The History and Development of the Dental Surveyor: Part I

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The dental surveyor is an indispensable instrument capable of performing a number of prosthodontic procedures. Surprisingly, the technique of surveying casts as part of the treatment planning procedure did not emerge until early in the twentieth century. This article reviews the origins and early use of the dental surveyor. It includes features common to all surveyors as well as the principal uses of these instruments.

INDEX WORDS: surveyor, dental surveyor, paralleling instrument, clasp surveying instrument

A DENTAL SURVEYOR is defined as "a paralleling instrument used in the construction of a prosthesis to locate and delineate the contours and relative positions of abutment teeth and associated structures."[1] In 1953, Dr. A. H. Schmidt described surveying as follows: "Reduced to its simplest terms, surveying a tooth is a mechanical method of obtaining its height of contour accurately. . .. If a vertical plane is brought into contact with a curved surface, it will touch at the greatest bulge on the convexity and nowhere else."[2]

In the early dental literature, removable partial dentures were usually described as restorations that had been assembled by soldering clasps to a swaged, gold baseplate.[3] Clasps were fabricated by carefully shaping strips of gold alloy to conform to the axial contours of the abutment teeth. The vertical heights of the clasps were as great as the clinical crowns of the abutments would allow. Consequently, the clasps were often referred to as "bands."

Precious metal alloy formulas had been established for such clasp fabrication. These alloys were readily adaptable to abutment teeth by means of special contouring pliers. In his 1860 textbook, Dr. J. Richardson[3] stated that, "Metallic bands have

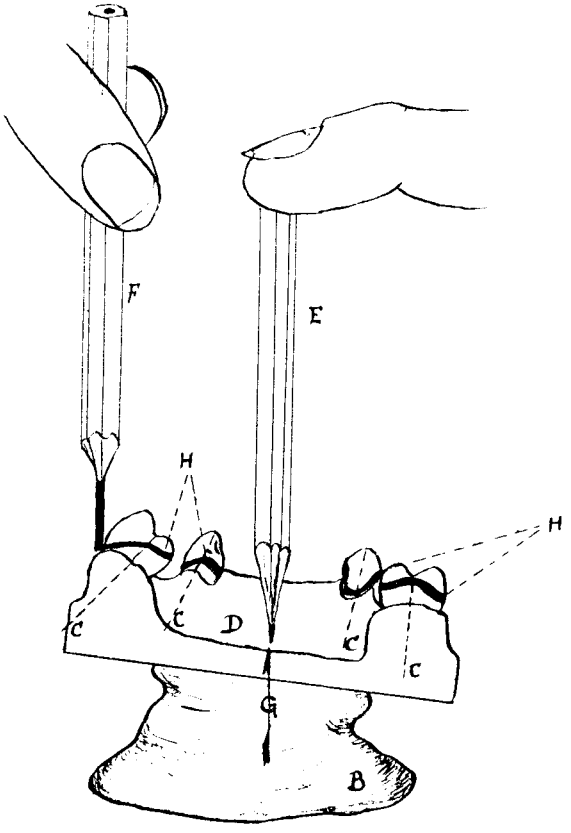

Figure 1. This illustration from Nichol's text shows Dr. W. M. Randall's technique for surveying a cast before the advent of the dental surveyor (circa 1890). The cast was stabilized on the table top with wax or impression compound after the path of placement had been determined. In principle, this technique was very similar to that used with a dental surveyor. Its accuracy, however, was completely dependent on the operator's ability to keep the pencils parallel and steady. (Reprinted with permission.[4])

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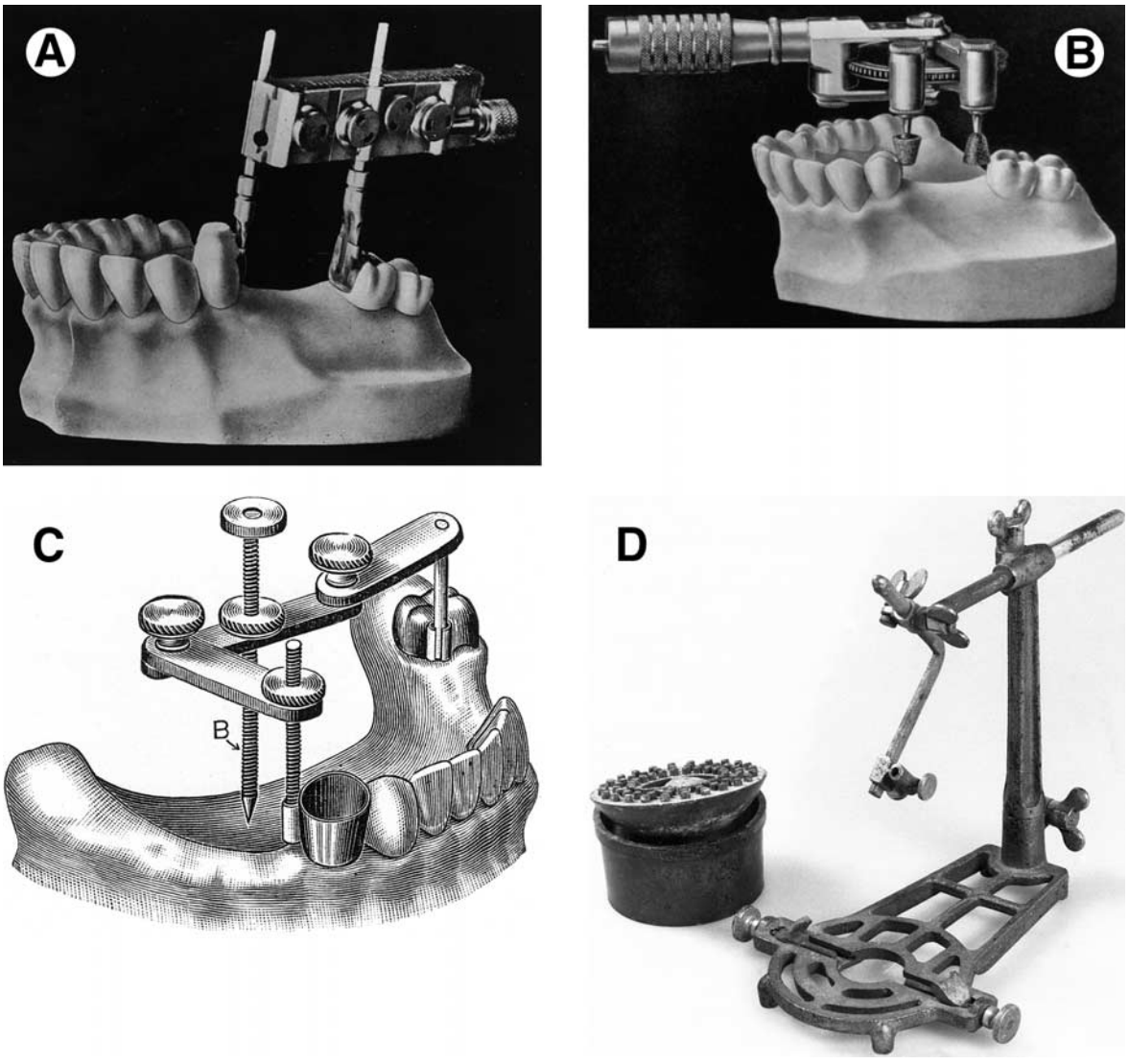


Figure 2. (*A*) The Chayes Parallelometer (circa 1920) was not a surveying instrument. It was intended to ensure the parallelism of the Chayes precision attachment system. (Reprinted from Chayes.[6]) (*B*) The Chayes Parallelometer System included a handpiece that could prepare 2 surfaces simultaneously. (Reprinted from Chayes.[6]) (*C*) This paralleling device was used with Dr. A. S. Condit's system for anchoring removable partial dentures by means of tube attachments. This device as well as that shown in Fig 2*D* date from the late 19th century. (Reprinted from Warren.[7]) (*D*) This paralleling device was the soldering jig for the Griswold attachment system. An unknown individual later converted it into a dental surveyor by adding the ingenious adjustable cast holder. The stage could be tilted in any direction then fixed to the base with modeling clay. (Instrument from the collection of Dr. Mark Connelly.)

been long and very generally employed as a means of retaining sets of teeth in the mouth." Dentists of the period recognized that undercuts were necessary for clasps to be effective. They also realized that these wide bands were plaque traps and that, even under the best circumstances, clasped teeth were subject to mechanical injury. Richardson wrote, "no other process in mechanical dentistry as that (of clasps) has been so fruitful of malpractice." As a result, empirical rules for clasp placement were developed by the mid-19th century. These rules included:

- Loose or decayed teeth were never to be clasped.
- Short and malposed teeth were never to be clasped.

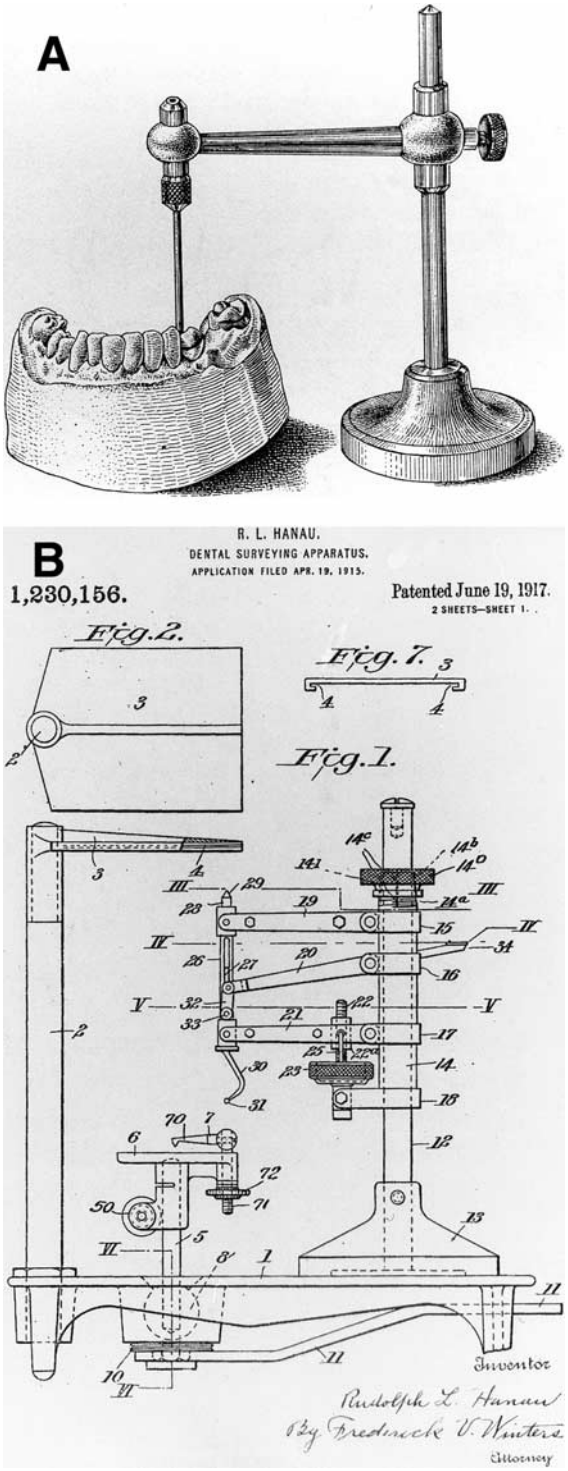


Figure 3. (*A*) The Robinson surveyor (circa 1918) developed by the Philadelphia Dental Clinic Club is perhaps the first surveyor designed for cast surveying as part of the clasp design procedure. (Reprinted from Cummer.[11]) (*B*) Illustrated is Hanau's 1917 design for a "dental surveying apparatus." This device was intended for orthodontic research and not for mapping the "heights of contour of the teeth." There is no evidence that the "Stanton-Hanau" surveyor was ever commercially available. (Reprinted from US Patent No. 1, 230, 156.[15])

- Because of esthetic considerations, incisors were rarely, if ever, clasped.

Before the invention of the dental surveyor, dentists evaluated axial contours and undercuts of teeth by visual survey of dental casts.[4] This was accomplished by holding a cast at arms length while viewing it with one eye closed. Then, using the other hand to hold a sharp pencil perpendicular to the occlusal plane, the practitioner would pass a pencil lead over the axial surfaces of the teeth to develop a survey line at the greatest diameter of each tooth (Fig 1).

Early Paralleling Instruments

Paralleling devices were in use long before the development of the dental surveyor. Their purpose was to assure the proper alignment of precision attachments. None of these, however, was used to survey casts as a basis for removable partial denture design. During the first 3 decades of the 20th century, Dr. Herman E. S. Chayes, an early pioneer in both fixed and removable prosthodontics, wrote extensively about precision attachments.[5,6] As a result, he is generally credited with first recognizing and describing the importance of parallelism in the fabrication of passive fixed and removable partial denture restorations.

Around 1920, Dr. Chayes developed the Parallelometer (Figs 2*A* and *B*).[6] This instrument could be used both intraorally and at the laboratory bench to ensure parallelism of precision attachments. The instrument also could be used to identify non-parallel and/or undercut surfaces of prepared teeth. The instrument consisted of 2 mandrels that remained parallel no matter how far apart they were placed. The mandrels were designed to hold the matrix (female) components of the Chayes' attachments during tooth preparation and restoration wax-up. Chayes' dissertations on parallelism led the profession to recognize that the major shortcoming of existing removable partial denture function could be traced to faulty clasp design.[6,7] Furthermore, it became apparent that these difficulties could be overcome by employing Chayes' principle of parallelism and his newly developed techniques for casting clasps as integral components of removable partial denture frameworks. These advances made it possible to place clasp arms at precise locations, while minimizing

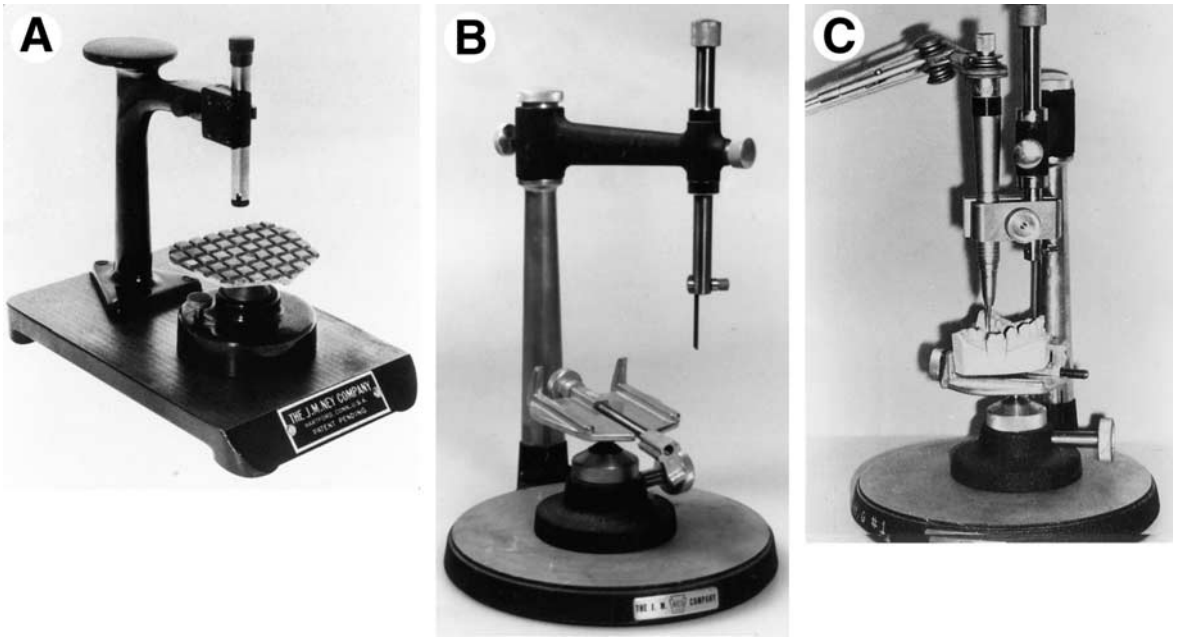


Figure 4. (*A*) The original Ney surveyor was introduced in 1923. It featured a convenient palm rest on the top of the vertical arm. Designed by Weinstein and Roth, it was the first surveyor to be commercially available to the profession. (Reprinted with permission.[14]) (*B*) The current model of the Ney surveyor was introduced in 1937. In principle, it is identical to its predecessor. In the mid-1950s, Ney offered the Ney Clasp Surveyor Junior Model. Although identical to the Ney Surveyor of that time, it was smaller and fabricated entirely from clear Plexiglas. (Reprinted with permission.[14]) (*C*) This instrument can be converted into a milling machine by clamping a straight handpiece to the surveying arm. Ney offers 2 types of clamps for this purpose. The Ney Surveyor was modified by The Dental Service at Lackland Air Force Base, Texas, by replacing the instrument storage compartment on the top of the vertical arm with a ball bearing, allowing the horizontal arm to rotate 360° horizontally. This mid-1960s modification facilitated surveying and milling. (Reprinted from Stewart et al.[18])

tooth coverage.[5] Additional examples of this class of paralleling instruments are illustrated in Figs 2*C* and *D*.[7,8]

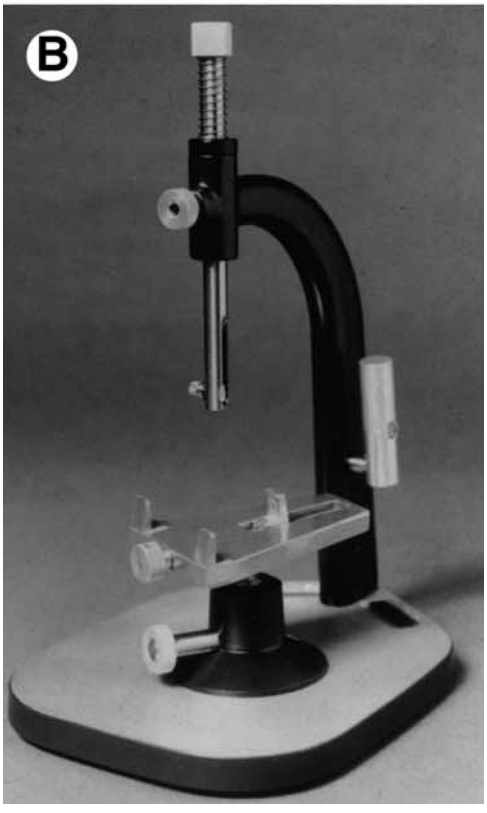
The First Dental Surveyor

According to Dr. Edward Kennedy, Dr. A. J. Fortunati was the first to demonstrate the advantages of using a mechanical device to map the contours of the abutment teeth.[4,9,10] At a 1918 clinic in Boston, Fortunati replaced the steel analyzing rod of a "Bridge Parallelometer" with a graphite rod, then accurately traced survey lines of the greatest convexities of the teeth. Dr. Kennedy was later credited with coining the term "height of contour" to refer to these lines.[4]

W. E. Cummer[11] reported that the technique of surveying casts was developed over a period of "some years" by the Philadelphia Dental Clinic Club. He further stated that the Philadelphia Dental Clinic Club, Dr. A. J. Fortunati, and others simultaneously and independently developed the concept of cast surveying. The Philadelphia Dental Clinic Club originally developed the Robinson Surveyor (Fig 3*A*). This instrument was probably the first surveyor designed as an instrument for removable partial denture planning.

J. R. Schwartz[12] credited Weinstein for pioneering "case and clasp surveying" and first developing an apparatus to accomplish the task. Schwartz cited Noble G. Wills as another early pioneer of removable partial denture design. Schwartz points out that Wills' lectures and writings applied engineering principles to removable partial denture design.

O. C. Applegate[13] credited Fortunati with "pointing out" in 1918 that a mechanical device could be used to chart correct clasp outlines and for suggesting that a "bridge parallelometer" could be used for this purpose. Both Applegate and Cummer



credited Weinstein and Roth for actually developing the first commercially available dental surveyor in 1923 (Fig 4*A*).[9-11,13,14]

A review of US Patent documents indicates that at least one patent for a dental surveyor was issued before 1918. This was the Stanton-Hanau Dental Surveying apparatus, patented in 1917.[15-17] This was an orthodontic instrument, and Rudolph Hanau's first dental patent. Its commercial failure led Hanau to drop his orthodontic research by 1920 and focus his efforts on articulator development (Fig 3*B*).

The Basic Dental Surveyor

Although they may vary significantly in design, all basic dental surveyors have certain features in common.[18] These include:

1. A level platform, parallel to the bench top.
2. A cast holder, which supports the cast to be analyzed and is free to move across the platform. It includes a clamp to hold the cast firmly in place and a ball-and-socket joint between the table and base.
3. A vertical arm that supports the suprastructure of the surveyor.
4. A horizontal arm that usually is parallel to the horizontal platform, and perpendicular to the vertical and surveying arms, which it connects.
5. A surveying arm that drops vertically from the horizontal arm and that is capable of vertical movement. Its lower end has a mandrel capable of holding surveying tools.
6. Interchangeable surveying tools including an analyzing rod, carbon marker, undercut gauges, and blockout tools.

The surveyors marketed by Ney Dental International (Bloomfield, CT) and J. F. Jelenko and Company (Armonk, NY) dominated the market during the 20th century (Figs 4 and 5).[5,14,18,19] By mid-20th century, many versions of the dental surveyor had been developed. In their 1950 text, McCall and

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Figure 5. (*A*) Developed by Noble G. Wills, this instrument was known as the Wills surveyor (circa 1937). It was the original surveyor marketed by the J. F. Jelenko Company and was preferred by many operators because of the spring-loaded surveying arm. (Reprinted from McCall et al.[5]) (*B*) Though no longer in production, the most recent design for the Jelenko surveyor still retained the spring-loaded surveying arm. (Reprinted with permission.[19])

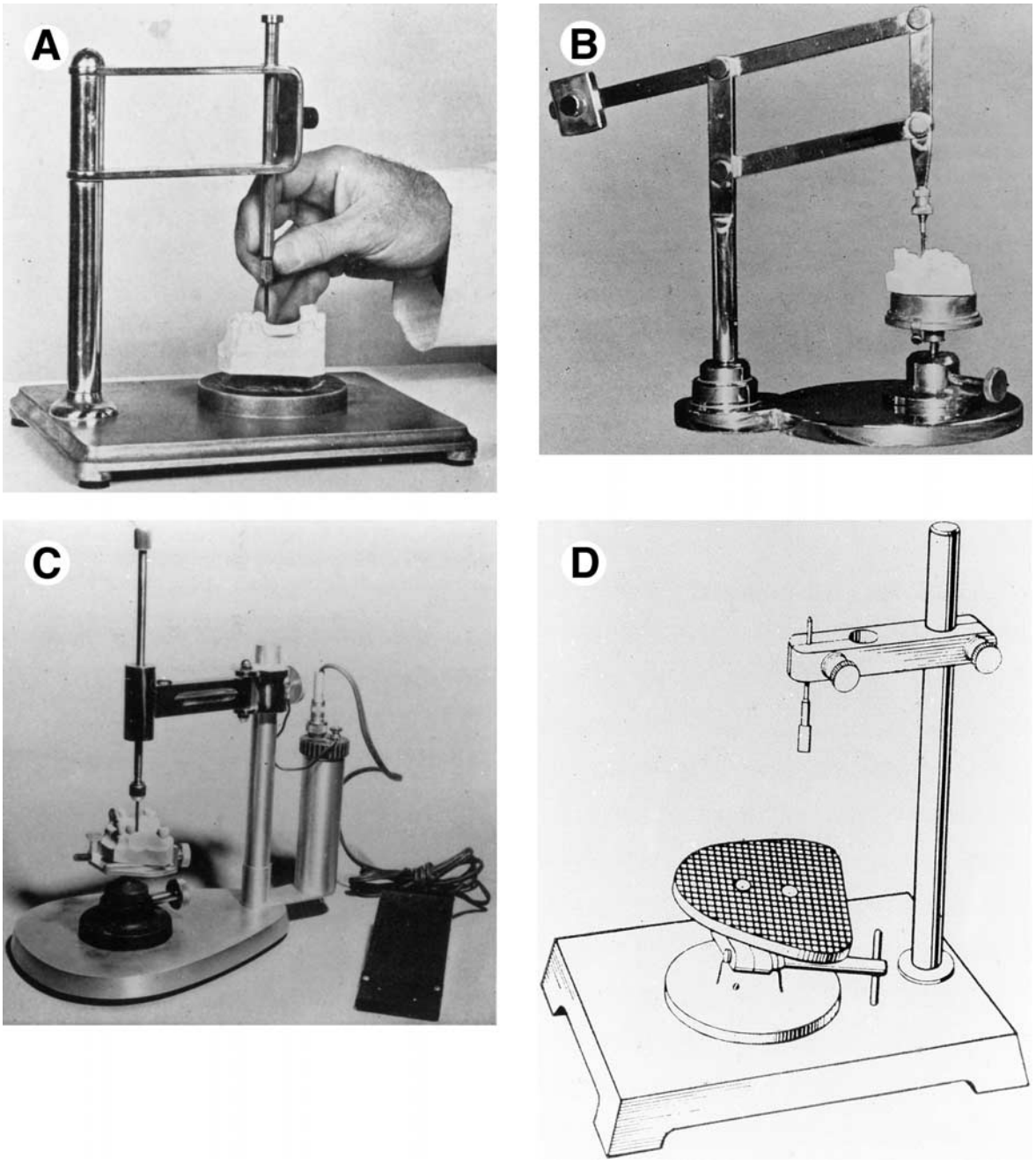
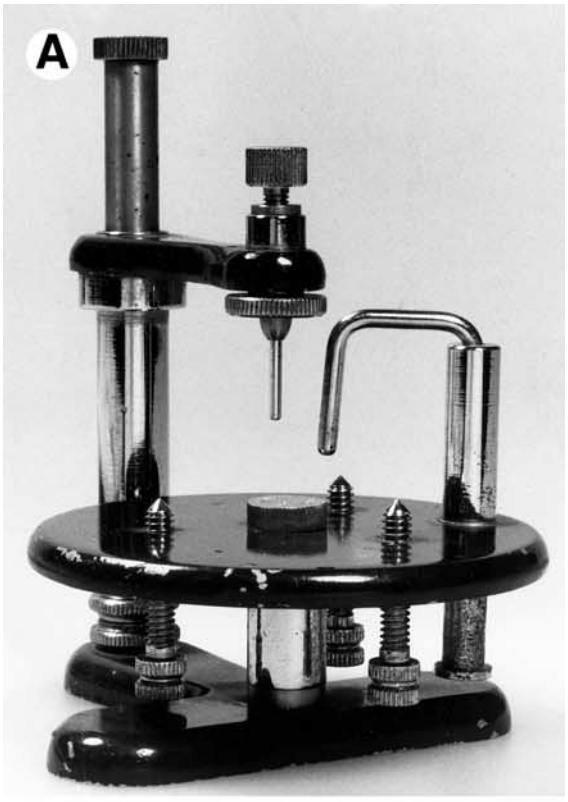
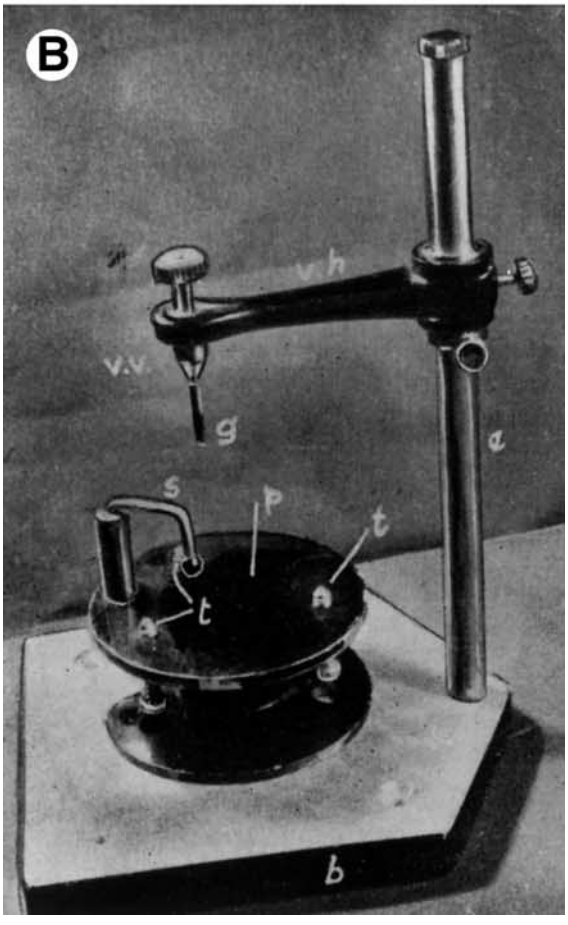


Figure 6. (*A*) The Original Wills surveyor (circa 1929) appears in a number of texts. It was marketed by Kerr Products of Detroit, MI. It came both with and without a work light and has been pictured with several different designs of cast holders. In this example, the cast is held in place with wax. (Reprinted with permission.[22]) (*B*) The Kings College surveyor (circa 1940) had an adjustable cast holder and interesting parallel, pivoting, horizontal arms. It also featured a powerful magnet in the tilting table. The cast had an iron ring imbedded in its base, so there was no need for a fixing agent. (Reprinted from Fenn.[23]) (*C*) This electronic surveyor, developed at the United States Air Force School of Aviation Medicine at Randolph Air Force Base, TX (circa 1958), was powered by dry cell batteries and was capable of passing a weak current through the surveying tool to the cast surface. Casts were treated with phenolphthalein, and contact with the surveying tool produced a fine, red survey line. (Reprinted with permission.[24]) (*D*) The Columbia Parallelor (circa 1940) was very similar to the Ney surveyor. This company was bought out by another manufacturer who produced the Brown-Maier Parallel-meter, which had 2 operating arms on a swivel joint. (Reprinted from McCall et al.[5])





Hugel[5] reported that 11 dental surveyors had been featured in scientific exhibits at the American Dental Association's 1948 Annual Meeting. These were:

- Ney—1923 (Fig 4*A*)
- Brown-Maier—1925
- Wills—1929 (Fig 5*A*)
- Lentz—circa 1935
- Lineer—1937
- Ney—1937 (Fig 4*B*)
- Franzwa—1937
- Ringle-Hiatt-Smith—1944
- McKay—1944
- Hagman—1944
- Roach—1944 (Fig 7*A*)

Also commercially available in 1948, but not included in the exhibit, were the Torit, the Columbia Parallelor, and the Chayes Survey-O-Meter (which included a milling device).[5] Examples of basic dental surveyors produced during the 20th century are illustrated in Figs 6 and 7.[12,20-25]

Currently, the principal uses of the dental surveyor are as follows[26]:

1. To determine the most desirable paths of insertion and removal for removable partial dentures.
2. To identify proximal surfaces that must be prepared to serve as guiding planes.
3. To delineate the heights of contour for all of the teeth and to locate and measure retentive areas.
4. To locate both dental and osseous contours that could interfere with insertion and removal of a partial denture framework and to allow accurate charting of the necessary mouth preparation.
5. To record the cast position and its relation to the path of placement.

Figure 7. (*A*) The Roach surveyor, developed in 1944, was marketed by the Kerr Manufacturing Company. This may have been the smallest surveyor ever developed. The cast holder was fixed to the base, but the table could freely rotate through 360°. The horizontal arm was free to rotate 360° as well as to move vertically on the vertical arm. (From the author's collection.) (*B*) At least one South American text shows the "Dee" Surveyor that was actually the Roach Surveyor produced under the manufacturer's name (ie, the Dee Company was a subsidiary of Kerr Manufacturing Company). An interesting modification of the Roach surveyor (circa 1950) is that of Dr. A. D. Rebossio of Argentina. He removed the vertical and horizontal arms from the Roach/Dee Surveyor, leaving only the rotating table/cast holder. He then used this as a cast holder on a full sized, basic surveyor similar to the Ney or Columbia surveyors. (Reprinted from Rebossio.[25])

6. To transfer the partial denture design to the master cast in the laboratory.
7. To block out the master cast and to trim the blockout material.
8. To develop the axial contours of wax patterns.
9. To machine guiding planes.
10. To facilitate the placement of intracoronal retainers.

Discussion

The dental surveyor has proven to be an indispensable tool in prosthetic dentistry. In his text, Dr. R. G. Miller[20] stated emphatically that "it is practically impossible to establish survey lines correctly on three or more teeth without the use of a dental surveyor." Part II of this article will review the modifications that have been made to the basic dental surveying instrument to enhance its capabilities and facilitate its use.

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