured to the mandibular and maxillary plates without recementing the casts. Each of the pivot structures **38, 39** and condylar pivot assemblies **68, 69** is a mirror image of the other and therefore only the pivot structure **38** and associated condylar pivot assembly **68** will be described in detail.

A ball element **130** of the assembly **68** is carried by the upper end of the jaw arm **64** and is received in a guide slot **132** formed in a cylindrical rotatable insert **133** of the pivot structure **38.** The insert **133** is carried in a cylindrical cup **134** secured to an end of the shaft **36** by a hub **135** received in a bore **137** of the shaft. The cup **134** is held in place by a screw **138** that passes through an axially elongated slot **139** in the wall of the bore **137** and threadedly received in the hub **135.** The guide slot **132** is the width of a ball **130***a* of the ball element **130.** An end surface **132***a* of the guide slot locates the ball with its center aligned with the center of the pivot shaft **36.** A back surface **132***b* of the slot is inclined at about **7°** from a plane perpendicular to the axis of the shaft **36,** as best seen in FIG. **6,** inclining inwardly from the end surface **132***a* toward the peripheral edge of the insert **133,** through which the guide slot opens. This angle was established to produce a desired sideways movement. Rotation of the insert **133** relative to the cylindrical cup **134** changes the angle of side surfaces **132***c*, 132*d* of the guide slot with respect to the axis of the shaft **36,** so that the side surfaces can be adjusted to correspond to the slope of the fossa of the temporomandibular joint, the function of which it simulates.

Adjustment of the rotatable insert **133** by rotation within the cylindrical cup **134** is made possible by a clearance fit between the two. An angular position is maintained through a clamping nut **141** on the outside of the cup **134,** threaded in clamping relationship therewith upon a shaft **142** secured in the insert **133** and extending radially therefrom through a peripheral slot **144** that extends partially around the cylindrical cup.

The ball **130***a* can be locked in a back position, against the end surface **132***a* of the guide slot with a pin stop **146** (FIG. **5**), controlled by a screw **147** threaded through the shaft **142.** The pin stop **146** is carried within the rotatable insert **133** on the end of a cantilever spring **148** secured at one end within a cavity of the insert. The pin stop **146** is carried within the rotatable insert **133** on the end of a cantilever spring **148** secured at one end within a cavity of the insert. The pin stop is movable on the spring lever into and out of the guide slot **132,** and is biased by the spring lever to a position out of the guide slot. An inner end of the screw **147** contacts the spring lever between the point of attachment and the pin stop carried on the free end. By turning the screw **147** to advance the screw inwardly, the pin stop **146** is moved into engagement with the ball **130***a*. The location of the pin stop relative to the end surface **132**a of the rotatable insert is such that it will retain the ball in the rearward position, while allowing the ball to rotate or pivot about its center. That is, the pin is spaced from the end surface **132***a* down the slot **132** a distance equal to about three-fourths the diameter of the ball.

Lateral adjustment of the pivot structures **38, 39** so as to shift the position of the guide slots and cooperating ball elements relative to the upper jaw element, for purposes of a side shift to establish lateral freedom of jaw movement, is facilitated by axial movement of the

shaft **36** relative to the L-shaped upright stand member **30.** The axial position of the shaft **36** is retained in or shifted to a desired position with two adjustment screw knobs **150, 151,** that are threaded in the enlarged end of the leg **30**b and which abut a respective inclined surface **154, 155** of the shaft. The screws **150, 151** are inclined toward one another and act substantially perpendicularly to the inclined surfaces **154, 155.** Thus, the two screws, cooperating with the respective inclined surfaces, locate the shaft **36** in a fixed axially position when the two screws are in direct contact with the respective surfaces. Upon retraction of one screw and extension of the other, the shaft **36** can be shifted axially in one direction or the other. Separate lateral adjustment of each pivot structure **38, 39** is facilitated by the associated screw **138** and the elongated slot **139.** Any separate adjustment outward requires adjustment of the distance between the support arms **64, 66** of the lower jaw element. Relative inward movement affords free sideways movement.

The ball element **130,** in addition to having a ball **130***a* has a shaft **130***b* extending outwardly from the ball, with threads **130***c* on the outer end. In addition, an integral flange **130***d* is carried by the shaft, spaced outwardly from the ball a distance sufficient to permit the ball to pivot within the guide slot **132.** The flange **130***d* serves as a clamping surface for the upper end of the support arm **64.** A clamping nut **158** is received on the threads **130**c and has a counter bore **159** that faces the flange **130***d*. Two diametrically opposite axial slots **161,** 162 are formed at the end of the clamping nut, in the wall of the counter bore. An annular centering guide **164** is slidable within the counter bore **159** and on the shaft **130***b*. Two diametrically opposite pins **165, 166** extend from the centering guide and are receivable within the slots **161, 162.** The length of the pins extends beyond the periphery of the clamping nut and are received in apertures **167** of a knurled sleeve **168** that slidably surrounds the clamping nut **158.** The outside diameter of the centering guide **164** is closely receivable within a circular aperture **170** in the upper end of the arm **64.** The depth of the counter bore **159** is substantially equal to the axial length of the centering guide **164,** so that the guide can be completely retracted into the counter bore. The length of the slots **161, 162** facilitate this movement. As a result of this construction, the centering guide can either be extended beyond the end of the clamping nut **158** so as to project into the aperture **170,** thereby centering the shaft **130** relative to the aperture **170,** or the centering guide can be retracted into the counter bore **159** so that the location of the shaft **130** within the aperture **170** can be adjusted or so the upper end of the arm **64** can float through an adjustable connecting relative to the shaft **130,** within the limits of the aperture **170.** In either event, i.e., whether the centering guide is retracted or extended, the nut **158** is rotatable through the sleeve **168** and the pins **165, 166,** to clamp the upper end of the arm **64** against the flange **130**d. Rotation of the shaft **130** is restrained by a pin **172** that extends into a slot **173** in the arm **64,** directly beneath the circular aperture **170** to keep the element **130** from rotating when the nut **158** is adjusted. The arrangement between the pivot assembly **68** and the arm **64** permits complete freedom of movement of the lower jaw element within a limited but adequate range so that the relationship of the lower jaw element plate can be changed relative to the pivot axis of the jaw element. The position of the lower jaw element can therefore be set to work toward an existing closed position; can be set with the centering element to work toward a closed position as determined by the mounting bite registration; or can be located in any desired relationship to the upper jaw element and locked in the relationship for pivoting and translation as controlled by the pivot structure and restraining linkage. It will be appreciated that readjustment of the ball elements relative to the arms **64, 66** permits tilting of the lower jaw member about an axis perpendicular to the axis through the ball elements, i.e., in a manner to tilt the mandibular plate **78** and crosspiece **70** so the left side, for example, is higher than the right side when viewed as in FIG. **3.** When this adjustment is made, the shaft portions **130***b* of the ball elements are no longer aligned (the ball element shaft of assembly **69** is tilted upward from the ball and the other is tilted downward) but the centers of the ball elements themselves will remain aligned with the axis of the shaft **36** as long as they are retained in a rearward position by the pin stops **146.** When the stop pin is retracted, the ball is movable along the fossae slope, with the lower jaw element having a new relationship with the upper element.

A modified clamping nut **158***a* is shown in FIG. **9A** having a threaded bore **171** for receiving threads **130***c*. A flat face **172** perpendicular to the axis of the bore **171** clamps against the support arm **64** when the nut is oriented as shown, to hold the arm in an adjusted position. When the nut is reversed on the shaft **130***b*, a smaller diameter portion **173** is closely received in the aperture **170** of the arm **64** and centers the shaft **130** relative to the aperture **170.**

The lower jaw member **26** is yieldably biased toward the upper jaw member by tension springs **174, 176.** Each spring is attached at its lower end to a screw adjacent the base of each support arm **64, 66,** one screw being shown at **178** in FIG. **1.** The upper end of each spring is secured to a tension wheel **180, 182** rotatably supported on the shaft **36,** directly adjacent the pivot structures **38, 39,** respectively. The tension wheel **180** is shown in detail in FIG. **9** and, as shown therein, the upper end of the tension spring **174** is received in a peripheral groove **184** that extends approximately halfway around the wheel. The end of the spring is secured to a cross pin **185** within the adjacent one end of the groove. A stop pin **188** extends radially through the wheel **180** and is secured for relative sliding movement in a radial direction by a screw **189** that intersects the radial aperture **190** in which the stop pin is located. The screw **189** is received in a recess **191** of the stop pin, which recess is axially elongated to permit movement of the pin in the radial direction an amount equal to approximately the length of an end portion **188***a* of somewhat reduced diameter. The end portion **188***a* is receivable in one of a plurality of peripherally spaced apertures **195** in the shaft **36.** By rotating the wheel about the shaft, and locating the end **188**a of the stop pin **188** in a selected aperture **195,** the tension on the spring on the lower jaw member can be varied.

The incisal guide pin **62** carried by the maxillary plate **42** serves as an anterior stop for the lower jaw member to limit its upward movement. The guide pin, as shown in FIG. **11,** is an assembly that includes a stop pin **198** with a threaded portion **198***a* that is threaded into a holder portion **199.** An integral collar **201** on the

holder portion has two a lower flange **202** and a central portion **204** with flat sides that cooperate with the slot **60** in the maxillary plate, to support and locate the pin. A threaded end **206** of the holder portion **199** extends upwardly above the collar **201** through the maxillary plate and receives a knurled clamping nut **208** that clamps the maxillary plate against the collar **201**. The upper end of the stop pin **198** extends above the threaded portion **206** and has a knurled knob **209** that can be turned to extend the stop pin **198** or retract the stop pin relative to the holder portion **199**. The holder portion **199** is split at its lower end as shown at **210** and tensioned inwardly to load the stop pin and eliminate any looseness or play. With this arrangement, the incisal guide pin assembly can be removed without changing its setting relative to the maxillary plate and is rigid for use of a cam follower on an incisal table that can be carried by the lower jaw member. By adjustment of the knob **209**, the pin can be extended to open the bite to compensate for the thickness of articulating papers and to change the freeway space between dental arch casts. The pin can also be used to make jaw movement tracings.

Upper and lower dental arch casts DU and DL (FIG. **10** and also in phantom in FIG. **1**) illustrate the manner in which the casts are secured to the articulator by upper and lower mounting plates **212, 213** and associated sponge walls **214, 215** against which the dental arch casts are positioned. The structure is shown in more detail in FIG. **13**. The mounting plates and sponge walls are mirror images, and only the plate **213** and wall **215** will be described in detail. The plate includes a central threaded aperture **217** for receiving a threaded shaft portion of the knob **91** that is received within a slot **221** of the tongue **80**, to secure the mounting plate to the movable mandibular plate **78** without interfering with the movement of the plate relative to the tongue. Two additional locating apertures **223, 224** are formed in the lower surface of the mounting plate **213** for receiving the locating pins **88, 89** of the mandibular plate. The wall **215** is of cellular or sponge-like material and is resilient. It extends about the periphery of the mounting plate **213** and has a peripheral opening **229** at a location that faces forward or outwardly of the articulator. The general shape of the mounting plate **213** and peripheral wall **215** is compatible with the shape of the dental arch.

Because of the resilience of the sponge-like cellular wall **215**, the dental arch cast DL, adapted to rest against an edge **215***a* of the wall, conforms the wall to the contour of the opposed surface of the cast. Thus, the wall affords complete peripheral support and together with the cast and mounting plates form a cavity therebetween. The resilience of the two walls **214, 215** forces the two casts DU and DL against one another when the jaw plates **42, 78** are parallel, thereby holding the two casts in a desired position, preparatory to affixing the costs to the mounting plates with plaster. Plaster is introduced through the opening **229** and into the cavity formed by the wall **215**, the lower mounting plate **213**, and the lower dental cast DL. The plaster hardens while the lower cast is held by the resiliency of the wall in a desired position relative to the opposed cast and mounting plate. By virtue of the construction of the articulator and the location of the opening **229**, plaster can be readily poured into the cavity formed by the wall **215** when the articulator is supported utilizing the leg **30**a of the L-shaped upright portion of the stand as a base.

## OPERATION

In use and by way of an initial summary, the articulator adjustments are set to an initial condition to facilitate mounting upper and lower dental arch casts to a closed position determined with the aid of a bite registration and face bow. The casts are mounted and certain articulator restraints are then removed. The jaw is then located in the existing closed position, as dictated by the teeth. The condyle pivot assemblies of the articulator are used to determine the difference between the bite registration-determined and the existing tooth-determined closed positions and a selection of a position is made to which the reconstruction will be performed. Fossa slopes are then set on the articulator from measurements made on the patient with a face bow or protrusive bite registration. Relationships, principally of anterior teeth, are determined with chewing movements, and posterior tooth clearance is evaluated with lateral movements, facilitated by the articulator.

Prior to mounting the dental arch casts, the following adjustments are made to the articulator. The condyle pivot assemblies **68, 69** are adjusted so that the centering guide **164** is positioned within the aperture **170** of each lower jaw arm **64, 66** so that the ball element **130** is centrally located, and the clamping nut **158** is tightened against the lower jaw arms. The side shift adjustment screws **150, 151** are adjusted and tightened to lock the upper jaw element centrally of the articulator. The mechanism **85–87** for moving it relative to the tongue **80**, is set to a reference or zero position, as indicated by a scale (not shown) carried by the plate and tongue. The condyle ball elements **130** are locked in the retruded hinge position by the pins **146** and screws **147**. Mounting plates **212, 213** are attached to the upper and lower plates **42** and **78**, and the jaw plates are locked in this mounting position by securing the latching lever **46** and the restraining linkage **94**.

In mounting the casts with the aid of a bite registration and face bow, the determination of the closed (maximum intercuspal or centric occlusion) position of the cast is very important. The closed position determines the relative heights and positions of the teeth and is the reference point from which movements are made. The closed position for most persons with good occlusion occurs with the condyles slightly forward of their most retruded position. The retruded position or centric relation of the condyles is the most repeatable position and therefore used as a reference in determining the closed position of the casts.

In mounting the casts in the articulator, a bite registration is used to relate the lower cast to the upper cast, and a face bow is used to locate the upper cast to the joint elements or pivot structures **38, 39** of the articulator. The bite registration is made with rearward pressure on the chin of the patient so that the jaw is held in the retruded position. The dental arch casts are then placed in the indentations of the bite registration and supported between the sponges **214, 215** of the mounting plates **212, 213**. The face bow pointers, attached to the bite registration, are then centered into the condyle pivot structures **68, 69**, a central aperture **130***e* at the outer end of the shaft **130***b* of the ball **130** facilitating this. The face bow is centered between the mounting plates **212,213**, the articulator is placed on its back and

a plaster slurry is poured into the openings **229** in the peripheral sponge walls. After the plaster has hardened, the bite registration and face bow are removed.

Adjustment of the mandibular plate **78** is achieved by rotating the screw **85** to slide the plate **78** forward relative to the supporting tongue **80** approximately one-half millimeter, to correct for over retrusion of the jaw which occurred while making the bite registration. This adjustment brings the jaw directly forward and not down the fossae slopes. A space between the casts, which exists with the removal of the bite registration, is closed by releasing the anterior end of the lower link pin **100,** by loosening the screw **120,** pivoting the lower jaw member about the hinge axis until the casts are in tooth-to-tooth contact, and then retightening the screw **120.** The locking screws **147** for the condyle pin stops **146** need not be loosened for this hinge axis rotation. The casts are now located in the closed position determined by the bite registration.

An existing or acquired (habitual) closed position for patients with enough opposing teeth can be found by placing the casts in their maximum intercuspal position. This position or any position can be achieved on the articulator by loosening the nuts **158,** the screw **120** that secures the anterior end of the link pin **100,** and the medial lateral position screws **150, 151.** The centering guides **164** are withdrawn from the apertures **170** of the jaw arms **64, 66** and the tension springs **174, 176** are released by the tension wheels **180, 182.** This completely releases the lower jaw element from restraint within limited confines and the lower dental arch cast can be positioned into the upper cast, as the teeth dictate. With the lower jaw thus in the existing closed position, the nuts **158,** with the centering guides withdrawn are retightened so that the front surface of the nut **158** clamps each arm **64, 66** against the flange **130***d* of the associated ball element **130,** which is now somewhat off center of the aperture **170.** The screw **120** of the lower link pin **100** is tightened, as are the adjustment screws **150, 151** to maintain the shaft **36** in the position dictated by the teeth. The difference between the bite registration and existing closed positions is observable at the ball elements **130** of the pivot assemblies **68, 69.** If the bite registration is made with the temporomandibular joints in their proper positions, then the difference between the existing and bite registration positions, as indicated by the condyle assemblies, is the measure of the harmony between the dentition and the temporomandibular joints. The construction or reconstruction of the teeth can be built to either the bite registration or the existing closed positions, or to some intermediate compromise, without remounting the casts on the upper and lower plates of the articulator. If the ideal closed position is chosen, the nuts **158** are again loosened, the centering guides **164** are moved inward into the apertures **170** to recenter the jaw element, and the medial lateral position adjustment screws **150, 151** are adjusted for jaw centrality.

The ability to release and reposition the lower cast and to indicate the change in position at the condyles is also useful for comparing bite registrations and, as a result, serves as an improved split cast technique. For example, if several bite registrations are found to position the casts in the same relationship, as measured at the condyles, the retruded position was probably recorded by the bite registrations, because protrusive jaw positions are seldom repeatable.

As the patient's jaw is moved forward and back, the temporomandibular joints allow the jaw condyles to translate along a narrow path determined by the fossa of the temporal bone. In the profile view, this fossa path is inclined with respect to the plane of the upper teeth. The slope of this path may be different on each side and can be as shallow as **0°** for some patients, and as great as **60°** for others. Since the inclination of this path is so dependent on the particular patient and because it is very important in determining the clearance of the posterior teeth, an adjustment for the fossa inclination is provided on each side of the articulator. Measuring the patient's fossa paths is commonly achieved with either a face bow or a protrusive bite registration. In the first method, a face bow is attached to a bite registration and the bite registration is cemented to the patient's jaw teeth. As the patient's jaw is moved forward and back, face bow pointers near the joints scribe lines on the skin or on a skull reference plate. The angle of the scribed lines is then measured with respect to the plane of the upper teeth and the angle of the surfaces **132***c* are set accordingly by rotating the insert **133** of each pivot assembly **38, 39.** In the second method, a protrusive bite registration is made and placed between the casts in the articulator. The surfaces **132***c* representing the fossa inclinations are then adjusted on the articulator so that the casts seat properly in the protrusive bite registration.

In beginning the reconstruction a desired closed position is selected based on either the existing or the bite registration occlusion, and the teeth are built thereto. The lower jaw element is locked in a fixed position with the stop pins **146** and the restraining linkage **94,** and the upper jaw element is opened and closed around the hinge axis provided by the shaft **36,** as the operator requires access to the work. The adjustment provided by the adjustment screw **85** and movable plate **78** of the lower jaw element and the medial-lateral position screws **150, 151** can be varied to produce anterior-posterior and side-to-side freedom of movement in the closed position, if desired. By loosening the pin **100** at the screw **120,** the lower jaw can be opened slightly around the hinge axis provided by the pivot structure **38, 39,** and coincident with the axis of the shaft **36,** to compensate for the thickness of articulating papers that may be used.

With maximum intercuspal position established, the tension applied by the springs **174, 176** is reapplied by rotating the tension wheels **180, 182** and securing them in a position that tensions the springs, with the stop pins **188.** The condyle ball pivot structures **130** are released by withdrawing the pin stops **146.** The upper jaw plate **42** should be locked in a horizontal or lowered position by the latching lever **49** and latch **46.** The relationships of principally the anterior teeth are now determined with chewing movements when the lower link **100** is securely clamped at both ends to establish a fixed length, initially with the posterior end tightened in the most upward position in the slot **92.** The posterior end of the link is then incrementally moved downward, with the knob **106** being retightened each time. Because the arc of the curved finger **90** is not circular with a center at the universal joint **98,** the screw **120** must be loosened for each shift in position of the posterior end of the link so that the closed position (maximum intercuspal position) remains the same.

At each position of the lower link **94**, the lower jaw element is moved to each side of the central position. This procedure generates a full range of chewing movements for evaluating the teeth in mastication. The posterior knob **106** of the lower link is finally adjusted downward until the flattest desired angle of approach of the lower jaw teeth relative to the upper (viewed frontally) is achieved. Although the lower jaw element is movable when the lower link **94** is released and adjusted, the inter-dentated casts maintain the jaw in the same, desired closed position until the link is retightened.

Tooth gliding movements can be performed with the articulator by loosening the screw **120** at the lower end of the link **100** to eliminate the link constraint. Tooth gliding movements are important for evaluating posterior tooth clearance in the natural dentition and posterior tooth balance in the denture occlusion, during lateral and protrusive movements. The lower cast is articulated against the fixed upper case during the tooth gliding.

Although one specific construction has been shown and described in detail, modifications thereof are contemplated, which retain certain but not all of the novel and advantageous features. For example, the movement of the pivots of the lower jaw member, analogous to the condyles of the jaw along a cam surface to provide movement analogous to that of the condyl along the fossa of the temporomandibular joint, can be restrained with different structure than that shown, as by separate pivoted links secured at a lower end to the stand and which carry the condyle pivots at the upper ends, and which ride along cam surfaces. Also, the lower restraint of the lower jaw movement can be achieved by two links rather than one. For example, one link can be provided on each side of the lower jaw plate, secured at a forward location to the stand through a universal joint, and the rearward or posterior end can be adjustably located in curved slots of the lower jaw mechanism to control chewing motions and to adjust the angle of approach of the lower jaw to the upper in articulation.

From the foregoing description it will be understood that an articulator has been provided that, in its concepts, utilizes a prime link constraint in combination with joint area constraints that include cams, a posterior stop, and condyle path grooves or condyle links. Various combinations of the prime link and joint constraints are utilized to duplicate such jaw positions and motions as (1) the cementing or bite registration position, (2) any other bite registration position, (3) the existing or acquired closed position, (4) a full range of chewing closure motions, both toward left side and toward right side, (5) hinge access movement, (6) protrusive movement, and (7) tooth gliding movements.

Modifications and alterations of the articulator described herein may be made without departing from the spirit and scope of the invention defined in the appended claims.

What is claimed is:

**1.** A dental articulator comprising a support, two generally opposed jaw-like first and second connections between one said member and the support that permit complex movement of said one member relative to the other, and means, including a rigid link functionally constant in length between said one member and the support pivotally connected to both, to constrain said movement of said one member relative to said support to simulate chewing movement.

**2.** An articulator as set forth in claim **1** wherein said first and second connections comprise movable pivots.

**3.** An articulator as set forth in claim **1** including means to change the location of at least one of said link connections to adjust its angular relationship with respect to said support and said one member to change the range of movement of said one member relative to said support.

**4.** A dental articulator comprising first and second structures, each adapted to support a dental arch cast in opposing relationship to the other; means at two locations of said first structure interengaged with said second structure at two locations to allow said first structure to move relative to said second structure with more than one degree of freedom; and means, including a rigid link functionally constant in length connected for universal pivoting at two locations, one location fixed with respect to the first structure and the other fixed with respect to the second structure, for providing one constraint for the movement of said first structure relative to said second structure.

**5.** A dental articulator as set forth in claim **4** wherein said second structure includes a support, a plate for supporting a dental arch and means defining a fixed axis about which said plate is selectively pivotable.

**6.** A dental articulator as set forth in claim **4** wherein said rigid link is adjustable in length.

**7.** A dental articulator as set forth in claim **4** including means for changing one of said two locations at which the link is connected.

**8.** A dental articulator as set forth in claim **1** including means to release said link at one of said locations to eliminate its restraint of movement of said first structure, and means to establish a fixed pivot axis at said interengaged means between said first and second structures.

**9.** A dental articulator as set forth in claim **4** wherein said first structure includes a first plate for supporting a dental arch cast and said second structure includes a stand and a second plate for supporting a dental arch cast, said second plate is located vertically above the first plate, and including means to secure said second plate in a fixed position relative to the stand analogous to a maxilla, and means securing said first plate to said first structure for articulation relative to the stand in an analogous manner to a mandible.

**10.** A dental articulator comprising a stationary support and a movable jaw member, means, including two portions of said jaw member interconnected with said support, for providing relative movement between the support and jaw member with a plurality of degrees of freedom that permit lateral movement of the jaw member to the left and right of a central position relative to said support, and single rigid link means functionally constant in length connected between a third portion of the jaw member that is displaced from an axis through said two portions and a point on the support, to maintain said third portion a constant distance from said point on the support and to constrain movement of said jaw member in directions both left and right of the central position.

**11.** A dental articulator comprising a support, a maxillary member pivotably connected to said support and adapted to support a dental arch cast, a manibular member movable relative to said support, said mandib-

ular member including a plate adapted to support a dental arch cast and also including two means located to one side of a plane defined by said mandibular plate for interconnecting the mandibular member with said support for relative translational and pivotal movement, and a rigid link on an opposite side of said plane from said two portions, connected between a third portion of said mandibular member and a point on said support, a universal pivot at each connection of said link, and means permitting adjustment of at least one of the locations of connection for the link to increase or decrease an angular relationship between the link and an imaginary plane defined by said point on the support and said two portions of the mandibular member.

**12.** A dental articulator as set forth in claim **11** wherein said means permitting adjustment of the location at which said link is connected includes a curved member providing different locations for connection of said link on one of said jaw member and support.

**13.** A dental articulator as set forth in claim **11** including means to change the length of the link between said two locations of connection to pivot the mandibular member relative to said maxillary member and thereby change the distance between the plates thereof.

**14.** A dental articulator comprising a support, a maxillary plate carried by said support, means hinging said maxillary plate to the support for rotational movement about a single axis, a mandibular plate, means connecting said mandibular plate to said support at two locations for rotational movement about plural axes, one of said plural axes being coincident with said single axis.

**15.** A dental articulator as set forth in claim **14** including means to lock the maxillary plate in fixed relationship to the support.

**16.** A dental articulator as set forth in claim **14** including means to restrict pivoting of said mandibular plate to universal pivoting about only one of said two locations.

**17.** A dental articulator as set forth in claim **14** including a rigid link extending between said mandibular plate and said support and pivotally connected to both.

**18.** A dental articulator as set forth in claim **17** including adjustment means connected with said link for changing the position of the mandibular plate relative to the maxillary plate.

**19.** A dental articulator comprising a support stand, a first member adapted to support a dental arch cast and carried by said stand, means securing said first member to said stand for rotational movement about a single fixed axis; a second member adapted to support a dental arch cast in generally opposed relationship to said first member and carried by said stand, and means securing said second member to said stand for rotational movement about a plurality of axes, including an axis coincident with said single fixed axis.

**20.** A dental articulator as set forth in claim **19** including a rigid linking means pivotally connected to and extending between said second member and said stand for permitting movement of said second member relative to said stand when said second member pivots about axes not coincident with said single fixed axis and which prevents movement of said second member relative to said stand about an axis coincident with said single fixed axis, and means for releasing the connection between said rigid linking means and one of said stand and second member.

**21.** A dental articulator comprising a stand, two supports for dental arch casts carried by said stand, two pivots on one of said supports with a common axis, two spaced pivot supports on said stand for receiving said pivots, said pivot supports each providing an elongated path of restrictive movement for said pivots, means securing said pivot supports to said stand for angular adjustment of said paths about a common axis, and means on said stand providing a fixed pivot axis for the other of said supports coincident with said last-mentioned common axis.

**22.** An articulator as set forth in claim **21** wherein said pivot supports are each in the form of a guide with a groove that receives the end of one of said pivots.

**23.** An articulator as set forth in claim **22** wherein each of said pivots terminates in a spherical surface and each of said grooves has a back surface that is inclined relative to a plane perpendicular to said common axis of the guides.

**24.** An articulator as set forth in claim **22** wherein the common axis of angular adjustment through said pivot guides is adjacent one end of each of said grooves so that the center of said pivots coincides with the common axis when the pivots are at said one end of the grooves.

**25.** A dental articulator comprising a stand, two supports for dental arch casts carried by said stand, two pivots on one of said supports with a common axis, two spaced pivot supports each providing an elongated path of restrictive movement for said pivots and each in the form of a guide with a groove that receives an end of one of said pivots, and means securing said pivot supports to said stand for angular adjustment of said paths about a common axis adjacent one end of each of said grooves so that the center of said pivots coincides with the common axis when the pivots are at said one end of the grooves, each said groove having a back surface that converges toward that of the other in a direction along the length of the groove from said common axis of adjustment.

**26.** A dental articulator comprising a support frame, two members with dental arch support portions in generally opposed relationship carried by said frame, one having two pivot parts movable relative to the frame to provide translational and rotational movement of said one member relative to the frame, rigid link means functionally constant in length pivotally connected between the frame and said one member to constrain movement of said one member relative to the frame, two cam surfaces one adjacent each of said two pivot parts to control movement of said one member in a direction along an axis defined by said pivot parts, and means carried by said frame for receiving said pivot parts and limiting movement thereof to elongated paths.

**27.** A dental articulator comprising a support frame, two supports carried by said frame representative of upper and lower jaws, one of said supports having two oppositely projecting pivot members, two grooves on said frame, each receiving one of said pivot members and constraining the received members to movement along the grooves, two cam surfaces carried by said frame and converging toward one another for constraining movement of each of said pivot members in its projecting direction, and a single rigid link function-

ally constant in length pivotally connected to both said one support and said frame.

**28.** An articulator comprising a support, a member carried by said support, cooperating connecting means on said member and the support at two locations to permit articulation between the member and the support, means to selectively establish a fixed pivot axis location between cooperating connecting means, and a position adjustment connection between the member and the connecting means thereon to permit selectively changing the location of the connecting means on the member.

**29.** Apparatus as set forth in claim **28** wherein said position adjustment connection includes means to selectively reestablish one particular location between the member and the connecting means.

**30.** An articulator as set forth in claim **28** wherein said connecting means at each of said two locations is comprised of an elongated guide slot on said support and a ball connected to said member and engaged with said guide slot and said means to selectively establish a fixed pivot axis includes means to prevent movement of said ball along said slot while permitting rotational movement thereof.

**31.** In a dental articulator, structure for interconnecting a dental arch support to a stand for relative translation and rotation, said structure including two spaced members on said support, two spaced receptacles on said stand located to concurrently receive said members for relative rotational and translational movement, and means to selectively change the locations of said spaced members on the support to change the relationship of the support relative to the stand.

**32.** Apparatus as set forth in claim **31** including means to selectively establish one particular location of each said spaced member relative to said support.

**33.** Apparatus as set forth in claim **32** wherein said means to selectively establish one particular location of said spaced member relative to the support includes a clamping nut with a counterbore, a circular aperture in the support, an annular centering guide movable in an axial direction within the counterbore of the clamping nut such that when the annular centering guide is extended axially beyond the clamping nut, its outside diameter is closely received within the circular aperture in the support and when the centering guide is retracted within the clamping nut, no effective restraint exists between the centering guide and the support.

**34.** Apparatus as connected forth in claim **33** wherein said centering guide is connencted by pins, which project through axial slots in the clamping nut, to a sleeve surrounding the clamping nut, such that rotation of the sleeve produces rotation of the clamping nut and centering guide, and sliding movement of the sleeve produces a sliding movement of the centering guide relative to the nut.

**35.** Apparatus as set forth in claim **32** wherein said means to selectively establish one particular location of said spaced member relative to said support includes a knob with a threaded bore, one end of the knob being flat and perpendicular to the axis of the threaded bore for clamping the member in a range of positions relative to the support, and with the other end shaped for positive seating of the member at one particular location relative to the support.

**36.** Apparatus as set forth in claim **31** wherein each said spaced member includes a pin offset from the central axis of the spaced member, which is received by an elongated slot in the said support such that rotational movement of the spaced member relative to the support is limited.

**37.** Apparatus as set forth in claim **31** wherein said support has two arms, said two spaced members are each adjustably secured to a different one of said arms, and each receptacle includes an elongated aperture that receives and guides movement of one of said spaced members.

**38.** Apparatus as set forth in claim **37** wherein said spaced members are ball pivots, and said apertures are located with one portion of each defining a pivot axis for rotational movement of said support relative to said stand, each aperture extending from said axis in a generally common direction with the other aperture, and said structure further including means to retain said ball pivots at said pivot axis.

**39.** Apparatus as set forth in claim **38** wherein said receptacles are movable relative to said stand to change the direction at which said apertures extend from the axis.

**40.** A dental articulator comprising a stand, two supports for dental casts carried by said stand in generally opposed relationship, means connecting at least one of said supports to the stand for relative pivotal movement, a stop member extending between said two supports to limit the proximity of the supports to one another, said stop member including means to adjust the effective length of the stop member between the two supports, means to releasably secure the stop members to one of said supports for removal without changing the effective length, two concentric relatively movable parts one of which is pin-like and movable longitudinally relatively to the other, and spring pretension means yieldably retaining said movable parts in longitudinally adjusted positions.

**41.** A dental articulator comprising a stand having a primary base portion and a frame portion extending therefrom, said frame portion forming a secondary base portion with said primary base portion oriented at approximately **90°** to the primary base portion, two dental arch cast support elements secured to said frame portion in generally opposed relationship, at least one of which is pivotally secured to said frame portion, said elements being positionable horizontally when said stand is supported with its primary base portion horizontal and vertically when said stand is supported with its secondary base portion horizontal, a receptacle secured to each of said support elements in opposed relationship for use in securing dental arch casts to said elements, said receptacles each including a side portion extending in a direction from the associated support element toward the other and forming a peripheral receiving surface for a dental arch cast, and an opening in the side portion located to face upward when said secondary base portion is horizontal.

**42.** A dental articulator as set forth in claim **41** wherein said side portion is deformable.

**43.** A dental articulator as set forth in claim **42** wherein said side portion is resilient.

**44.** A dental articulator as set forth in claim **41** wherein said side portion is a foamed sponge-like resilient material.

**45.** A device for securing a dental arch cast to a support member of an articulator, comprising a base and a readily deformable wall secured to said base, extend-

ing therefrom along a path defining a concave shape and with a distal surface adapted to receive a dental arch cast.

**46.** A device as set forth in claim **45** wherein said wall is resilient.

**47.** A device for yieldably supporting a dental arch cast and constraining a hardenable material in contact with the arch cast, comprising a compressibly yieldable and resilient barrier means capable of temporarily supporting a dental arch cast and retaining a flowable hardenable material, shaped to form a receptacle for flowable hardenable material and having an opening in the barrier means through which said material can be introduced.

**48.** A device as set forth in claim **47** wherein said barrier means is formed of sponge-like material.

**49.** In combination, a dental articulator with two dental arch support members in generally opposed relatively pivotable, relationship and soft, resilient, positioning members carried by said support members for supporting and resiliently urging dental arches into opposed interengagement during mounting.

**50.** A dental articulator comprising a base, two supports carried by said base, each adapted to support a dental arch cast, means securing one of said supports to the base for relative pivotal movement, a plate carried by one of said supports, means securing the plate to the carrying support for relative movement in the plane of said plate, guide means to limit the movement in said plane to a straight path in a direction perpendicular to a plane containing the pivot axis of said pivotally secured support, positive drive means to provide controlled movement of said plate along said path, and a spring bias acting perpendicularly to and between said plate and carrying support to yieldably maintain position of said plate relative to said support.

**51.** An articulator comprising a support, a member carried by said support, cooperative connecting means on said member and the support at two locations to permit articulation between the member and the support, and adjustable biasing means to urge the member and support in the direction of articulated movement, said adjustable biasing means including a tension wheel rotatably supported on a shaft of the support, a tension spring secured between the tension wheel and the member, and a stop pin extending radially through the wheel and movable to selectively engage in one of a number of apertures in the shaft to control the rotational position of the wheel and hence the tension of the spring.

**52.** An articulator comprising a support, a member carried by said support, a shaft on the support movable axially, cooperative connective means on said member and the support carried at two locations on the shaft and constructed to permit articulation between the member and the support, and means to laterally shift the shaft relative to the support, including two screws movable in threaded bores, of the support inclined toward one another and acting on and substantially perpendicularly to generally opposed surfaces on said shaft.

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UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 3908271

DATED : September 30, 1975

INVENTOR(S) : Harry J. Derda and Charles H. Gibbs

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 3, line 2, "aactual" should be -- actual --;

Column 4, line 45, after "is" -- confined -- was omitted;
line 45, erase "t";

Column 9, line 54, "connecting" should be -- connection --;

Column 11, line 1, cancel "two".

In the Claims:

Claim 8 (Column 16, line 33) change "1" to -- 4 --.

Signed and Sealed this

*sixteenth* Day of *December 1975*

[SEAL]

*Attest:*

**RUTH C. MASON**
*Attesting Officer*

**C. MARSHALL DANN**
*Commissioner of Patents and Trademarks*