The History of Articulators: "Scribing" Articulators—Those with Functionally Generated Custom Guide Controls, Part III

Edgar N. Starcke, DDS

THIS is the third article in a series on "Scribing" articulators, or those with functionally generated custom guide controls.[1,2] US Patent Office records indicate that the first patent for a "Scribing" articulator was issued to Charles E. Luce of Stuttgart, Germany, in 1911.[3] Many "Scribing" articulators have since appeared in the literature and in the marketplace. Some have been relatively successful and some have not, and it appears that some, like that of Carl O. Boucher, of Columbus, Ohio, were developed primarily as research instruments.

The Carl Boucher "Oral Recorder" and "Tripod" Articulator

In 1932, Carl O. Boucher reported his method of registering and reproducing the anatomical movements of the mandible as reflected by movement of the complete denture record bases in function.[4] Boucher believed that any recording method must accurately register all paths of the denture bases during the various excursions of the mandible while the teeth are in contact. Acknowledging, therefore, that complete denture bases are not stable during function, Boucher suggested that "any changes in relationship of the bases must be recorded *regardless of the cause* if balanced occlusion is to be perfected on an articulator."[4] For the purposes of his study, Boucher devised an oral functional recorder with an extraoral Gothic arch tracing assembly and a tripod-type "scribing" articulator.

The "Oral Recorder" (Fig 1) consisted of upper and lower triangular metal bite-plates. The upper metal plate (7) had a tracing cup (3) attached at each corner, a central bearing post (6), and an extraoral tracing pin (1). The lower metal plate (5) had three corresponding rounded tracing posts (4), a flat plug (9) screwed into the center of the plate [interchangeable with a "tooth form die" (10)], and an extraoral tracing tray (2). Boucher explained that the "Oral Recorder" was used for two purposes: first, by using the extraoral "Gothic arch" assembly, to establish centric relation, second, by using the intraoral tracing cups and posts, and by applying the appropriate "tooth form die," to record the movement of the denture bases in function.

Boucher's "Tripod" articulator (Fig 2A) consisted of a maxillary tripod member (1), the legs of which—terminating as articulating pins (8)—fit into three corresponding cup holders (9) in the mandibular base (6). A fitted and keyed steel cup with a removable lid (10) for holding the tracing material was in each holder. A centering device was placed in each cup for mounting the casts in centric relation.[4]

Boucher described the technique for the use of the "Oral Recorder" in detail. Essentially, after the vertical dimension was determined with occlusion rims, the casts were mounted in tentative centric relation "by means of interposed wax." The maxillary cast was mounted in the articulator to the hinged cast holder (4) and the mandibular cast directly to the base cast mounting (7). The wax was removed and the hinge (3) closed "until the bite rims have approximately the same relation as in the mouth."[4] The "Oral Recorder" was then attached to the occlusion rims (Fig 2B). A spacer

Clinical Professor, Department of Prosthodontics, University of Texas, Houston, TX.

Correspondence to: Edgar N. Starcke, DDS, University of Texas, Health Science Center—Houston Dental Branch, 6516 M.D. Anderson Blvd., Houston, TX 77030, E-mail: Edgar.N.Starcke@uth.tmc.edu

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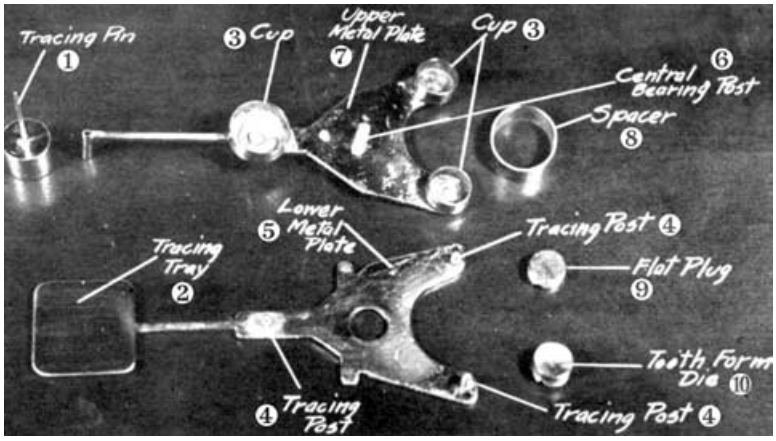

Figure 1. The Boucher "Oral Recorder." This display of the various parts and accessories is annotated by Dr. Boucher. (Reprinted from *Journal of Dental Research*, Boucher CO, 1934, p. 42.)[4]

(1) was used to insure that the metal plates were exactly parallel. With the flat plug in place in the lower metal plate, centric relation was determined using the extraoral Gothic arch tracing needle and tray assembly (2). Centric relation was recorded with a plaster check-bite. The plaster check-bite was then removed and the flat plug in the lower metal plate was replaced with "the 'tooth form die' that corresponds to the mould of the posterior tooth [selected for the patient]."[4]

The three cups on the upper metal plate were filled with modeling compound and while the compound was still soft, the "Oral Recorder" was placed in the patient's mouth for the patient to make all possible motions of the mandible while keeping the central bearing post in contact with the "tooth form die." The records were made in the modeling compound by the tracing posts. "The 'Oral Recorder' is then returned to the 'Tripod' articulator [that] is adjusted by means of the guides in the compound cups of the recording apparatus."[4]

In order to adjust the articulator, the three centering devices were removed from the cups on the articulator base. The cups were filled with modeling compound and placed in position in the cup holders in the base. The modeling compound was resoftened and the tripod was brought back to position guided by the recording apparatus. The "Tripod" articulator was moved into all relations permitted by the recorder tracings, resulting in corresponding tracings being made in the articulator cups. The next procedure was to convert the modeling compound tracings in the cups to metal. Impressions were made of the tracings with plaster in the cup lids. The modeling compound was removed from the cups and filled with a molten eutectic alloy (Hooper's metal). The cup lids with the plaster impressions in position were quickly replaced on the cups, reproducing the tracings in metal. The articulating pins of the tripod in contact with these tracings form the only movable controls of the articulator.

What did Boucher specifically say about the issue of maintaining balance during complete denture function?

"The [tracings] are entirely relative as to the bases, showing only the end result, or the combined effects of all known and unknown forces involved in jaw movements and occlusion in dentures. The condyle paths, whether curved or straight, Bennett movement, compression of tissue, and shifting of the denture bases on the ridges, are disregarded as such; but the effects of these, and any other forces, are registered by the recording apparatus and reproduced on the articulator."

So, what about the widely held presumption that "*Enter bolus, exit balance*" prevails as a problem common to all denture wearers with balanced occlusion?

Boucher argued that "[b]alanced occlusion may be so accurately adjusted that a balancing contact is maintained when a bolus of food is interposed on

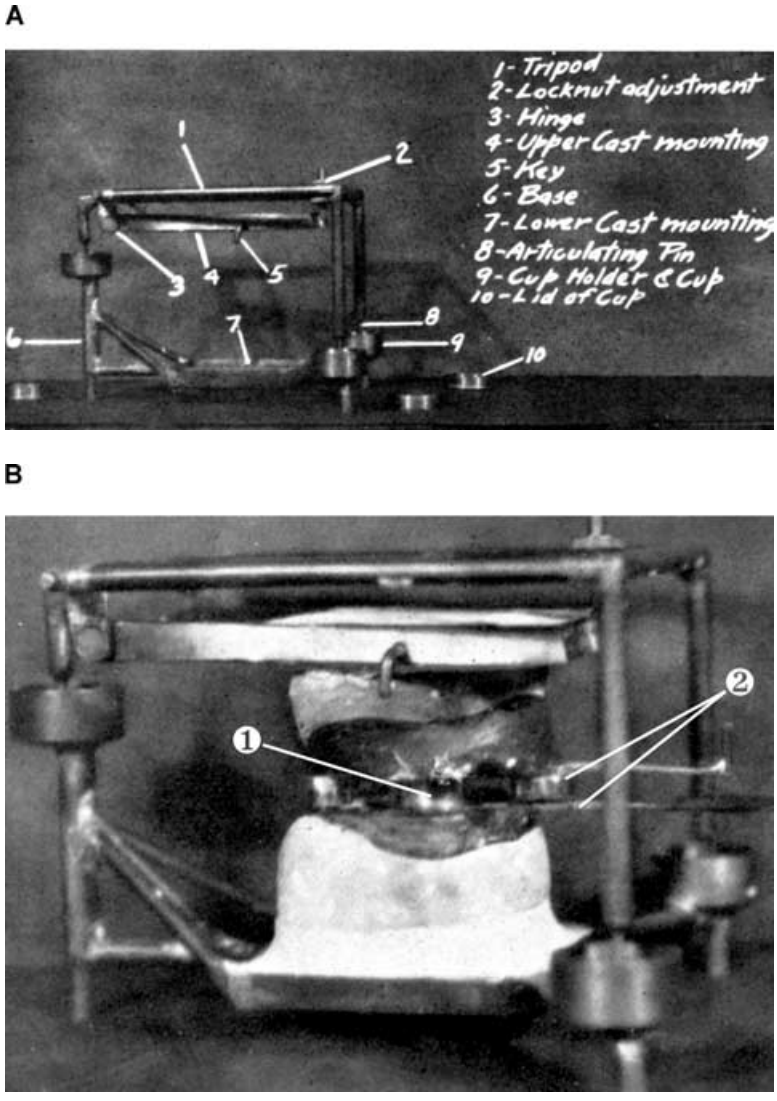

Figure 2. (*A*) The Boucher "Tripod" Articulator. This display of the various parts of the articulator is annotated by Dr. Boucher. (Reprinted from J Dental Research, Boucher CO, 1934, p. 42)[4] (*B*) The Boucher "Tripod Articulator" with the "Oral Recorder" mounted on the occlusion rims in position. (1) spacer; (2) Gothic arch tracer pin and tray assembly. (Reprinted from *Journal of Dental Research*, Boucher CO, 1934, p. 43)[4]

the working side, within the limits of compression of the tissues on the ridges and in the condyle fossae."[4]

The Jaw Bone is Connected to the Head Bone. . .

The only "Scribing" articulator patented in the 1950s was that of Louis A. Fine of La Palisse, France. Fine received a patent for his articulator on May 18, 1954.[5] Fine's interpretation of the physiologic movements of the mandible and how they translate into mechanical equivalency in an articulator seem a little peculiar, to say the least.

Fine began the patent letter[5] by proclaiming, "Articulators. . .made up to the present day for the making of dental prostheses. . .for completely toothless persons all provide in quite an imperfect manner the functional movements that they are

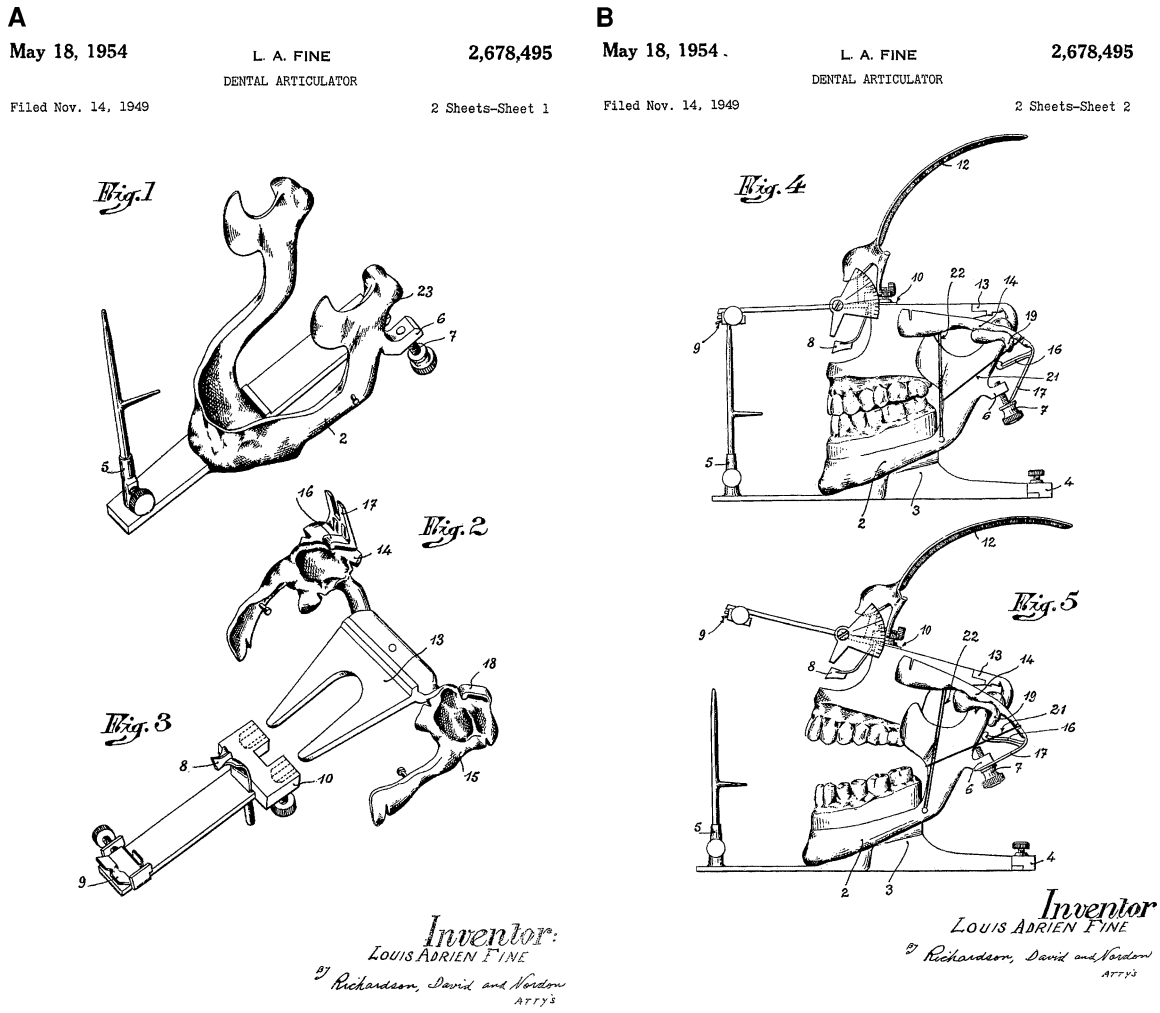

Figure 3. (*A*) The Fine Articulator, disassembled view. Fine referred to the anatomical structure of the lower member (2) as an "exact" replica of the "average" mandible and to the incisal pin (5), as the "stylus." The upper member had two sections. To the posterior section were attached parts 14 and 15 that carried the glenoid fossae, and to the anterior section the adjustable incisal guide table or "box" (9). The adjusting screw (7) and lug (6) of the locking device posterior to the left condyle (23) worked with cams (16 and 17) to provide a type of sliding hinge device. (Reprinted from the 1954 US patent.)[5] (*B*) The Fine Articulator, open and closed views. Appearing very bizarre in profile, Fine's articulator did resemble a human skull, especially with the addition of naso-frontal part (12) that, he said, "allows defining directly the facial angle and the 'Simon Line,' that is, the perpendicular line at the point of the greatest slope of the orbital recess. The subnasal (8) and chin reference marks [aids in determining] Cuvier's angle, that is, the angle between the lines connecting the center point of the incisors with the frontal point and the aural channel respectively." These illustrations show more clearly the supposed function of the posterior hinge-locking device showing that cams 16 and 17 were intended to place a force on the neck of the condyle to depress the mandible against the rubber bands (21, 22) "that correspond to the constrictor and depressor muscles", respectively. (Reprinted from the 1954 US patent.)[5]

to execute. No standard form of articulator is therefore physiological or productive of the normal functions." Fine envisioned that for his articulator to "operate in conformity with anatomically and physiologically correct principles," it should be constructed to conform to human anatomy (Fig 3A, B). As Fine described it, "My improved articulator comprises upper and lower members forming *exact replicas* of the temporo-maxillary bones, the interengaging surfaces of which are in exact conformity with the average shape of a man's cranium and said members are associated

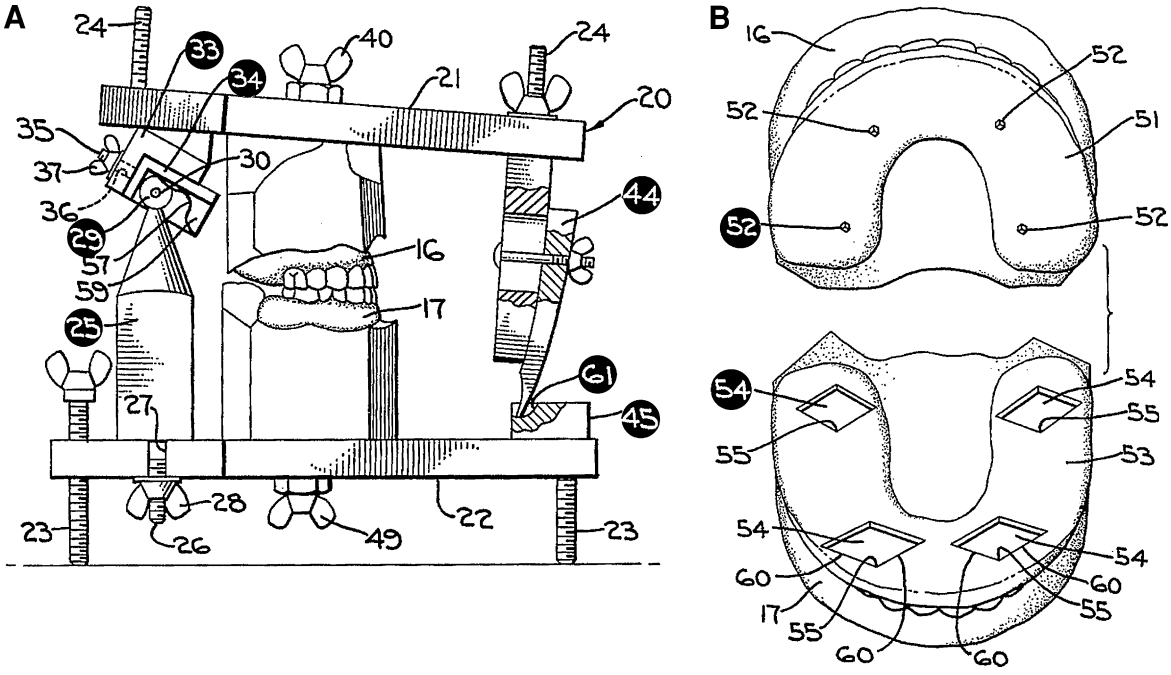

Figure 4. (*A*) The TMJ Articulator, 1965, from Swanson's first articulator patent. This model was improved dramatically in the second model. (25) Condyle post; (29) condyle head; (34) three-sided open box; (44) incisal pin; (45) incisal guide table; (61) functionally contoured pocket. (Reprinted from the 1965 US Patent.)[6] (*B*) Swanson's functionally generated path ("chew-in") method included in the patent of his first model. Similar to the Needles-House "Chew-in" method, four triangular studs (52) were placed in the maxillary base plate to generate the functional pathways (54) in the mandibular base plate. (Reprinted from the 1965 US Patent.)[6]

with bodies engaged between the upper member and the parts of the lower member corresponding to the condyles, said bodies corresponding to the complete menisci of the temporo-maxillary jointing. These menisci have a volume corresponding to the actual cranial menisci and their presence provides for relative movements between the two members of the articulators that are exactly similar to the natural physiological relative movements between the upper and lower portions of the skull."[5] The menisci were fashioned of acrylic resin and Fine hinted that they may have had a flexible component to them for "scribing" purposes. The "bony anatomical" structures were cast in brass or bronze. In order to further maintain the anatomical components in their correct physiologic positions, Fine used two pairs of rubber bands to correspond to the masseter and external pterygoid muscles.

Unfortunately, Fine did not discuss the other components of this device and their functions in any detail. The incisal pin and guide, for example, was referred to only as the "front stylus and box" while the posterior hinge joint mechanism was described as a "rear clamping screw allowing. . .a gradual adjustable opening of the jaws."[5] Similarly, he described the various reference points, but not the process with which they were used. And in regard to his scribing method, his only reference was to "plaster tracings." Fine's inverted incisal pin and guide assembly deserves further mention because his articulator is the first to be patented with this feature. He must have stumbled upon something of merit because several contemporary articulators, such as the Kavo EWL* and the SAM** provide this option.

The articulator was not constructed as one with a moveable lower member; that is, permitting the lower member to be manipulated while the articulator remains on the bench top. Nevertheless, Fine suggested that as far as the "opening movement of the main lower member is concerned, the operator should exert a stress to open the articulator through a lowering of the lower member in which case the two members act as levers and transmit said stress to the menisci."[5]

Fine did indeed devise an articulator, the major components of which resembled human

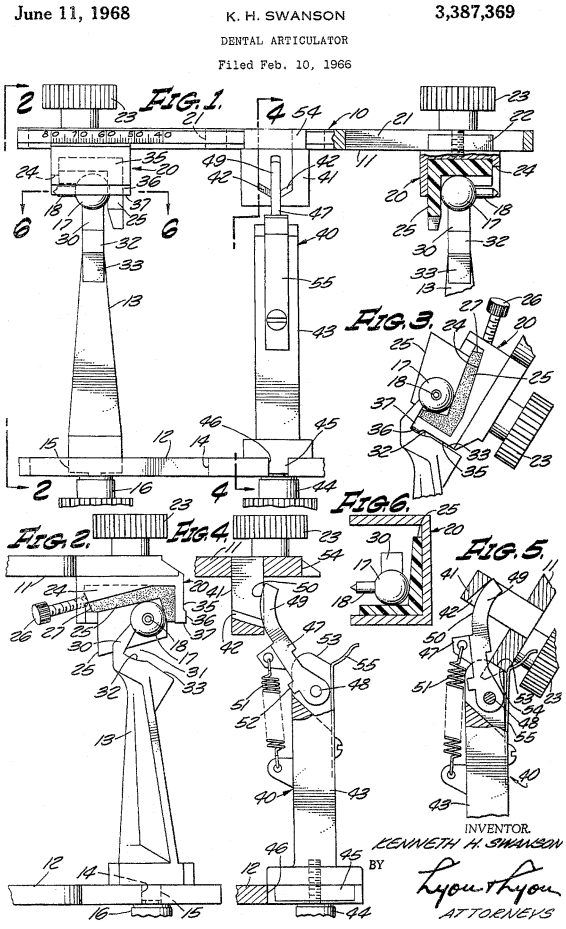

Figure 5. The TMJ Articulator, 1968. Swanson's second articulator patent embodied structural improvements, many of which were retained in subsequent models. (Reprinted from the 1968 US Patent.)[7]

anatomical structures. Furthermore, he painted a detailed picture of how he believed the "anatomic" components of his articulator would imitate exactly the function of the corresponding structures in the human skull. Unfortunately for Fine, he apparently was not aware that function is rarely best achieved when a mechanical equivalent is designed to imitate nature. Perhaps he never even noticed that airplanes do not have feathers or flap their wings. So, as fascinating as Fine's device may be, it has been duly filed under "Curiosities" in the historical archives of dental articulators.

The TMJ Articulator

On September 21, 1965, Kenneth H. Swanson, of Glendale, California, received the first of three patents,[6] the culmination being the development of an articulator that would be the first to define a "scribing" articulator as a "fully adjustable" (or, as some may prefer, "highly adjustable") articulator.[7,8] Even though Swanson received the patents, the development of the TMJ Articulator and the methods for its use was due to the collaborative efforts of Swanson and Harvey H. Wipf, of Solvang, California, who worked together for well over a decade.[9,10]

The first model of the TMJ Articulator itself, designed with familiar contemporary features, (Fig 4A) actually embodied several departures for a "scribing" articulator. Significant among these were provisions for the "arcon" feature (29, 34), adjustable condylar posts, and an adjustable curved incisal guide pin that was concentric with the arc of closure (44).

Furthermore, Swanson advocated the use of a facebow, a feature that previous inventors suggested was unnecessary with this type of articulator. The "centric" or "hinge axis" position of the condyles was verified by palpation, and the position of the maxillary cast was determined with a conventional facebow with an infraorbital pointer-type rod to establish a third point of reference.

The three functional controls of the articulator were the two posterior condylar elements and the anterior incisal guide. The two posterior controls consist of spherical condyle heads (29) on the condyle posts (25) of the lower frame, and on the upper frame, "angle guides" (33) are positioned at an angle "that approximates the minimum angle between a horizontal plane and the plane of the human socket and ball joint." Three-sided open boxes (34) are mounted in the "angle guide" to accept a moldable material [wax] for generating the functional mandibular pathways. Stone dies were then made of the pathways and were replicated in acrylic resin. The incisal guide table (45) had a "guide socket" in which "a contoured socket (61) may be formed. . .to give the desired mouth opening and bite characteristics."[6]

The 4-stud functionally generated path ("chew-in") procedure (Fig 4B) Swanson advocated was essentially developed by Milus M. House in the mid-1920s. Reportedly, House's was an improvement over John Needles' 3-stud system.[11] Similarities of Swanson's method to the adopted Needles-House "chew-in" procedure included constructing baseplates to fit the maxillary and mandibular teeth or alveolar ridges and placing four triangular studs

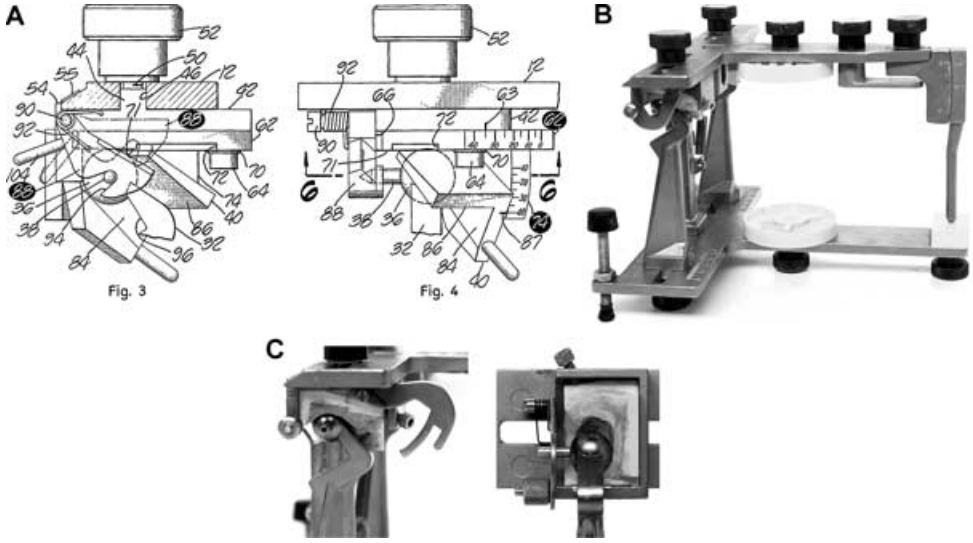

Figure 6. (*A*) The TMJ Articulator, 1975. Swanson's third patent featured the addition of the right and left centric latches and optional mechanical condylar guide controls. (Reprinted from the 1975 US Patent.)[8] (*B*) The third model of the TMJ articulator, lateral view. (*C*) The third model of the TMJ articulator. Detail views of the condylar controls with a patient's condylar pathways reproduced in methyl methacrylate.

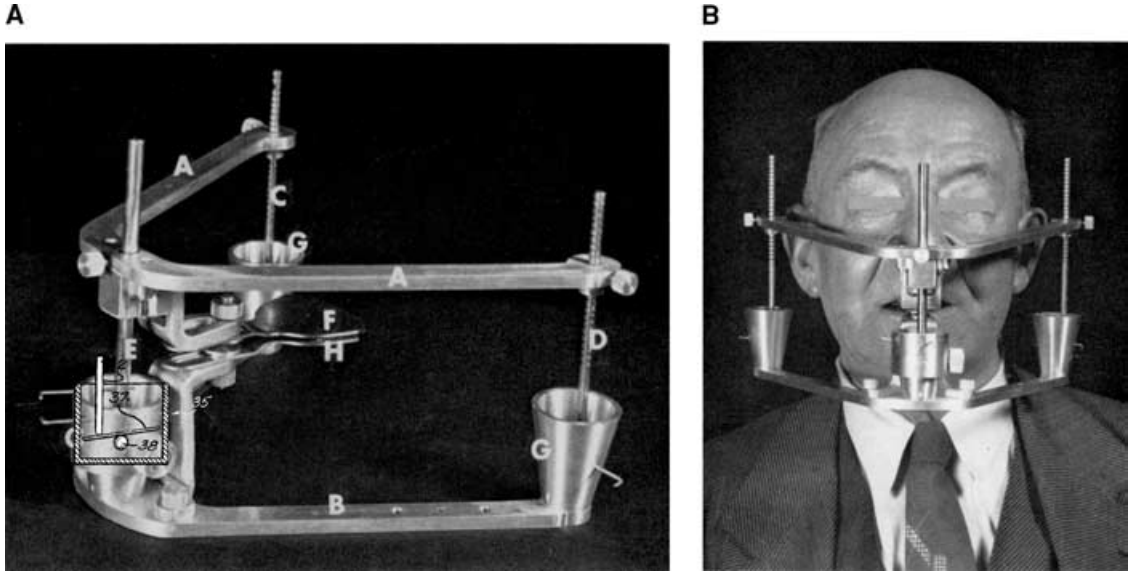

Figure 7. (*A*) The "Dupli-Functional" Articulator: the recording apparatus. This shows the upper (*B*) and lower (*C*) recording assemblies with the bearing plates (*F,H*) attached. The vertical recording rods (*C–E*) are in the central position of the three lower receptacle cups (*G*). (Reprinted from *Journal of Prosthetic Dentistry*, Irish EF, Dupli-Functional Articulator, p. 643, Copyright (1965), with permission from the Editorial Council of the *Journal of Prosthetic Dentistry*.)[15] (*A*) (Overlay). The anterior receptacle cup (35) and recording rod (2) serve as the incisal pin and guide assembly because of the function of the adjustable plane guide (37) on bar (38). (Reprinted from the 1969 US Patent.)[14] (*B*) The functional recorder assemblies are attached to occlusion rims in the patient's mouth in preparation for making the three-dimensional mandibular registrations. (Reprinted from *Journal of Prosthetic Dentistry*, Irish EF, Dupli-Functional Articulator, p. 644, Copyright (1965), with permission from the Editorial Council of the *Journal of Prosthetic Dentistry*.)[15]

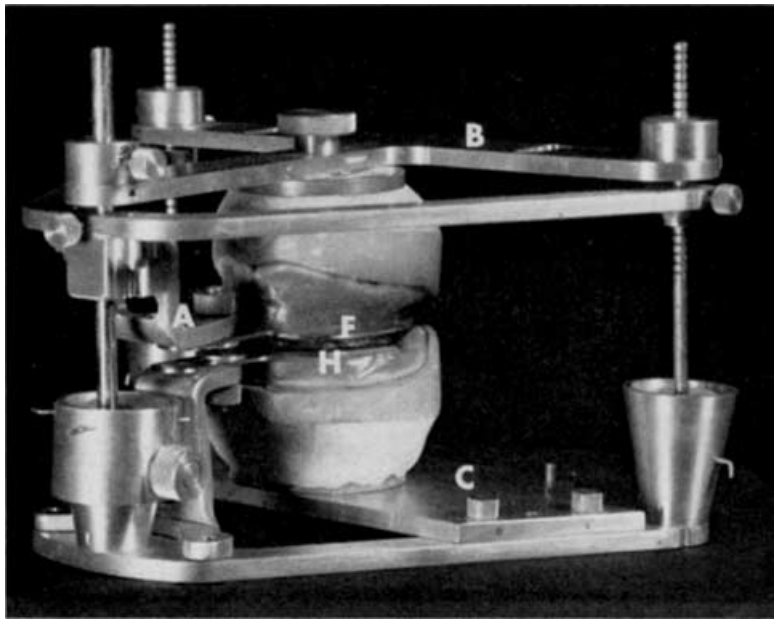

Figure 8. The "Dupli-Functional" Articulator: conversion to the tripod-type articulator because the casts have been mounted on the recording apparatus. The occlusion rims were attached to bearing plates F and H, the upper anterior extension (*A*) of which orients the occlusion rim and recording assembly. After the functional recordings were made, the casts were attached to the upper (*B*) and lower (*C*) mounting plates. (Reprinted from *Journal of Prosthetic Dentistry*, Irish EF, Dupli-Functional Articulator, p. 643, Copyright (1965), with permission from the Editorial Council of the *Journal of Prosthetic Dentistry*.)[15]

(52) in the maxillary baseplate for generating the mandibular functional pathways (54) in the mandibular occlusal surface. A departure from the Needles-House method was the suggestion by Swanson that ". . .if an impression compound has been used in the surface of [the mandibular plate], a hard plastic reproduction is made of this plate."[6]

On June 11, 1968, Swanson, then of Thousand Oaks, California, received a patent[7] related to structural improvements to his articulator (Fig 5); specifically to the condylar posts and the addition of a centric guide and spring tension assembly post (Patent Figs 1 and 2) mounted on the lower frame between the condylar posts (Patent Figs 1 and 4). These changes were made to the existing articulator to permit free hinge movement and full support of the upper frame in the open position without detachment of the upper and lower frames (Patent Fig 3). The nondetachable feature (Patent Fig 5) was designed to "not adversely affect or interfere with the normal manipulation of the dental articulator for simulating the jaw movements."[7]

In about 1968–1970, this improved model of the TMJ Articulator was introduced to the profession. This articulator essentially embodied all the features of the final version except the right and left centric locking hooks had not yet been added. In addition to the improvements to the posterior structures of the articulator as indicated in the second patent letter, improvements were made to the upper and lower frames as well as to the incisal pin and guide assemblies. Accessories included a facebow, hinge axis locator, and an occlusal plane analyzer system consisting of an analyzing "flag" and use of the Hanau mechanical incisal table with the Schuyler pin. Plastic fossa boxes of 15° and 45° were also available.[12]

In September 1975, Swanson received a patent[8] for a third model of the TMJ Articulator (Fig 6A). This model was essentially the same as the previous one, except that the right and left centric locking hooks were included (Patent Fig 3, No. 88). More significantly, however, this patent included mechanical condylar controls. The fundamental

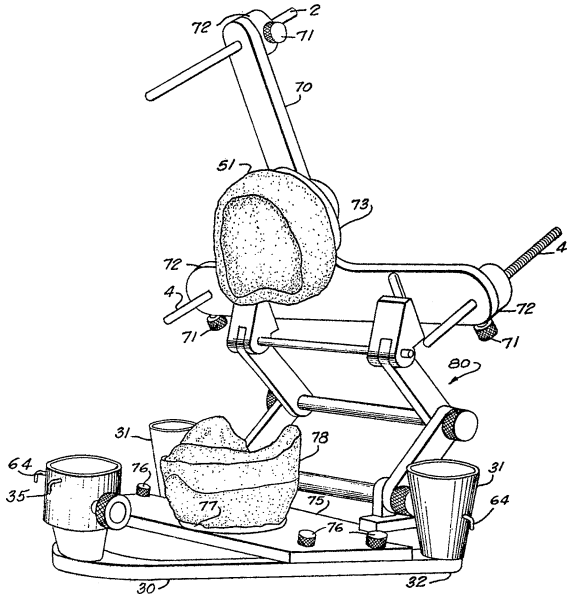

Figure 9. The "Dupli-Functional" Articulator, showing the optional removable hinge. This device was used for convenience for initially setting the denture teeth. (Reprinted from the1969 US Patent.)[14]

design of these controls included adjustable Bennett (62) and protrusive angles (74) (Patent Fig 4). It is assumed that these mechanical fossae were intended as an added accessory.[13] In addition, plastic preformed fossae of 28°, 35°, 40°, 45°, and 50° were offered.[9]; Figure 6B is a photograph of the third model with functional condylar controls and right and left locking hooks. Figure 6C shows details of the condylar controls with a patient's functional condylar pathways reproduced in methyl methacrylate.

The "Dupli-Functional" Articulator

On January 20, 1969, Edwin F. Irish, of Richmond, Virginia, received a patent for the "Dupli-functional" Articulator.[14] It was about $3\frac{1}{2}$ years earlier, however, that Irish had introduced his invention to the profession in an article published in the July 1965 issue of the *Journal of Prosthetic Dentistry*.[15] In this article, Irish characterized his instrument as an extraoral tracing device that records three-dimensional mandibular movements and without requiring the transfer of records, is converted into a "tripod-type of dental articulator upon which dentures may be constructed and their occlusion balanced."[15]

The recording apparatus (Fig 7A) was composed of two semicircular framework assemblies. The upper assembly (A) ran approximately from one condylar region around the face to the other condylar region. Passing through the upper assembly were three vertically adjustable rods, one each through the right terminal (C) and left terminal (D) positions, and one through the anterior position at the midline (E). Three corresponding "receptacle cups" (G) were located on the lower assembly to hold an auto-polymerizing acrylic resin for recording the functional movements of the mandible (Fig 7B). The anterior cup [Fig 7A (Overlay)] functioned as an incisal guide control and accordingly, contained an adjustable plane guide (37) on bar (38) that was variable from 0° to ± 25° for rod (2). The plane guide was arbitrarily adjusted to be compatible with the desired anterior vertical overlap when posterior teeth with cusps were used. This was accomplished either before or during the functional registration of mandibular movements. Corrected occlusion rims*** were then attached to the bearing plates of the upper and lower assemblies. When the casts were mounted in the articulator using mounting plates, the conversion to the "Tripod" articulator was complete (Fig 8).

The central bearing recording device devised by Irish is noteworthy. Irish explained that "Pascal's laws of hydraulics have been utilized, and the central bearing "point," with its unwanted concentration of forces has been broadened so that the bearing surface includes the areas overlying the ridges."[15] The bearing device was a cellophane "pillow" filled with water interposed between the two flat bearing plates. The fluid-filled "pillow" was pliable but not elastic. It was bonded to the upper bearing plate while the lower bearing plate was free to move against the under side.[15]

An optional simple hinge device (Fig 9) could be attached to the upper and lower assemblies to facilitate the early laboratory procedures of setting the denture teeth. It would then be removed for balancing the occlusion according to the patient's recorded functional controls.

There will be more on the history of articulators in a future issue of *The Journal of Prosthodontics*.

Notes

*Initially, the patient's vertical dimension of occlusion and a tentative centric relation were

established using wax interocclusal records and mounting the casts on a planeline articulator. The relationship of the occlusion rims was then transferred to the bearing plates of the recording assembly.

**KaVo Elektrotechnisches, Wangener Strasse 78, D-88299 Leutkirch im Allgau, Bundesrepublik Deutschland.

***Great Lakes Orthodontics, Ltd., 199 Fire Tower Dr., Tonawanda, NY 14150.

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