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# The History of Articulators: The Wonderful World of "Grinders," Part 2

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**Keywords**
Articulators; denture grinders; denture-milling machines.

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Accepted June 7, 2011

doi: 10.1111/j.1532-849X.2011.00813.x

## Abstract

This is the second article in a three-part series on the history of denture grinding devices. The first article reviewed the earliest attempts to mechanically grind the occlusion of artificial teeth from the manipulation of simple articulators to very elaborate and complex machines powered by hand cranks. This article explores motor-driven grinders, most driven by way of a belt-driven pulley powered by an external source. A few were self-contained; that is, the motor was mounted on the grinder base. There were basically two types of grinders: those with cast holders for mounting processed dentures and those with provisions for using articulators for that purpose.

Contrary to the general perception of the profession, numerous examples of articulators and other devices designed for "grinding" or "milling" denture teeth can be found in both the literature and patent records.[1] The first article of this series presented several articulator-grinding devices: from the simple, handheld instruments employing thumb plates to produce a seesaw movement, to the incredibly complicated mechanical marvels employing a hand crank and claiming to produce the "complex movements of the mandible" or to obtain "perfect occlusion" even by the "average non-specialist."[1]

## The emergence of electric motors in the production of "denture grinders"

For some dentists, the "hand-powered" devices for grinding or milling denture occlusion were not getting the job done. So naturally, several inventors turned their attention to producing denture grinders that were "horse-powered" (electric motor driven). And once again, disappointing no one, the extraordinarily resourceful imaginations of these dentists (and, without a doubt, countless fragments of porcelain denture teeth) began to take flight. Just as with the "hand-powered" denture grinders, the "horse-powered" ones can be placed in three general categories: those designed specifically for mounting processed complete dentures; those to which an articulator was attached; that is, to either the incisal or condylar controls; and those that were an integral part of the articulator.

Although it is evident that various devices for grinding or milling denture occlusion were created over a span of many years, the 1920s were their heyday. A surprising number of these motor-driven grinders were patented; and, as though in keeping with tradition, many of these were incredibly complicated. Just how many were actually manufactured for sale is anyone's guess, but it has become clear that the grinding devices that eventually did make it to dental offices embodied simpler mechanical concepts.

In addition to those dentists whose work has previously been described, a number of others are associated with the design of some type of denture grinding device. Only a very few of these inventors are well known to the profession, and clearly, it is largely for their other professional accomplishments. Nevertheless, although all but forgotten, these imaginative individuals who have contributed to *"the wonderful world of grinders"* deserve fitting recognition in this series. Included are Roscoe W. Upp,[2] Walter J. Wilson,[3] James S. Miller,[4] Charles A. Priest,[5] Robert H. Downing,[6] Leslie N. Roebuck,[7,8] Henry P. Pfeiffer,[9] Joseph E. Scott,[10] J. T. Patching,[11,12] and William M. Gambill, who, incidentally, received no fewer than seven patents between 1924 and 1929 for grinding devices and articulators.[13-19]

And notably, those dentist–inventors who are well known to the profession for their other achievements are: Milus M. House,[20,21] John W. Needles,[22] William E. Van Dorn and Wilfred H. Terrell,[23] Claude J. Stansbery,[24] A. De Witt Gritman,[25] and last but certainly not least, Rupert E. Hall.[26] Needless to say, the articulators devised by House and Needles, Terrell and Van Dorn, and Stansbery were the most commercially successful, and test questions relating to the grinding devices of these instruments were favorites of the American Board of Prosthodontics for many years.

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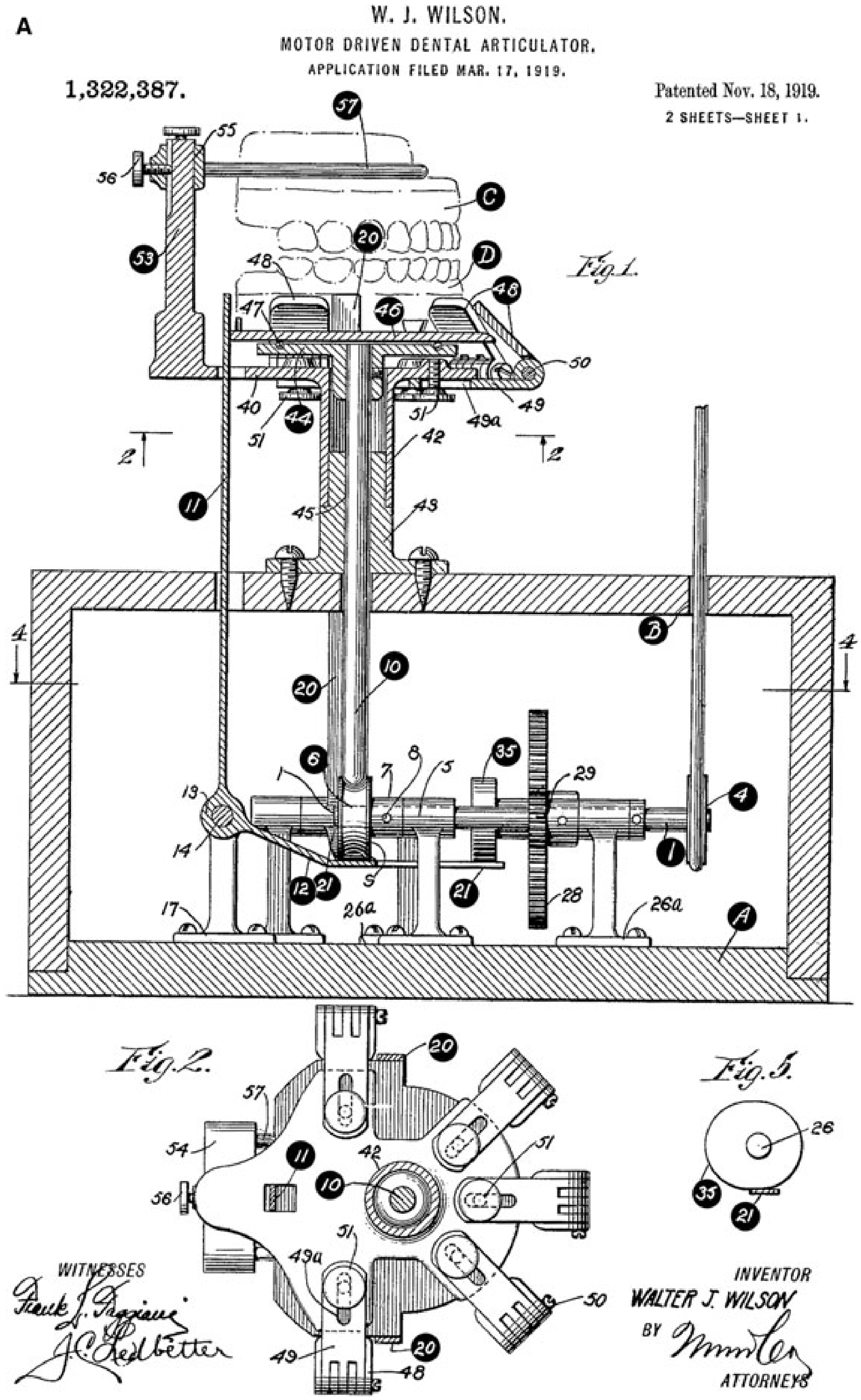



**Figure 1** (A & B) Walter J. Wilson, "Motor Driven Dental Articulator," 1919. (1A: Side view. 1B: Top views of the cast holders and the power train.) The power train was located within case (A) with the power supplied to pulley (4) from an external source. The mandibular denture, through vibrating table (44), was subjected to three types of movements: horizontal, vertical, and vibratory. Cam (6) acted upon vertical slab (11) through horizontal slab (12) and acted upon shaft (10) to produce anterior–posterior horizontal and vibratory movements and vertical movement. Lateral cams (35) acted upon vertical slabs (20) through horizontal slab (21) to produce lateral and vibratory movements. (Reprinted and modified from the 1919 US patent.)[3]

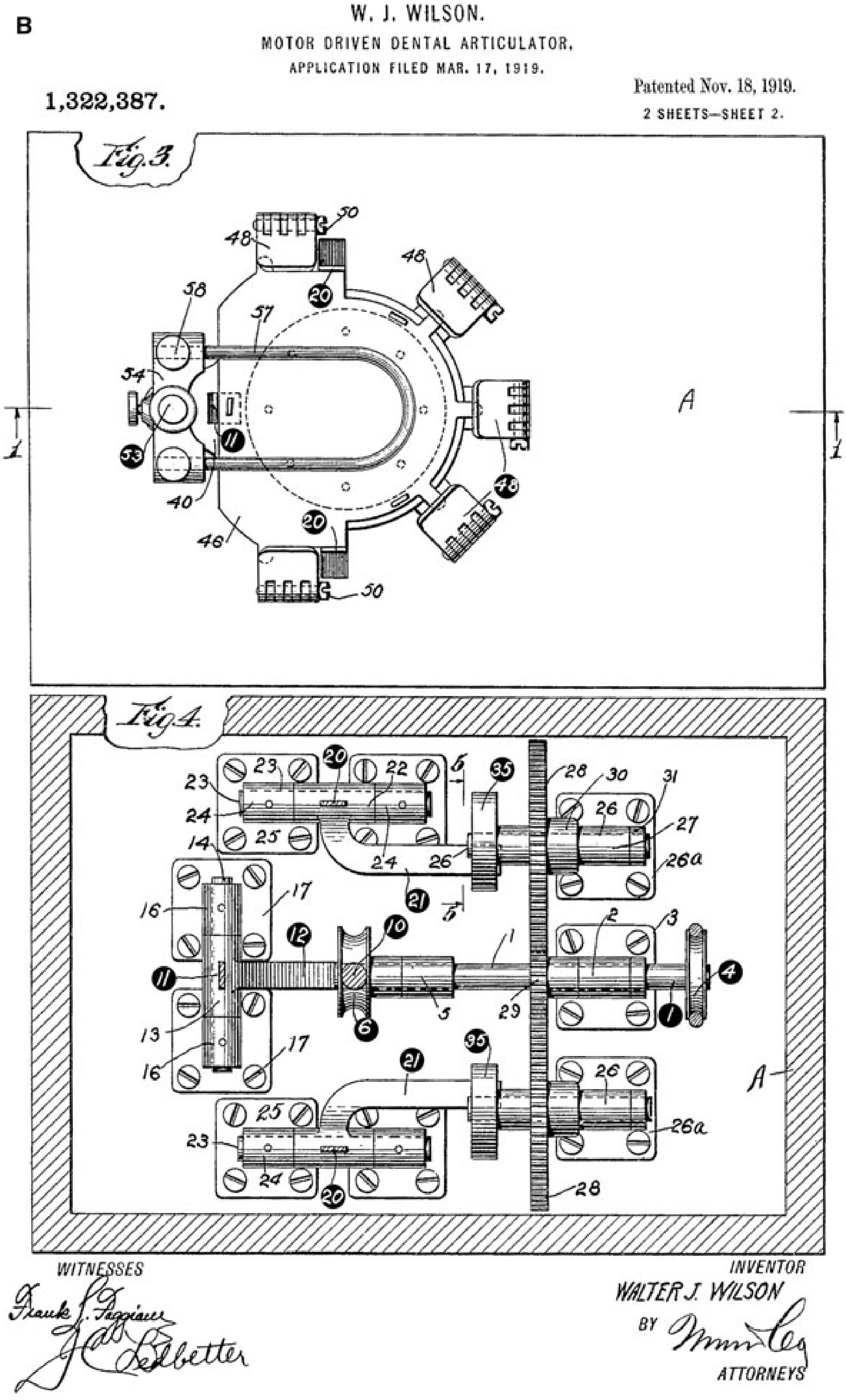



**Figure 1** (Continued).

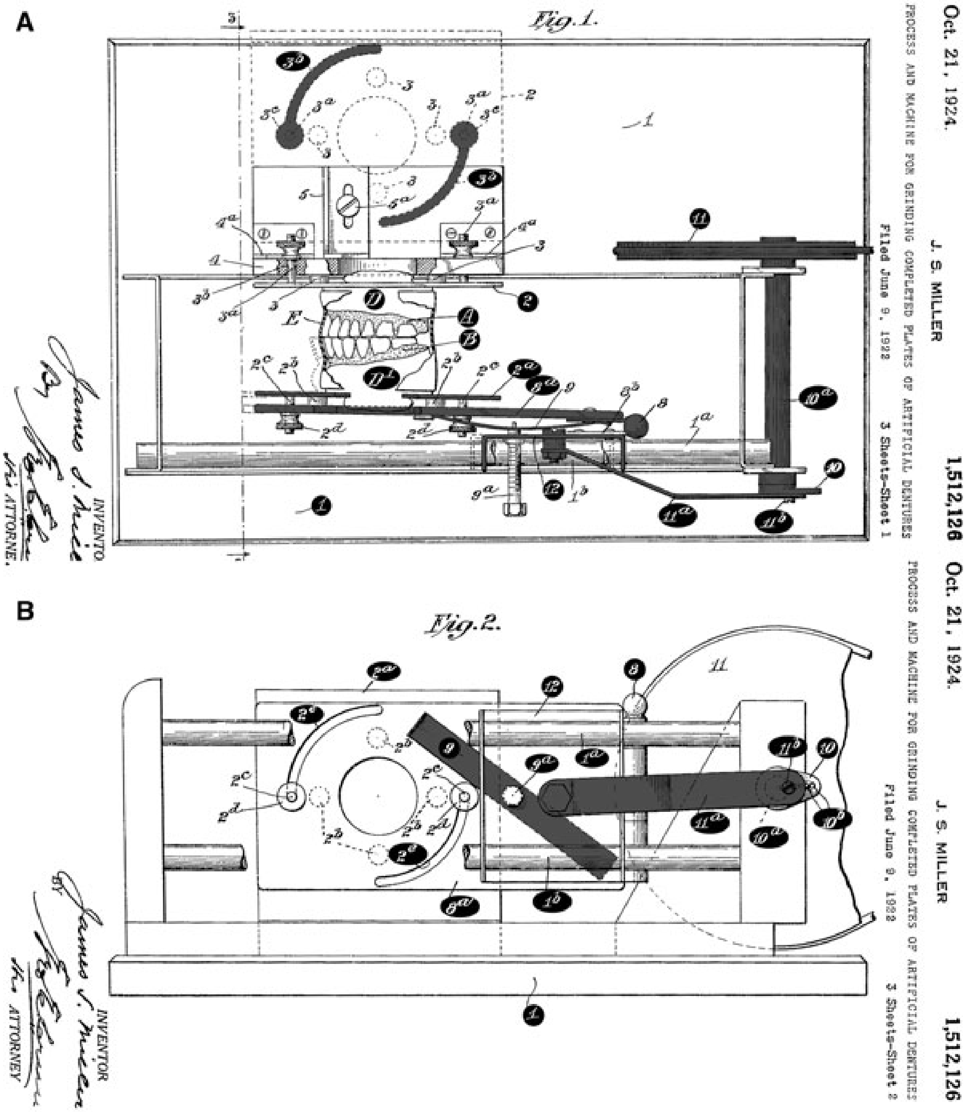


**Figure 2** (A & B) J. S. Miller, "Denture Grinder," 1924 [Note that Patent Figure 2(A) presents a top view and Patent figure 2 (B) a side view revealing that during the grinding process, the mounted complete dentures (A, B) were suspended on their side from the base (1)]. The base (1) was designed to suspend and support the grinding assembly that travels on guide rods (1a & 1b). Platform (12) was attached to the eccentric crank arm (10) by link (11a) and moved on the guide rods by driving pulley (11) through the rotation of shaft (10a). The distance the platform traveled was determined by the position of screw (11b) in slot (10b). Cast holder (8a) was connected to platform (12) by a hinge (8). This allowed variance of the occlusal pressure that lower denture (B) applied to upper denture (A) during the grinding process by adjusting bolt (9a) that engaged tension spring (9). The dentures were mounted with plaster (D) and (D1) to the upper (2) and lower (2a) cast holders, respectively, into the holes provided. The plaster mountings were also supported by arcuate arm assemblies (3e & 2e) to provide for an angular adjustment up to 90° "to simulate all eccentric positions of the mandible." (Reprinted and modified from the 1924 US patent.)[4]

## Grinding devices designed for mounting processed complete dentures

US patent records and available literature suggest this type of grinder is likely to be the least common but has some of the most complex designs. The earliest of these devices to be patented was that of Walter J. Wilson of Petersburg, IN. In 1919, he designed a denture grinder he called his "Motor Driven Dental Articulator"[3] (Fig 1A). James E. House categorized this grinder as one with a "vertical bumping action."[1]

Wilson claimed that the purpose of his invention was, by continuous "motive power," to adequately grind and finish the artificial teeth, "in shape to a desired engaged masticating relation one with the other." This, he said, would be accomplished by three simultaneous actions: vertical motion, horizontal motion, and vibratory motion.[3]

The power train producing these actions (Fig 1A [patent Fig 1] and Fig 1B [patent Fig 4]) was secured to the base of an enclosure case (A). Power was supplied to the drive shaft (1) from an external electric motor using drive pulley (4).

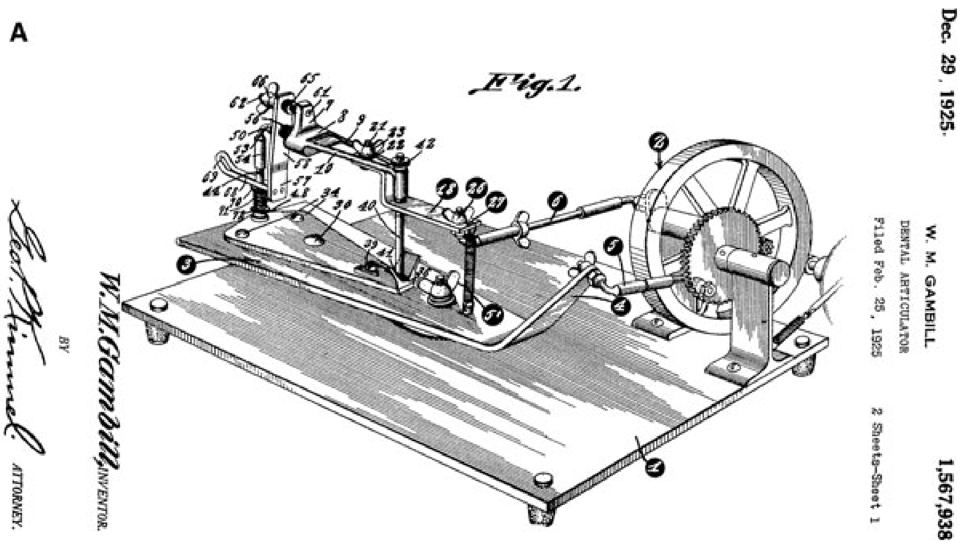



**Figure 3** (A & B) William M. Gambill, "Dental Articulator," 1924. (A) A perspective view of Gambill's "specialized articulator," relating it to the power source and controls of the driving attachment. Unfortunately, this drawing does not show some of the important details to their best advantage; however, it does illustrate what influence the power wheel (2) and driving arms (5 & 6) had on the movement of the upper cast holder (9) during the grinding process. It should also be noted that the driving arm (6) was connected to the coupling strip (18) by wing nut (26), and that spring (5′) was connected at position (27). Furthermore, driving arm (5) stabilized the action of driving arm (6) by its connection to the "oscillatory base" (3) at its inclined anterior end (4).

The belt used to turn the pulley passed through slot (B) in the case.

Referring again to Figure 1, the maxillary cast (C) is secured to post (53) of the grinder with plaster using adjustable cast holder (57). The mandibular cast (D) is secured to holder plate (46) by adjustable lugs (48). The holder plate is mounted on a vibrating table (44) fixed to the upper end of shaft (10). The vibratory and horizontal movements of holder plate (46) are a result of the action of grooved and offset cam (6), through horizontal stem (12), on shaft (10) and on vertical stem (11). Additionally, grooved and offset cams (35) act upon a pair of vertical stems (20), through horizontal stems (21), producing vibratory and lateral movement. Wilson describes the vibratory and horizontal movements as "timed" to "function as a bell-crank capable of transmitting a high frequency vibratory movement." The abrasive medium suggested by Wilson was carborundum and glycerin.[3]

Remarkably, Wilson believed that his device produced a level of precision so it would "not be necessary for a mechanic to constantly attend the machine while in operation."[3] This makes little sense, but neither do the effects of his device on the teeth. Realistically, it does not matter, because Wilson is likely the only one who understood it.

In 1924, James S. Miller of Trenton, NJ, designed a grinder with a mechanism for milling denture teeth that was not only quite complex, but during the grinding operation, the casts were mounted in a peculiar orientation. It had the potential to easily grind the occlusion to excess.

Miller received a patent[4] for a grinder (Fig 2) whereby the maxillary denture was held in a fixed position, and the mandibular denture was moved in a straight line by a piston action, "in simulation of the backward and forward motion of the human jaw." The teeth could then be milled in eccentric positions by rotating the mandibular denture to the left and right up to 90° as needed, "until the masticating surfaces of the bicuspids and molars can move over each over without hindrance [and] without any separation of the dentures." The grinding operation, that is, the movement of the mandibular cast holder assembly (2a, 8a, 9, 11a, 12), was powered by pulley (11) mounted on vertical shaft (10a) and turned eccentric crank arm (10).[4]

According to Miller's description, the milling of the teeth must have been excessive.[4] Is it possible Miller was not aware that monoplane teeth were on the market, and there was no need for him to create his own for each patient?

William M. Gambill of Merkel, TX, was a prolific inventor who was the first to produce a grinding device using elements of an articulator. His preference for the grinding controls was with the incisal pin and guide and in December 1925, he received a patent[14] with a mechanism of this type (Fig 3).

Gambill claimed, "...when operated, [the] device will efficiently grind in the teeth to obtain a thoroughly satisfactory occlusion for producing and perfecting the three-point contact, the rotational point, the inward slant, the downward slant and the incisal slant on the occlusal surface of the teeth." Gambill also claimed that his device had "the means for preserving the depth of the cusps of the teeth when grinding in occlusion and [for indicating] the proper positioning for... central occlusion." He further included a mechanism for "positioning a retruded and protruded bite." In his patent letter, Gambill described the provisions that he incorporated into his grinding device to perform these functions.[14]

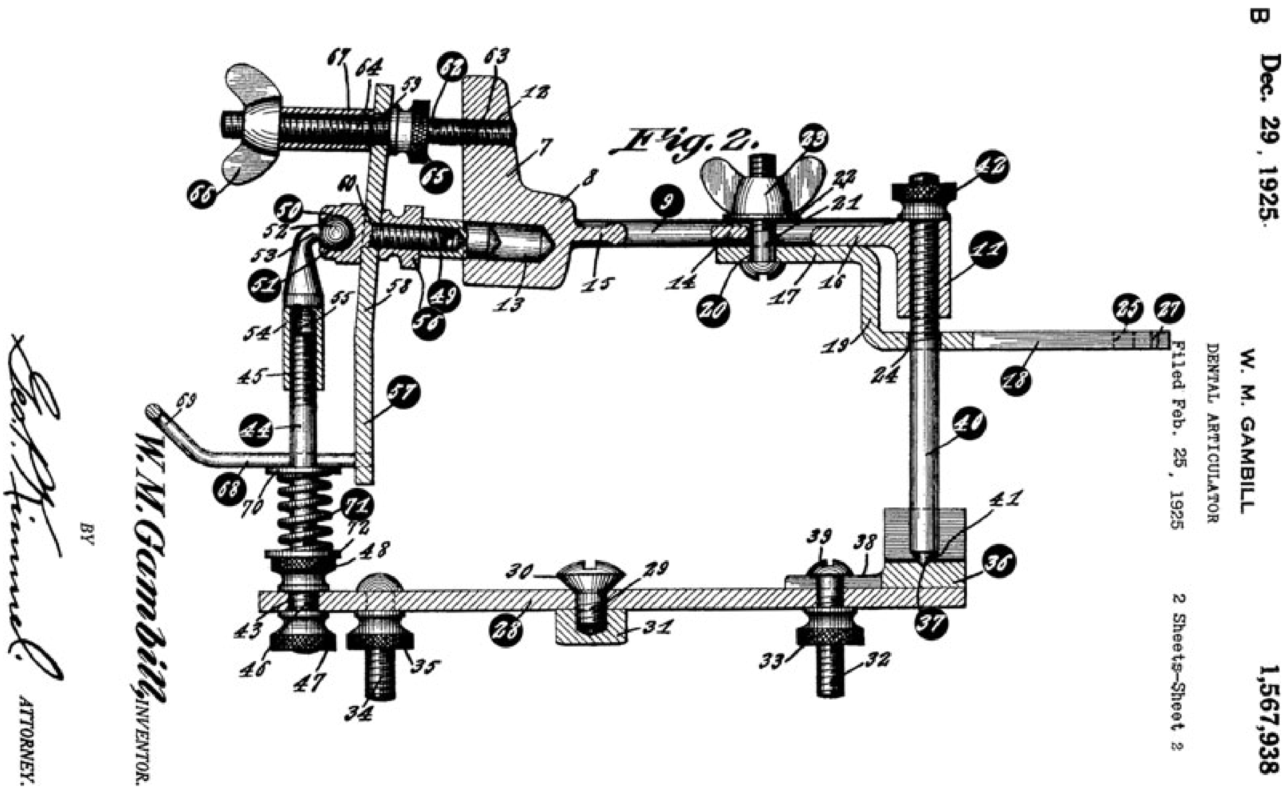



**Figure 3** (B) This longitudinal sectional view of the "specialized articulator" shows its major functional and other components more clearly. The coupling strip (18) is attached to the upper cast holder (9) by bolt (20) within the anterior one-third by bolt (20) and wing nut (23). The incisal guide pin (40) is incorporated within the coupling strip to further strengthen the moving components during the grinding action. To maintain centric relation, the tip of the incisal pin (40) rested in a depression (37) in the incisal guide table (36) while the casts were being mounted. To grind the teeth in a retrusive or protrusive position, it was necessary to adjust bolts (62 & 49) and locknuts (56 & 65). Mounted on rod (44), ball and socket assembly (50, 51) acted as a universal joint, and tension spring (71) and tension plate (57) adjusted with yoke (68) controlled the force applied to the teeth during the grinding operation and to allow the articulator to stand open as well. (Reprinted and modified from the 1925 patent.)[14]

Figure 3A is a perspective view of the specialized articulator as it relates to the power source and controls mounted on base (1). Gambill referred to these controls as the driving attachment that included a power wheel assembly (2) and two driving arms (5, 6). The specialized articulator was mounted on "oscillatory base," (3) and driving arm (5) was connected to its anterior vertically inclined terminal end (4) at position (27). The driving arm (6) controlled the movement of the incisal pin (40) within incisal guide (36) by its connection to coupling strip (18) secured to and extended anteriorly from the upper cast holder (9) of the specialized articulator. The coupling strip also secured at position (27) spring (5') connected at its lower end to the oscillatory base (3).

The incisal guide was a common design for the period, having a horizontal protrusive orientation with 45° lateral wings. Gambill did not go into any detail describing the driving attachment, but it would appear from the patent drawing that the driving arm (5) would have functioned as a stabilizer, and driving arm (6) would have produced a bell-crank effect, moving the incisal pin in a straight lateral direction.[14]

Figure 3B is a longitudinal sectional view of Gambill's "specialized articulator." This view provides more detail with regard to Gambill's other claims. His means "to preserve the depth of the cusps during grinding in occlusion" was to adjust the height of the incisal pin (40). A section of the top end was threaded, and by use of the inner threads (11) at the incisal portion of the upper cast holder, the pin could be adjusted and then secured by nut (42). His means to "indicate the proper positioning for central occlusion" was a cavity (37) located in the incisal guide table. And finally, his means for "adjustably positioning a retruded and protruded bite" was complicated because it required adjusting a series of nuts and bolts (49, 56, 62, 65, and 66) located on the posterior/superior portion of the upper cast holder.[14] Connecting the upper and lower (28) cast holders was rod (44). At its upper end, located where the posterior hinge would likely be, was a ball-and-socket joint assembly (50, 51) to enable "free movement of the parts."[14] At the lower end of the bar was a coiled extension spring (71), which, along with tension plate (57), allowed control over the opening and closing of the upper

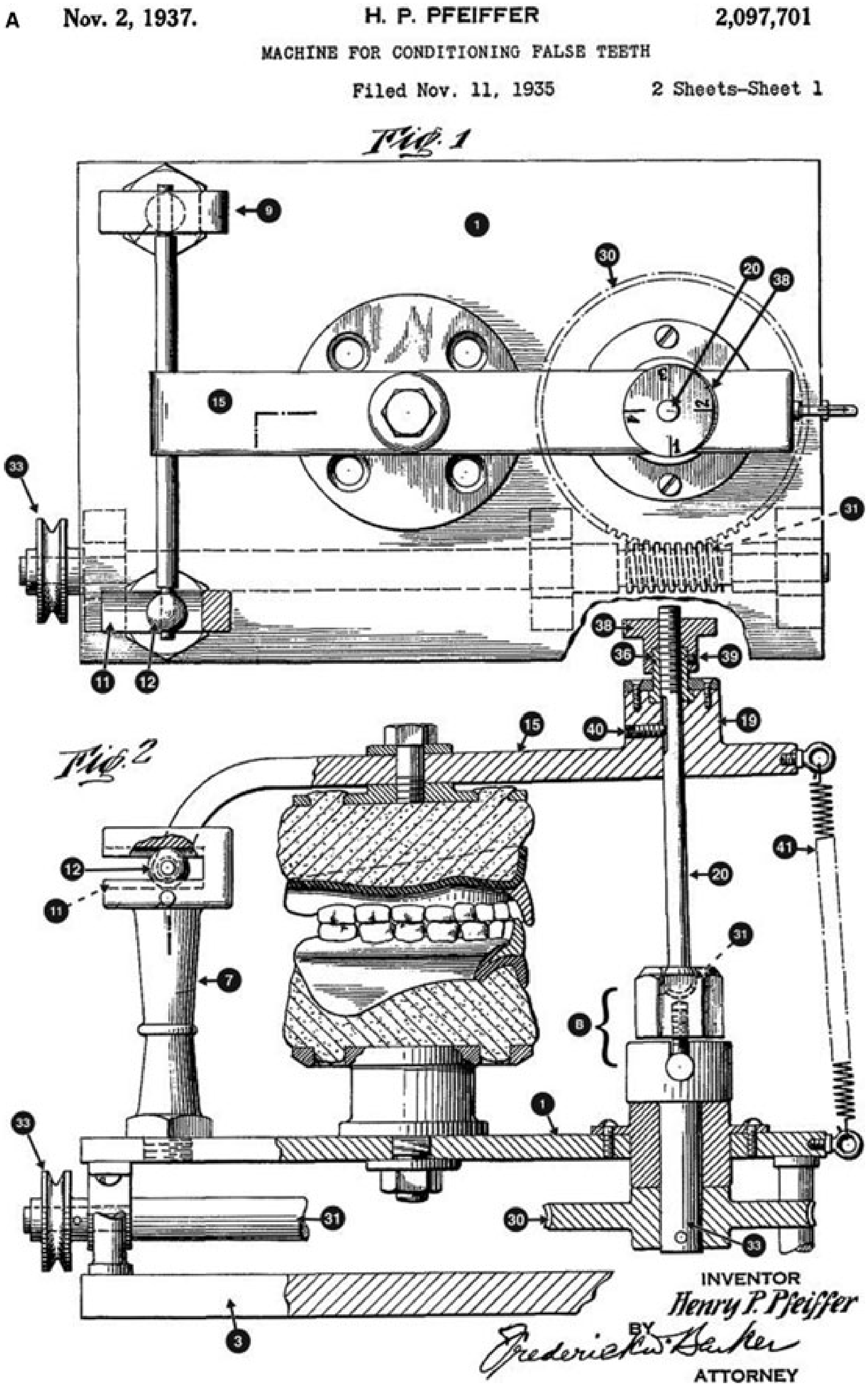



**Figure 4** (A & B) H. P. Pfeiffer, "Machine for Conditioning False Teeth," 1937. (A) This illustration shows the top and side views. To rotate the incisal rod (20) within the lower control assembly (B) power pulley (33) rotated worm shaft (31) that engaged gear (30). The "micrometer" disk (38) was used to control the vertical height of the incisal rod. The condylar elements (9) were intended for counter balance and as "universal joints."

cast holder. Specifically, by means of yoke (68), the upper cast holder could be closed and exert pressure on the teeth during the grinding process, or it could be enabled to stand open.[14]

From Gambill's description of the movement of the incisal pin, it is doubtful that all of his claims would have been achieved by the outcome of the grinding process. Another item of interest is anterior spring (5a). Because posterior tension spring (71)

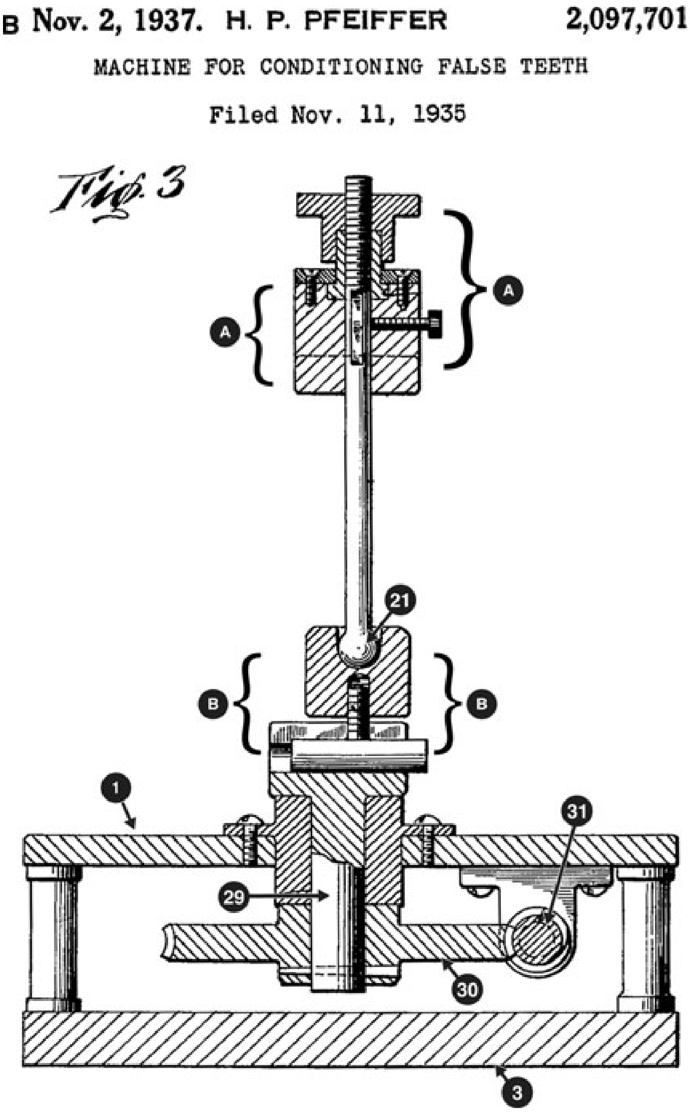



**Figure 4** (B) Anterior view of the grinder by belt (25) incisal rod control assemblies. The upper assembly (A) controlled the length of incisal rod (20). The incisal rod was fixed to disk (38) and a portion of it was threaded at the top. The lower assembly (B) controlled the elliptical pattern. The ball tip (21) of the incisal rod fitted into a round receptacle (22) in a nut-like block (23), allowing the ball tip to swivel freely in the receptacle. From below, the block was centrally engaged by screw (24) that carried horizontal cylinder (25). The cylinder could be moved axially in groove (26) located in mount (27) to "vary the range of the ellipsis at will." (Reprinted and modified from the 1937 patent.)[9]

was designed to maintain pressure on the teeth, the anterior spring seemingly had no function.

In 1937, Henry P. Pfeiffer of East Orange, NJ, received a patent for his "Machine for Conditioning False Teeth."[9] In the patent letter, Pfeiffer claimed that to "condition" the denture occlusion, the teeth must be "subjected to elliptical [grinding] movements [with an abrasive] in the horizontal plane." Furthermore, Pfeiffer believed that for this "conditioning" process to be effective, provisions must be made to control the force and extent of the vertical grinding operation as well as "a means whereby the [elliptical path] may be varied at will."[9] To accomplish these objectives, Pfeiffer devised a grinding machine (Fig 4A) believed to be the second to consist of elements of an articulator. The milling action was achieved by producing an elliptical motion of the incisal rod (20) that carried the maxillary cast holder (15). This motion was powered by a mechanism consisting of drive pulley (33) turning worm gear shaft (31) that engaged worm gear wheel (30), thereby rotating through vertical shaft (29) attached to mounting cylinder (27). The nut-like receptacle (23) received the ball tip of the incisal rod. The entire power train was suspended between the platform (1) and the base (3).

Specifically, the incisal milling controls consisted of two assemblies (Fig 4B). The upper assembly (A) regulated the vertical adjustment of incisal rod (20). Seated into the top of housing (19), was an internally threaded sleeve (36) to receive and secure, by lock screw (39), the treaded end of incisal rod (20). A knurled thumb nut (38) seated over both the incisal rod and threaded sleeve had numerical indexes for the vertical adjustment of the incisal rod to regulate the depth to which the denture teeth were milled; that is, the predetermined distance that the incisal rod traveled during the milling procedure before it came into contact with vertical stop screw (24) centered in nut-like receptacle (23) of the lower assembly.

The lower assembly (B) regulated the horizontal displacement of incisal rod (20) for the purpose of milling the denture

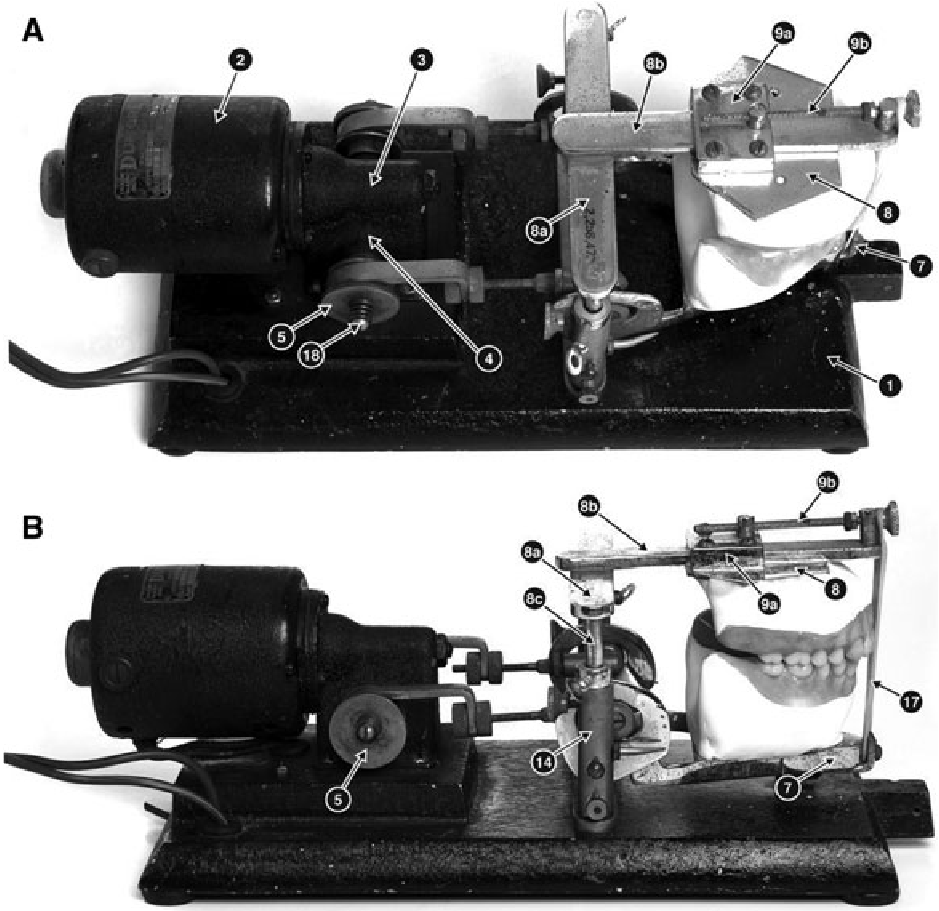


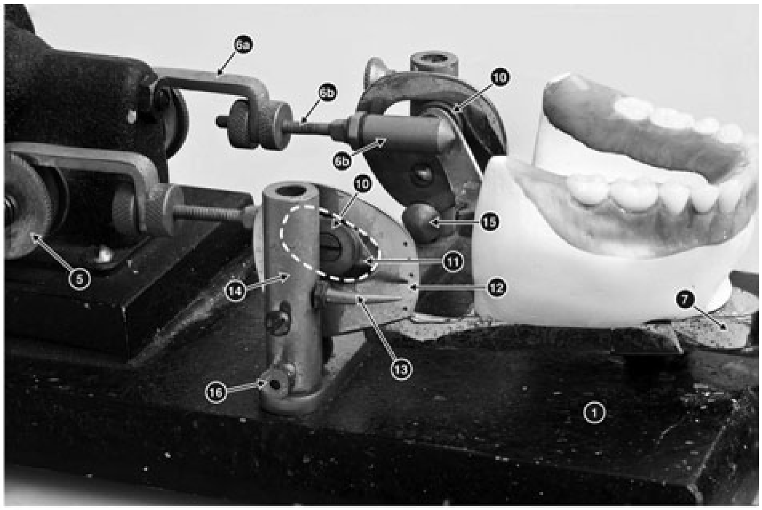

**Figure 5** (A & B) Joseph E. Scott, "Reciprocal Dental Grinder," 1941: Lateral and superior-lateral views of the grinder. These photographs give the reader a "bird's eye view" of the electric motor (2) and the positions of its components, the drive shaft (3) and worm gear and lateral rod (4). At each end of the lateral rod is attached an "eccentric control collar" (5), which with its adjustable tension spring (18), determined the movements of the lower cast holder (7) through the adjustable connecting links. The upper cast holder (8) is stationary during the grinding operation; however, a T-shaped support, consisting of a head plate (8a) and leg plate (8b), provides for two adjustment features. The height of the upper cast holder is adjusted by inserting the vertical rods (8c) located under each end of the head plate into the tubular posts (14) and tightening the wing nuts. The anterior–posterior position of the cast holder is adjusted on the leg plate (8b). The cast holder (8) is secured to a "saddle slide" (9a) that allows free movement along the leg plate. A screw (9b) is secured by a stud at the anterior end of the leg plate and is inserted in a threaded stud in the "saddle slide." Turning this screw is the means by which the cast holder can be adjusted forward or backward.[10]

teeth in the horizontal plane. The mechanism for this action was vertical stop screw (24) attached to and centered upon horizontal rod (25) located in mounting cylinder (27) below incisal rod receptacle (23). Obviously, if ball tip (21) of the incisal rod was located in the cup-shaped depression (22) on the receptacle and the vertical stop screw was centered on the mounting cylinder, rotation of the incisal rod receptacle would have no effect. But if the screw was axially offset by moving horizontal rod (25) in slot (26), the effect would be to "sway" the incisal rod, and thus upper cast holder (15), causing "an orbital movement." When the displacement of the incisal rod was established, it was fixed in that position by set screw (39). Pfeiffer claimed that this adjustment provided a means whereby the range of the "ellipsis" could be varied at will for wider or narrower paths of the "conditioning" operation.[9]

The condylar "elements" were simply fixed horizontal slots (11) on the condylar posts (7) extending from the platform (1) with the condylar balls (12) on the upper cast holder. The condylar balls could not be locked (Fig 4A). This arrangement was intended for counterweight and balance, and to allow free movement during the "conditioning" operation. Anterior tension spring (41) was used to increase the occlusal pressure during the operation if needed.[9]

Incidentally, the notion that it was necessary to provide added tension anterior to the mounted dentures during the grinding process was quite common and was seen often in these devices. Generally, either elastics or springs were used for this purpose; but apparently, little attention was given to how much added force was applied or what effect it might have on the outcome.

C

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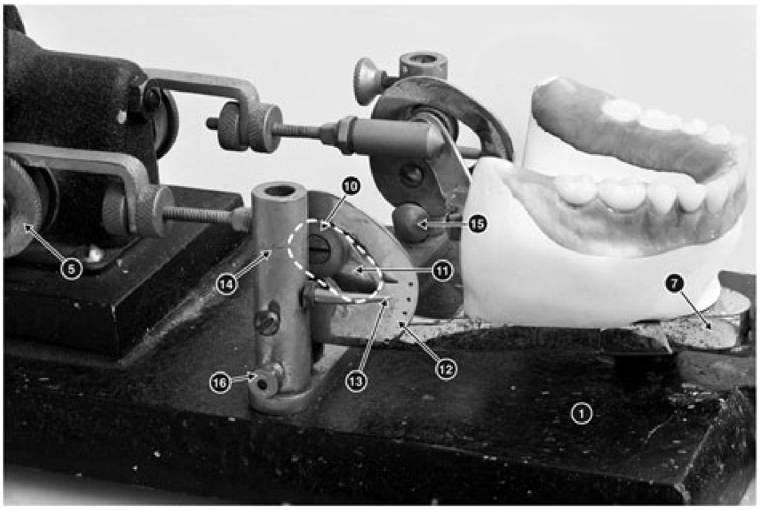



**Figure 5** (C & D) Joseph E. Scott, "Reciprocal Dental Grinder," 1941. These figures show the details of the power train links from the eccentric control collars (5) to the lower cast holder (7). Each collar has an L-shaped arm (6a), an adjustable shaft (6b), and a coupling device (6c) attached to the flanged roller (or "condylar") elements (10) that move in the "condylar slots" (hatched areas) (11) of the "condylar link elements" (12). The condylar pointers (13) indicate the angles of the condylar slots. Lugs (15), tightened by nuts (16) are used to maintain the condylar link elements in position. C shows a "condylar link element" at its lowest position. D shows a "condylar link element at its highest position.[10]

## J. E. Scott's "Reciprocal Dental Grinder" and J. T. Patching's "Millerator"

The following devices for grinding processed dentures represent those that at least made it into dental offices and laboratories. Many were crude and far from being highly profitable for the inventors, but they had several features in common that would have made them more attractive to dentists than their "mechanical marvel" predecessors were. They were relatively small, were self-contained, or were powered by a belt-driven pulley, and their grinding operations were based largely on simpler mechanical concepts.

The first and perhaps only one of this kind to appear in patent records is that of Joseph E. Scott of Pratt, KS. Scott received a patent for his "Reciprocal Dental Grinder" on October 7, 1941.[10]

As stated in the patent letter, Scott's first objective was, "to provide a machine in which measurements taken [from the patient], the movements of [the mandible] may be reproduced for the purpose of grinding false teeth." A second objective was to obtain balanced occlusion or, as Scott expressed it, "three-point contact in the biting motion of the mandible thereby establishing a compensating curve."[10] Thus, Scott was the first to attempt to mimic the movement of the mandible by adjusting the grinding controls to the patient's condylar paths.

Figure 5 is composed of photographs of a Scott "Reciprocal Dental Grinder" annotated with numbers for easier location and identification of the essential operational parts. This device was designed to be self-contained and portable. It was fairly lightweight but heavy enough to keep it steady during the grinding process. It was only 5.5" wide and 13.25" long, including the base (1).

The lower cast holder (7) provided the grinding movements powered by an electric motor (2). The maxillary cast holder (8) was stationary, but had both height (8b, 8c, 14) and anterior–posterior (8a, 9a, 9b) adjustment features.

The electric motor could be plugged in to any 110 v outlet. The drive shaft, located at (3) had a worm gear that engaged a lateral rod, located at (4). An "eccentric control collar" (5) was fastened at each end. Each "control collar" (Fig 5C) had adjustable connecting links including an L-shaped arm (6a), adjustable threaded shaft (6b) and a coupling element (6c) transmitting an elliptical movement to the triangular-shaped

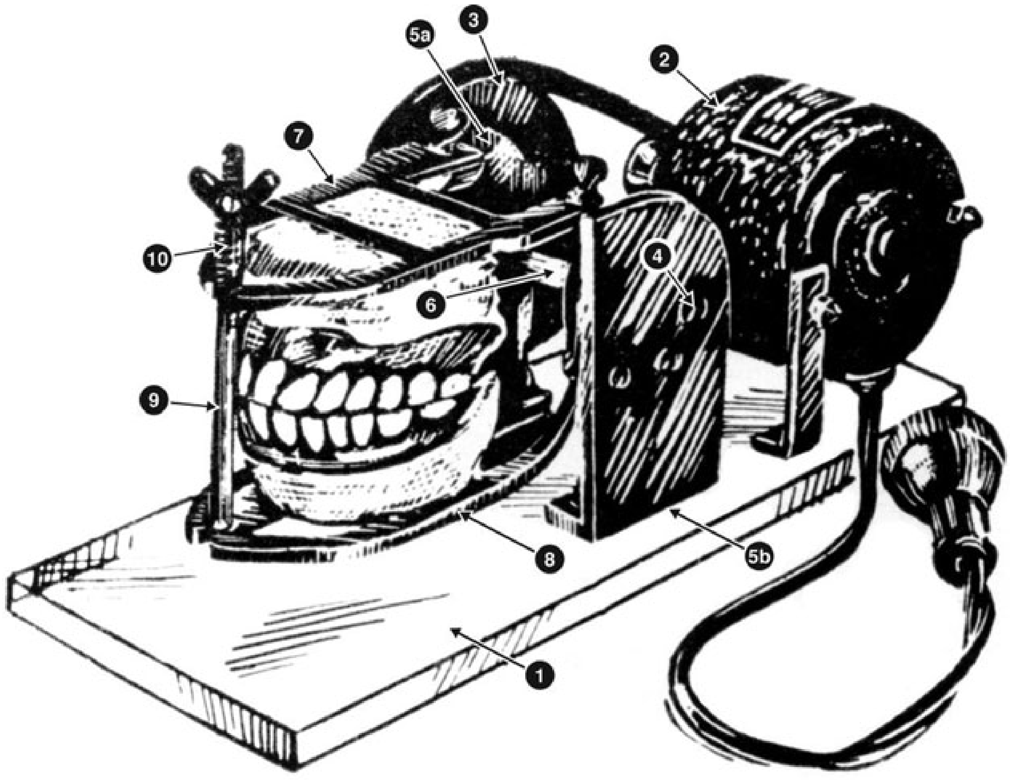


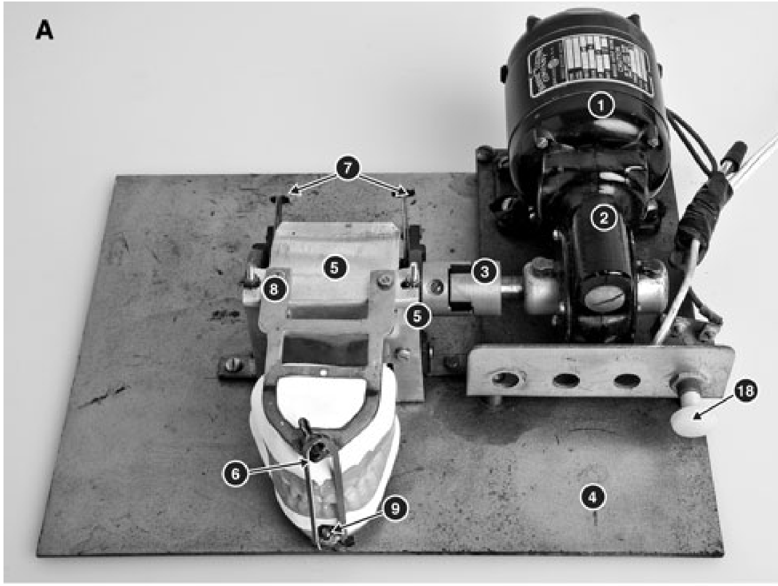

**Figure 6** The "Millerator," J. T. Patching, 1949.[12] The base (1) was likely made of metal. From the center of the large wheel (3) turned by the motor (2) was a rod (4). This rod, supported at each end by plates (5a & b), embodied a surface that contacted the posterior strap (6) of the lower cast holder (8). When the rod was rotating, it likely produced an elliptical movement in the lower cast holder. The anterior tension rod (9) was attached to the cast holder at its ball-shaped lower end, and pressure could be applied to the teeth during the grinding process by tightening the spring (10) with the wing nut.

mandibular cast holder (7) through Scott's "condylar link elements" (12). Scott claimed that these "condylar link elements" could be adjusted and set by taking measurements from the patient.[10]

The components of the entire condylar assemblies (Figs 5C, D) included the "flanged roller elements" (10) that moved in the "curved condylar slots" (11) of the "condylar link elements" (12). Condylar pointers (13) attached to a pair of vertical tubular posts (14) indicated the angles of the condylar slopes. The "condylar link elements" were maintained in place by hand-tightening lugs (15) with nuts (16). With strong rubber bands or springs (17) in place anterior to the incisor point, the angle of the condylar slots determined how high "the elliptical and upward rocking motion" of the mandibular denture would be during the grinding process.[10] Scott also described the other grinding requirements: By the use of the tension spring screws (18) of the "eccentric control collars," (5) the control collars could be adjusted to produce a reciprocal motion, a straight protrusive motion, or, by unilaterally tightening each tension screw, disengage the control collar, thereby allowing lateral movement.[10] Scott summed it up by saying, "The false teeth thus ground, it is obvious that they will fit and properly engage each other under all conditions of protrusion and chewing."[10]

The next "grinder" found in the literature was a device called the "Millerator" (Fig 6). It was manufactured by J. T. Patching of the Pacific Dental Laboratory in Sacramento. In 1949, the "Millerator" was introduced in the April and May issues of the *Dental Laboratory Review*.[11,12] Patching described it as a new milling machine that "will mill dentures until they slide into lateral and protrusive movements without tripping or locking."[11] Intended for use by dental laboratories, the objective, as stated in the operation booklet, was to instruct laboratory technicians in its use. According to the instructions, all that was necessary was to mount the dentures in centric relation, apply milling paste to the teeth, and turn on the motor. The "Millerator" was said to mill the dentures in "4 to 8 minutes" into free centric occlusion and grind down all high spots until a fine, precise sliding action was attained, reducing ridge trauma and resorption of the alveolar process. "The machine required no adjustments and carries on where the articulator leaves off."[11]

At the present time, not much is known about the mechanical grinding components of Patching's "Millerator," but it is very likely that it produced an elliptical movement of the lower cast holder. Figure 6 reveals that the power train was secured to a base (1) and included an electric motor (2) that turned a belt-driven large wheel (3). From the center of the large wheel a



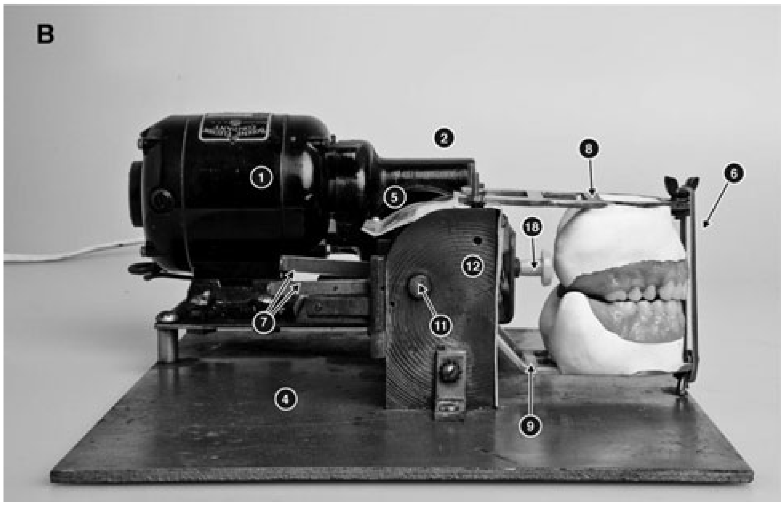




**Figure 7** (A & B) "Millerator," c. 1973, lateral and "bird's eye" views. Comparisons made between this "Millerator" and that of J. T. Patching (Fig 6) suggest a close relationship because of the similarities between the two grinding assemblies (4, 8, 9, 11, 12). Furthermore, both "Millerators" were created in Sacramento. The obvious differences are the position and type of motor (1) with an anterior drive shaft-worm gear assembly connected to the grinding activator by a coupling device (3).

rod (4) was secured and passed through supporting plate (5) into supporting plate (5') and rotated, carrying a "device" that directly engaged the posterior strap (6) of lower cast holder (8). The upper cast holder (7) was stationary, attached to the tops of the supporting plates. The anterior tension rod (9) was likely secured to the lower cast holder in such a manner as to move with it. The adjustable spring (10) would have been used to control the grinding pressure on the denture teeth.

With only Patching's 1949 drawing to go by, the mechanism that produced the grinding movement would have undoubtedly remained a mystery; however, with the discovery of a 1973 prototype version of a *second* "Millerator," some conclusion can be drawn as to what mechanical features may have been in common to both devices (Fig 7). There surely must have been a relationship between the two "Millerators." A letter (since the inventors of the 1973 "Millerator" cannot be unequivocally confirmed, no persons will be identified) from a Sacramento dental office to a laboratory technician was found with this second grinding device. It was dated February 12, 1973. The device was referred to as a "Millerator" and, indeed, it has many of the characteristics of J. T. Patching's "Millerator" of 1949. It is also evident from the letter that there were aspirations to receive a patent, but thus far, no patent letter has been found.

Figure 7A, a "bird's eye" view, and Figure 7B, a lateral view, reveal the obvious similarities, but they also demonstrate that this model was likely a prototype, and that the concept of construction was more complicated than Patching's design. The 1973 "Millerator" required a larger motor (Speed Reducer Motor, Bodine Electric Co., Chicago, IL) (1) because of the drive shaft/worm gear component (2), a coupling device (3), and a larger and heavier base (4).

When comparing Patching's grinder (Fig 6) with this device (Figs 7A, B), it is conspicuously apparent that the grinding assemblies are practically identical. From outward appearances, the only differences seem to be the L-shaped cover plate (5), the use of anterior elastics (6) instead of a tension rod, and the

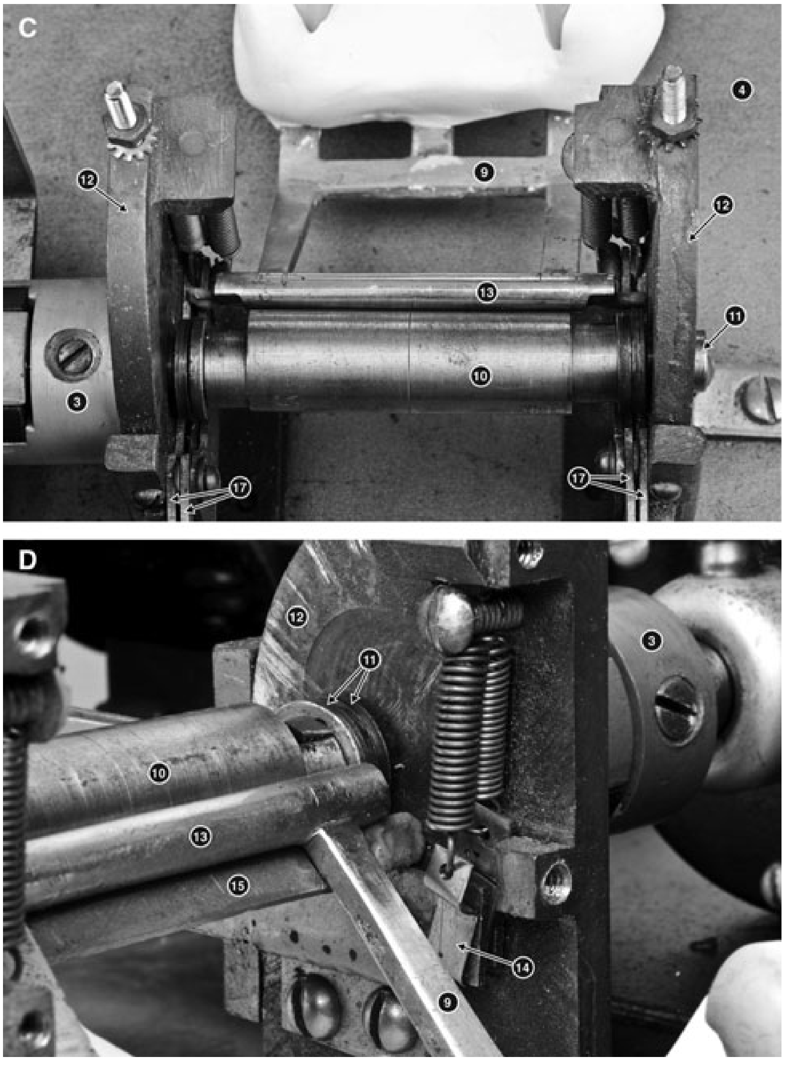



**Figure 7** (C) "Millerator," c. 1973, detail view of the primary grinding mechanism. The primary activator, that is, the offset ovoid surface (10) of rod (11), was supported by the two vertical plates (12). This surface was always in contact with horizontal rod (13) and produced a "wave" action creating the elliptical movement pattern of lower cast holder (9). (D) "Millerator," c. 1973, detail of the vibratory mechanism. An added feature of this "Millerator" was a vibratory component of the grinding process that could be deactivated when desired. This vibration during the grinding process was created by the reciprocal vertical action of the spring-loaded plates (14) on the cast holder's horizontal plate (15). Two offset disks (16) that moved with the primary grinding rod activated the spring-loaded plates. By moving the lever arms down, the spring-loaded plates were disengaged.

right and left sets of two levers (7), which will be discussed later.

Figures 7C and D show the grinding apparatus in detail. The cover plate and upper cast holder (8) have been removed to uncover the controlling components. The primary grinding activator that produced the elliptical movement of lower cast holder (9) was a rod with the major center portion (10) being ovoid-shaped but gradually offset from one end of the functional surface to the other to produce lateral as well as protrusive movement. Each end of the rod (11) was round and was held in place by vertical support plates (12). The right end was secured to the coupling device (3) that was secured to the lateral shaft of the motor. When the lower cast member was in place, the rod portion (13) of its posterior horizontal rod and plate assembly was in intimate contact with the ovoid functional surface (Fig 7C).

Interestingly, this "Millerator" also produced a vibratory motion to the lower cast holder by the reciprocal operation of right and left sets of two spring-loaded vertical plates (14) acting on plate portion (15) of the rod and plate assembly (Fig 7D). The plates were activated by two offset disks (16) that moved with the ovoid functional surface. The vibratory motion could be stopped on one or both sides by pushing down a set of two levers (17) that moved the plates down and out of contact with the disks. The grinding process was activated by pulling the knob (18) in front of the motor (Fig 7A). There was only one grinding speed. It is not clear how a vibratory motion would enhance the grinding process; furthermore, it is doubtful that Patching's "Millerator" had this feature.

## Grinding devices designed for using articulators

These grinders basically worked on the same principles; that is, they generated the movements of the upper member (with one exception, the Gritman "Dental Apparatus"[25]) of the articulator with attachments to either the condylar controls or to the incisal guide pin. The earliest of these was patented in 1916, while the others were patented and/or produced in the 1920s. Obviously, these devices were intended for the most

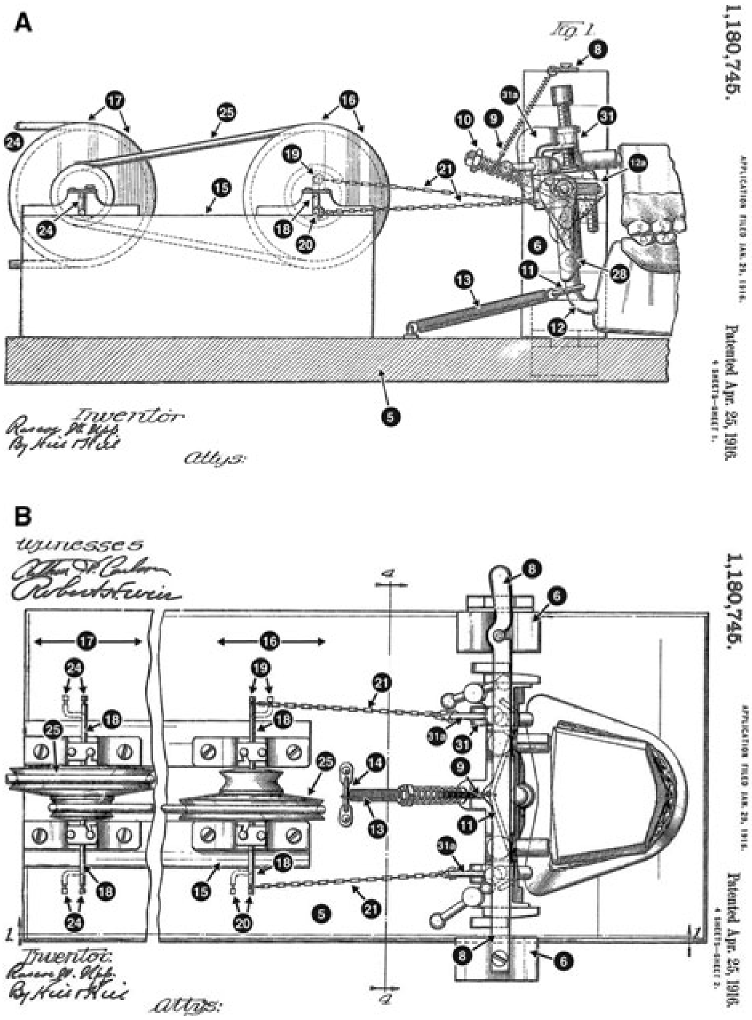



**Figure 8** (A & B) Roscoe W. Upp, "Dental Device," 1916, side and top views, respectively. The power source (not shown) was attached to the grinding assembly (17). Note that latch (8) holds the vertical standards (6) in position, but can be released (in the direction of the arrow) to remove the articulator. (Reprinted and modified from the 1916 patent.)[2]

popular articulators of the day, so they could only accommodate articulators such as, for example, the Gysi Simplex, the Gritman, the Snow "New Century" and "Acme," and the Kerr. The motion assemblies of these grinders produced either a reciprocal seesaw and/or protrusive action, principally following the fixed or adjustable controls of the articulator. Only one grinder, the Priest,[5] was found for use with the Hanau and the Wadsworth articulators, and incidentally, this device was the only one that produced an elliptical grinding motion.

On April 25, 1916, Roscoe W. Upp of Chicago received a patent[2] for his "Dental Device" in which he claimed that his grinder would make "... provision for matching of the teeth in both ... the protrusive bite and ... the lateral bite .... This," he said, "is to secure what is termed in the art, a balancing effect."[2]

Figures 8A and B are side and top views, respectively, of the grinder showing the entire apparatus with the articulator in place. The power source (not shown) was located posterior to the grinding assembly.[17] The grinder was mounted on a base (5) with two grinding assemblies (16, 17) centrally suspended between standards (15) to support them at the desired position. The articulator, facing forward, was secured between two vertical standards (6). To stabilize the lower cast holder in its most downward and backward position, a tension spring (13), arising from the base at (14) was attached to the lower member (12b) by means of a heavy wire (11) connected to the right and left vertical portions (12) of the cast holder. Similarly, a tension spring (9) was placed between the central spring of the articulator (10) and the center of latch (8) on top of the vertical standards to force the upper member (12a) downward during the grinding process (Fig 8A).

The power train consisted of the power source connected by belts (25) to the two grinding assemblies. Each grinding assembly had right and left crankshafts (18) with offset right angle ends. To initiate the grinding function, a chain (21) was connected to the crankshaft ends and to two special clamps (31) located on the upper member (12) of the articulator. The positions of the clamps [with flanges (31a)] are best displayed in Figures 8B and C. And for clarity, in Figure 8D, large arrows show the positions of the clamps on a photograph of the type of articulator Upp chose for his patent letter.

It is important to note that each grinding assembly was used for a different grinding function. Therefore, even though they moved in tandem during the operation of the grinder, only one

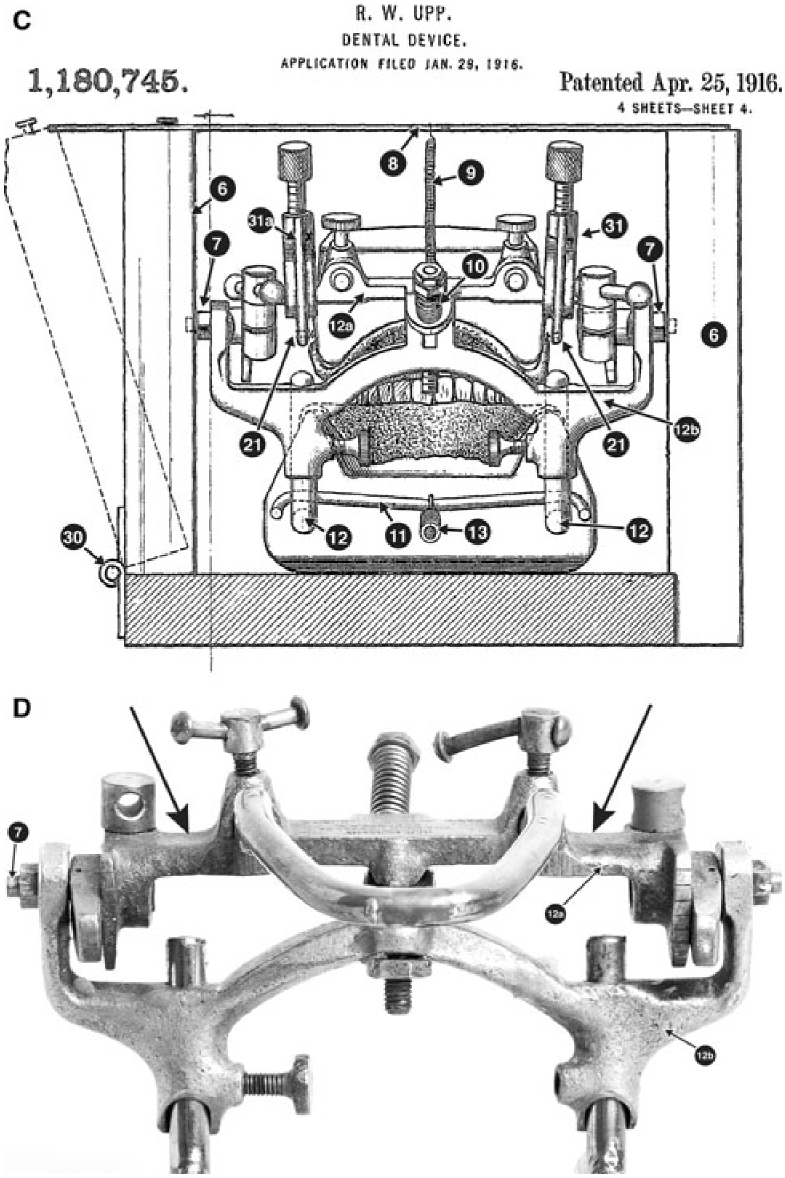



**Figure 8** (C) Roscoe W. Upp, "Dental Device," 1916, posterior view of articulator. The articulator is held in position between two standards (6), each of which had a receptacle to receive the lateral-most projections (7) at the condylar assemblies. These projections are actually the bolts that hold the articulator together. To place and remove the articulator, the latch of a horizontal gate (8) was released, and the left standard was moved outward, having a hinge (30) at the bottom. (Reprinted and modified from the 1916 patent).[2] (D) "New Century" Articulator, 1907, George B. Snow. (In the collection of Dr. Starcke.) The large arrows point to the position that Upp placed his special clamps (31). The right and left bolts (7) lateral to the condylar assemblies helped stabilize the articulator when they were in the vertical standard receptacles.

assembly was functioning at a time. This is clearly illustrated in Figure 8B. For assembly (16), the right angle ends (19, 20) of the crankshafts were set facing opposite directions. This would have produced lateral movements of the upper member of the articulator. Conversely, for assembly (17), the right angle ends (24) were set in the same direction. This would have produced a straight protrusive movement. To achieve both lateral and protrusive movements in the grinding process, it was necessary to interchange the grinding assemblies for each of these two functions.

Incidentally, the articulator shown in the grinder is a Snow "New Century" without the accessory incisal pin and guide. Apparently, Upp looked down on that feature, although it was becoming more generally accepted by the profession since being introduced by Gysi in 1912.

In 1924, W. M. Gambill modified the device he designed for grinding the occlusion of mounted processed dentures to accept articulators (Fig 3). Obviously, this grinder would have produced the same lateral movement in the articulator.

A Gysi "Simplex" was used for his patent letter.[13] However, it is probable that the Snow "New Century" and "Acme" articulators would have been used in this device as well.

At least three inventors received patents for denture grinding devices in 1927. Those of C. A. Priest,[5] A. De W. Gritman,[25] and R. H. Downing[6] will be discussed in this article.

On July 12, Charles A. Priest, of Marion, IN, received a patent for his "Dental Machinery" (Fig 9A).[5] This device was manufactured by Charles Priest himself as the "Anatomic Denture Grinder" (Figs 9B, C), and it likely had some commercial success. It was a high-quality machine of simple design and was easy to use. In his patent letter, Priest claimed his dental grinding machine was convenient and effective and produced a simple elliptical movement in the articulator with a control on the incisal pin (Fig 9A).[5]

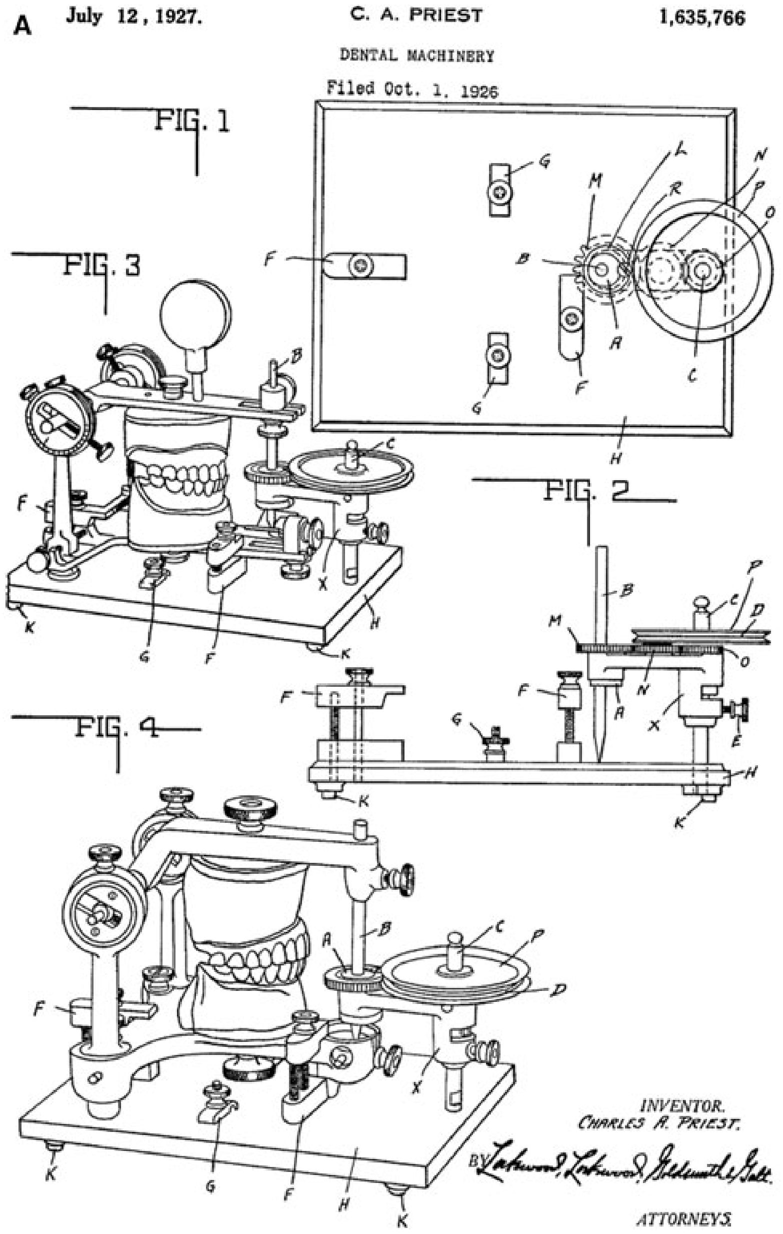


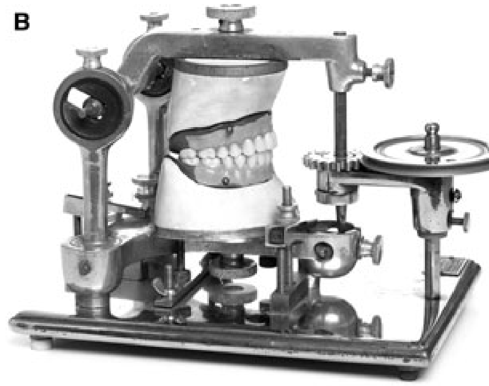

**Figure 9** (A) Charles A. Priest, "Dental Machinery," 1927 and Hanau Model H Articulator.

Patent figure 1 is a top view, and patent figure 2 is a side view showing the details of this control, a belt-driven eccentric gear system. Belt driven pulley (P) drives three gears (O, N, M). Gear (M) is in a drive shaft (L) with an eccentric bushing (A) into which the incisal pin (B) of an articulator is held during the grinding process. The incisal pin controls and articulator clamps (F and G) all are on metal base (H). Patent figure 3 is a perspective view of a Wadsworth articulator in position.[5] Patent figure 4 is a perspective view of a Hanau Model H articulator in position.[5] It is interesting that this is the same very early model of the Hanau articulator in Figure 9B. These earliest of the Model H articulators can be recognized by the round condylar posts and the absence of a centric lock.

Abel DeWitt Gritman of Philadelphia received a patent for his "Dental Apparatus" on October 25, 1927.[25] This device truly deserves to be in a class by itself: *Über*grinder! For no other reason than for its comparative size to and the enormous forces it was capable of inflicting on the small articulator (the *Gritman*, naturally) that it operated.

The base (10) of the grinder (Fig 10A) supported three main structures, the motor (17), two vertical standards, (11) and the housing (12) for the control module (Patent fig 2). The power train consisted of the motor, with its drive shaft (15) coupled to a worm shaft (16), meshed with worm gear (14) to turn shaft (13) that was within the control module perpendicular to the motor drive shaft. Shaft (13) turned the right and left eccentric wheels

B



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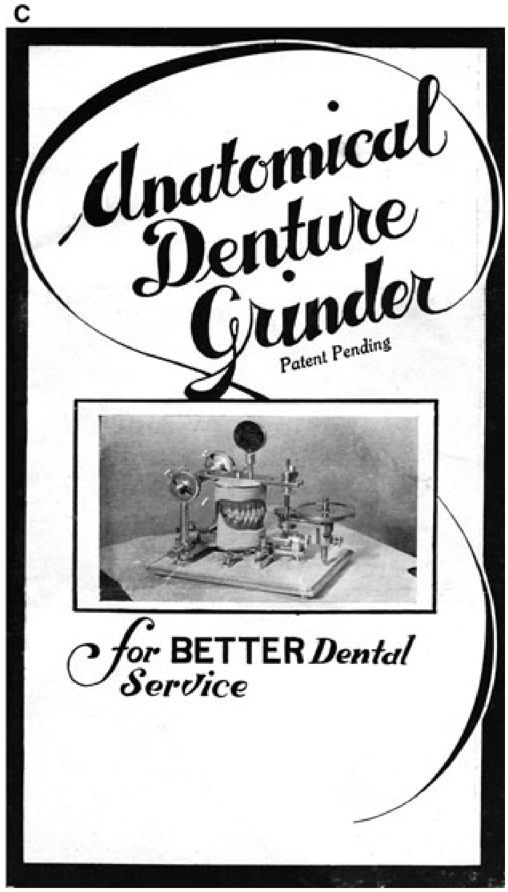


**Figure 9** (B) Charles A. Priest, "Dental Machinery," 1927. Patent figures 1 & 2 are top and side views, respectively, showing the belt-driven eccentric gear system. Pulley (P) drives three gears (O, N, M). Gear M contains an eccentric bushing (A) that holds the incisal pin (B) during the grinding process to produce an elliptical movement. Patent figure 3 is a perspective view with a Wadsworth articulator, and patent figure 4 is a perspective view with an early Hanau Model H.[5] (C) Brochure for the Priest "Anatomical Denture Grinder."

(26) (not seen) in housing (22). By moving the positions of the eccentric wheels with the hand wheels (33), the "offset" of the eccentric wheels could be adjusted separately. The amount of change in the "offset" was determined by comparing the numbers on the right and left sets of annuli; that is, (19) to (21). Gritman did not adequately explain or show the intricate details of how the control module operated; therefore, the function of the module is being described only in general terms. The two vertical standards (11) were primarily used for three purposes: by being substantially joined at the top, to support and stabilize the articulator, to secure the linkages essential for the grinding process, and to monitor the independent movements of the articulator by means of a gauge (51) (Fig 10).[25]

The eccentric wheels (26) controlled arms (36) connected to bell cranks (37), hinged at (38) on each standard (Fig 10A). When the eccentric wheels were in motion, this caused the bell cranks to rock forward and backward to move the lower member of the articulator. Each bell crank had a flange (39), and an L-shaped extension (40) having a pin (41) facing forward. Vertical lever (42) with pin (43) was attached to the flange. Pin (43) was opposed by pin (41) with both being enclosed in tension spring (44). According to Gritman, the spring was intended to provide a cushioning effect as the pins came into contact during the grinding process. (It is fair to say that hopefully, Gritman chose a *very* strong spring.) Connected to lever (42) were rods (45), each connected to the lower member of the articulator by clamps (46) secured by a crossbar (53) below the condylar slots (Fig 10B). And finally, lever (42) was hinged at (49) to horizontal lever (50) that moved within gauge (51) providing a visual means of monitoring the "throw" (distance moved) of rods (45).[25]

The articulator was suspended by two means. First, a plate (54) that extended from the supporting structure. The plate held a bolt and wing nut (55) attached to an extension (47a) welded to the upper cast holder. Second, the lower member was provided with two rods (52) that passed through apertures in the supporting structures (11) (Fig 10B). The denture teeth were held in occlusion by a tension spring (48) that was suspended from plate (54) and could be adjusted by moving it up or down through a hole in an extension (47b) of the lower cast holder (Fig 10A).

Gritman stated in the patent letter that "[t]he leading object of the present invention is to provide a device . . . for the automatic grinding of the articulating surfaces of artificial teeth . . . in which is combined simplicity, efficiency, cheapness and numerous adjustable movements for attaining desired results."[25] He was certainly correct about his grinder's ability to produce numerous adjustable movements. Clearly, his grinder could produce independent lateral and protrusive movements, and the length of these movements could be controlled as well. On the other hand, it is obvious that this machine would have been expensive to develop and manufacture. It would also have been awkward to adjust and monitor during operation because the gauges could not be seen at the same time. Therefore, as for "simplicity" and "cheapness," these terms obviously do not apply to this 1920s *Über*-wonder.

As a lyricist once wrote about a riverboat, "big wheels keep on turning," and one of the more notable characteristics of some of the grinders was a large wheel primarily used for power and speed management. Examples of devices with this feature discussed in this article are the *Upp* "Dental Device," 1916,[2] the *Downing* "Denture Grinder,"[6] 1927, and a grinder produced by the Kelly Brothers Manufacturing Company, Abilene, KS.

Downing's "Denture Grinder" (Fig 11), designed for the Gysi "Simplex" articulator, had a large belt-driven pulley that was

A

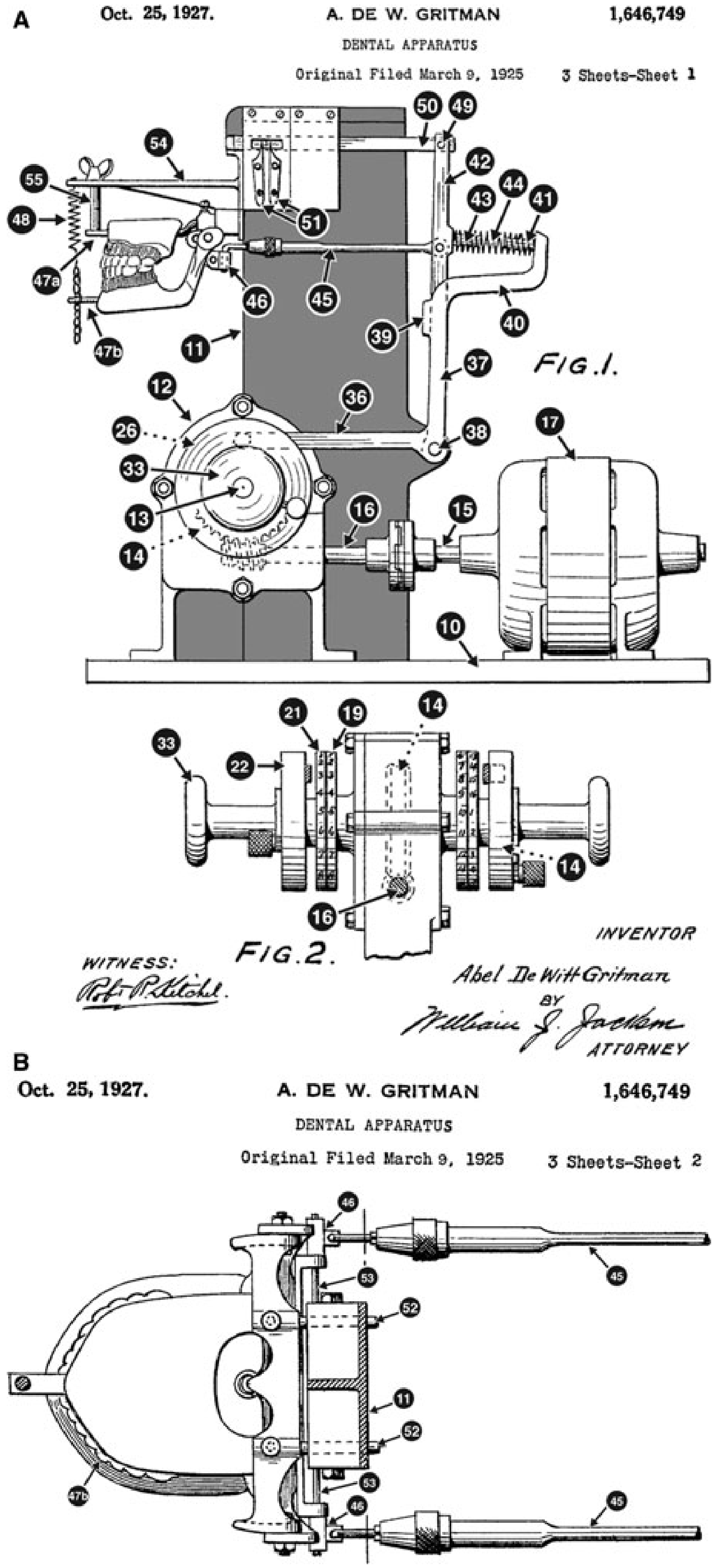


**Figure 10** (A) Abel De W. Gritman, "Dental Apparatus," 1927. Patent figure 1 is a side view of the grinder in its entirety. The important features to note are the motor (17) and how it drives the control module (12). In addition, note the bell crank (37) secured to the vertical standard (11) at position (38). When eccentric wheel (26) is turning, the bell cranks rock forward and backward, allowing pins (41 and 43) to contact, pushing the vertical levers (42) forward. This action moves both the rods (45) attached to the lower member of the articulator and the horizontal levers that pass through the gauge (51) for monitoring the "throw" of rods (45). Patent figure 2 is a detail of the control module. It is important to note that the "throw" or distance traveled by rods (45) can be controlled independently. This is accomplished by adjusting hand wheels (33) that change the "offset" of eccentric wheels (26). (B) Abel De W. Gritman, "Dental Apparatus,'' 1927. This is a superior view of a cross section of the Gritman articulator with rods (45) attached to the lower member by clamps (46). Note the two rods (52) that pass through the supporting structure to secure the lower member (27).

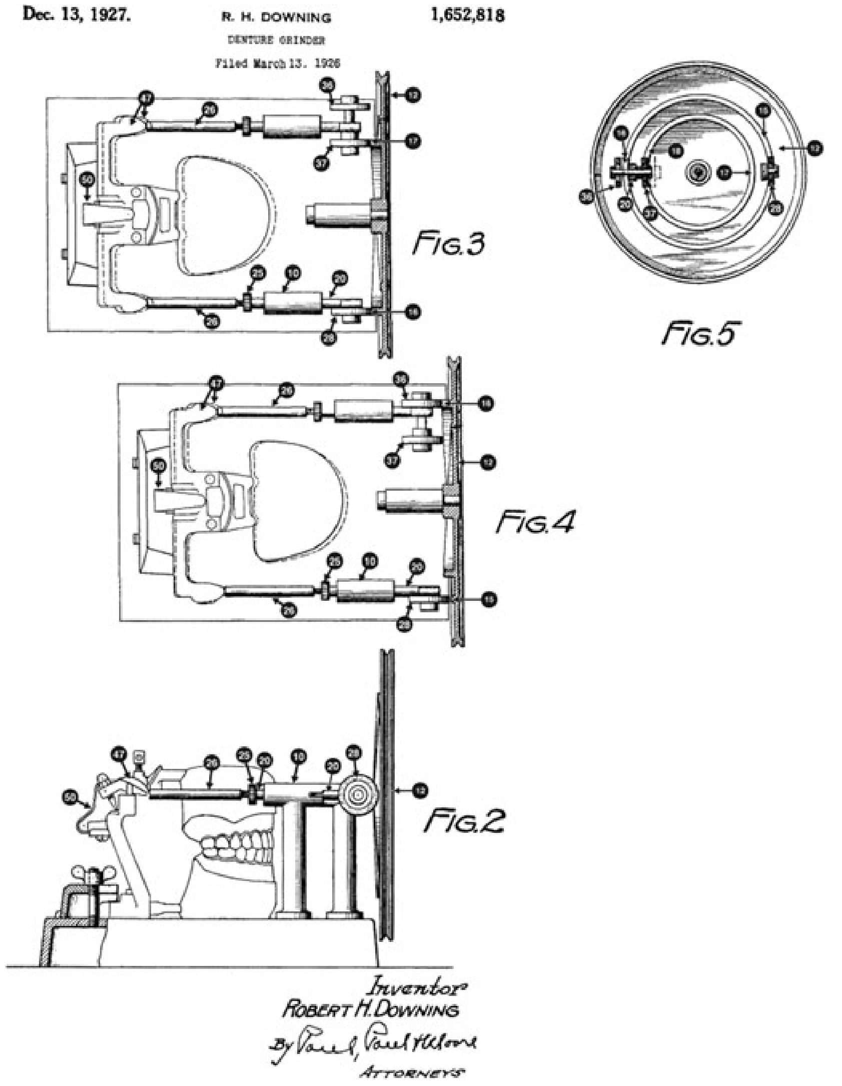


**Figure 11** R. H. Downing, "Denture Grinder," 1927. Patent figure 2 shows the relationship of the right roller (28) to a cam located on the inner surface of the belt driven pulley (12). There are two concentric cams that have high and low points. The one right and two left rollers control the piston-like assemblies (10, 20, 25, 26) that move the condylar guides (47) against the force of the spring (50) of the Simplex articulator. Patent figure 3 illustrates how a protrusive movement is created. The grinding motion is set to begin with the right roller (28) engaging the high point (16) of the outer cam and the left roller (37) engaging the high point (17) of the inner cam. Similarly, patent figure 4 illustrates a lateral movement with the grinding motion to begin with the right roller (28) engaging the low point (15) of the outer cam, and a left roller (36) engaging the high point (16) of the inner cam. The process is then reversed for opposite lateral movement. Patent figure 5 shows the relationships of the two concentric cams and the three rollers (6).

not only part of the power train, but was also the source of the grinding action. The pulley was in a peculiar position, having been located in front of and perpendicular to the articulator (Patent fig 2). The inner face of the pulley had outer and inner cams [ridges with flat superior surfaces] concentric to each other as well as to the pulley (Patent fig 5).

The cams, however, were configured for action parallel to the rotation of the pulley; that is, each cam had a high and low point. This, therefore, produced grinding movements parallel to the piston-like adjustable assemblies (10, 20, 25, 26) activated by right roller (28) and by left rollers (36, 37) when one of them engaged a cam. The rods (26) simply pushed the condylar guides (47) against the force of the central spring (50) of the articulator to achieve reciprocal action. It is interesting to note that no attempt was made to attach the rods to the condylar guides to avoid disengagement during the grinding process.

As was common with denture grinders in this category, Downing's device was designed to produce two grinding functions: right and left lateral movements and protrusive movement. Patent Figures 3 and 4 illustrate the setup of the cams and wheels to produce these movements. Patent figure 3 shows that engaging right wheel (28) with the high point (16) of the outer cam while on the left, engaging the wheel (37) with the high point (17) of the inner cam, produced a protrusive movement. Similarly, if right wheel (28) engaged the low point (15) of the outer cam while on the left, the wheel (36) engaged the high point (16) of the inner cam, lateral movements would be achieved (Patent fig 4).

This early, prepatent model (Fig 12) (Produced by the Kelly Brothers Mfg. Co. c. 1910s) of the Kelly Brothers Denture Grinder (c. 1910s) embodies the attributes that would make one of these devices a "success;" that is, at least finding its way into some dental laboratories and offices. It was inexpensive to make, simple in concept, and easy to use. Constructed on a base of wood (1), the two major components, the vertical standards (2) and the posterior receptacles (3), used to secure the Gysi Simplex articulator (4) were each cast as single units. The power train consisted of a large pulley (5) from the center of

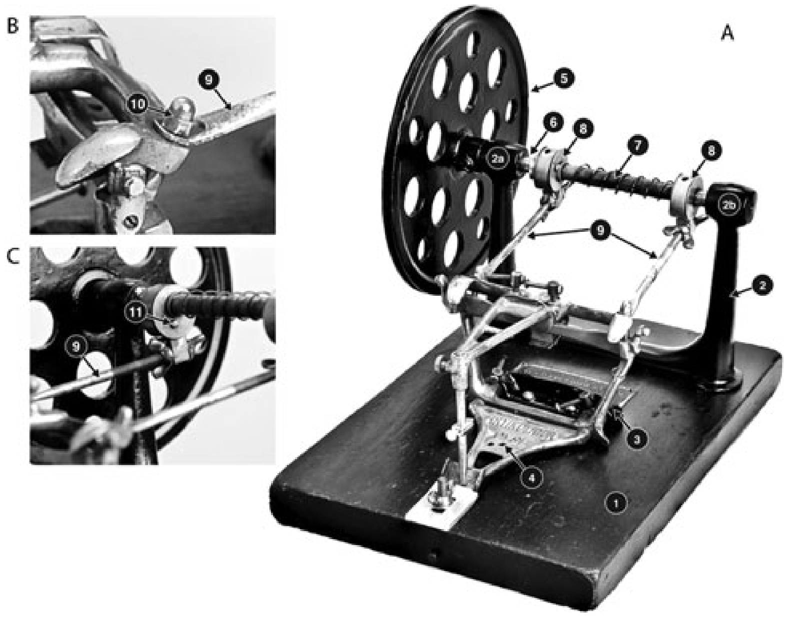


**Figure 12** The Kelly Brothers Denture Grinder (early model), c. 1920s. The Kelly Grinder (A) is shown with a Gysi Simplex articulator secured by receptacles (3) for the posterior extensions of the lower cast holder and an adjustable aluminum plate (3a) for the incisal table. The belt-driven pulley (5) with rod (6) projecting from its center is supported by elements (2a) of the vertical standards (2). The rod (6) turns the offset plate assemblies (8), each having an attached adjustable arm (9) to control the movements of the articulator. Inset (B) is a detail of the connection of the adjustable arm (9) of the offset disk assembly to the articulator with nut (10) that holds the posterior pin of Gysi's condylar guide mechanism. Inset (C) is a detail of the offset disk assembly and screw (11) that allows setting the grinder to produce either protrusive or lateral movements.

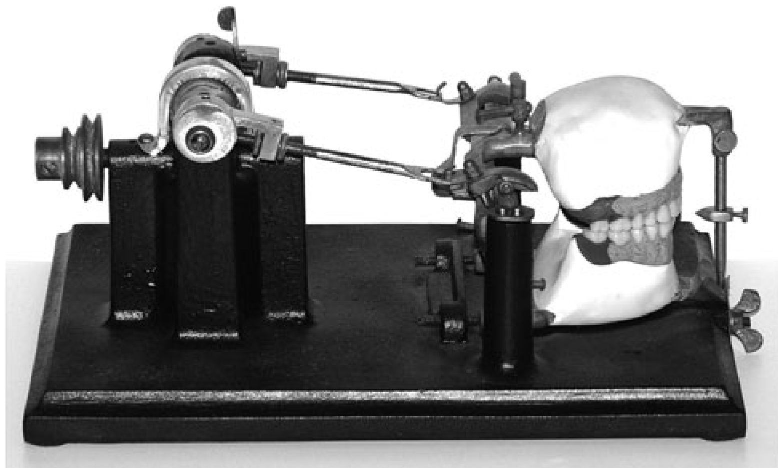

**Figure 13** The Kelly Brothers Denture Grinder, ("New and Improved" model), c. 1920s. This grinder was fabricated of all-metal parts and had a complex power train. It had advantages over the early model, but it almost certainly had a higher price tag.

which was attached a rod (6). The rod entered the left standard at (2a) and then into the right standard at (2b). A tension spring (7) separated the right and left disk assemblies (8) that controlled the movements of the articulator. The disk assemblies had adjustable arms (9) connected to the articulator by the nuts (10) that secured the posterior vertical pins of Gysi's condylar mechanism. By simply loosening the retaining screws (11) on the disk assemblies, each one could be set in the desired position to accomplish right and left lateral or protrusive movements of the articulator.

Recently, the patented model (1916) of the Kelly Brothers Denture Grinder was discovered (Fig 13). (Produced by the Kelly Mfg. Co., Kansas City, MO. It was patented on April 25, 1916; however, no patent letter has been found.) Certainly, this is a much more refined example, having a metal base, complex gear system, and substantial linkages. But it also had only one setting, producing lateral movements, added at least 13 pounds to the weight and many more dollars to the cost. Was this "new and improved" grinder more successful? Admittedly, the weight and enhanced power train would make the grinder more stable during operation, and perhaps the inventors felt that a protrusive movement was unnecessary; however, there is no evidence that either model was a true commercial success.

It is fairly safe to say that most of the inventors of these "mechanical marvels" were more obsessed with the process than the outcome. From many of the descriptions in the patent letters, it certainly *appeared* that the inventors were sure what they wanted to achieve. But realistically, did they? In a future issue of the *Journal of Prosthodontics*, the final entry in this series will present those denture grinders that were incorporated as a feature of articulators.

## Acknowledgment

Photography and artwork by Brian Schnupp. The authors wish to acknowledge Mr. Schnupp's important contributions.

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