United States Patent [19]

Balamuth et al.

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[54] **ULTRASONIC KITS AND MOTOR SYSTEMS**

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[73] Assignee: **Ultrasonic Systems, Inc.,** Farmingdale, N.Y.

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[21] Appl. No.: **544,134**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **3,809,977**
Issued: **May 7, 1974**
Appl. No.: **119,298**
Filed: **Feb. 26, 1971**

[52] **U.S. Cl.** ..... **318/116;** 32/58; 128/24 A; 206/223

[51] **Int. Cl.**[2] **H01V 7/00**

[58] **Field of Search** ..... 310/8.1, 26; 318/116, 118; 15/22; 32/56, 58, 28, DIG. 9; 128/24 A; 206/16 R, 16 S, 17, 172, 172 A; 228/1

[56] **References Cited**

UNITED STATES PATENTS

591,160	10/1897	Dow	128/172.1
2,846,874	8/1958	Horn	310/8.1 X
2,874,470	2/1959	Richards	128/24 A
2,917,691	12/1959	DePrisco et al.	318/118
3,176,167	3/1965	Vosseler	310/8.1
3,368,280	2/1968	Friedman et al.	310/26 X
3,375,583	4/1968	Blank et al.	310/26 X
3,427,480	2/1969	Robinson	310/8.1
3,432,691	3/1969	Shoh	318/118 X
3,447,051	5/1969	Attwood et al.	318/118 X
3,488,788	1/1970	Robinson	15/22
3,518,766	7/1970	Burt	310/8.1 X
3,539,888	11/1970	DePrisco et al.	310/8.1
3,544,866	12/1970	McLeroy	318/118
3,586,936	6/1971	McLeroy	310/8.1 X
3,689,781	9/1972	Kawada	310/8.1
3,703,037	11/1972	Robinson	32/DIG. 4 X

Primary Examiner—Donovan F. Duggan

[57] **ABSTRACT**

The invention discloses various embodiments of an ultrasonic kit adapted to be used in the home or for industrial purposes, as well as a variety of ultrasonic motor constructions and ultrasonic converter designs to be used either individually or in combination with each other. The ultrasonic motor is generally of a piezoelectric material having a removable tip or of a design in which the complete motor is contained in a housing, which housing has electrical contact means adapted to be plugged into an adapter which, in turn, is connected to a converter. The motor may be designed such that frequency sensing is provided therein and the feedback signal is utilized by the generator to adjust itself thereto.

34 Claims, 32 Drawing Figures

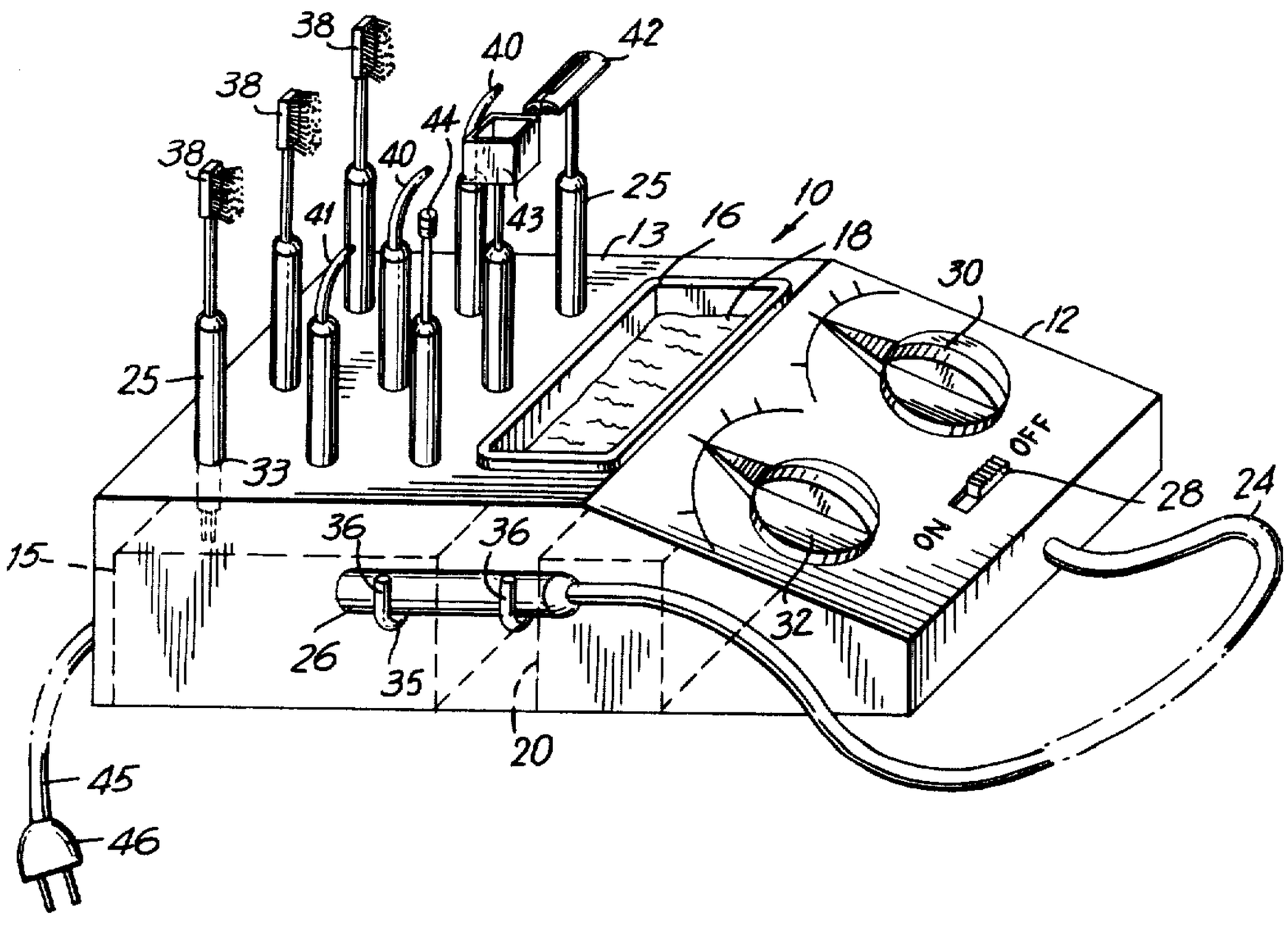


FIG. 1

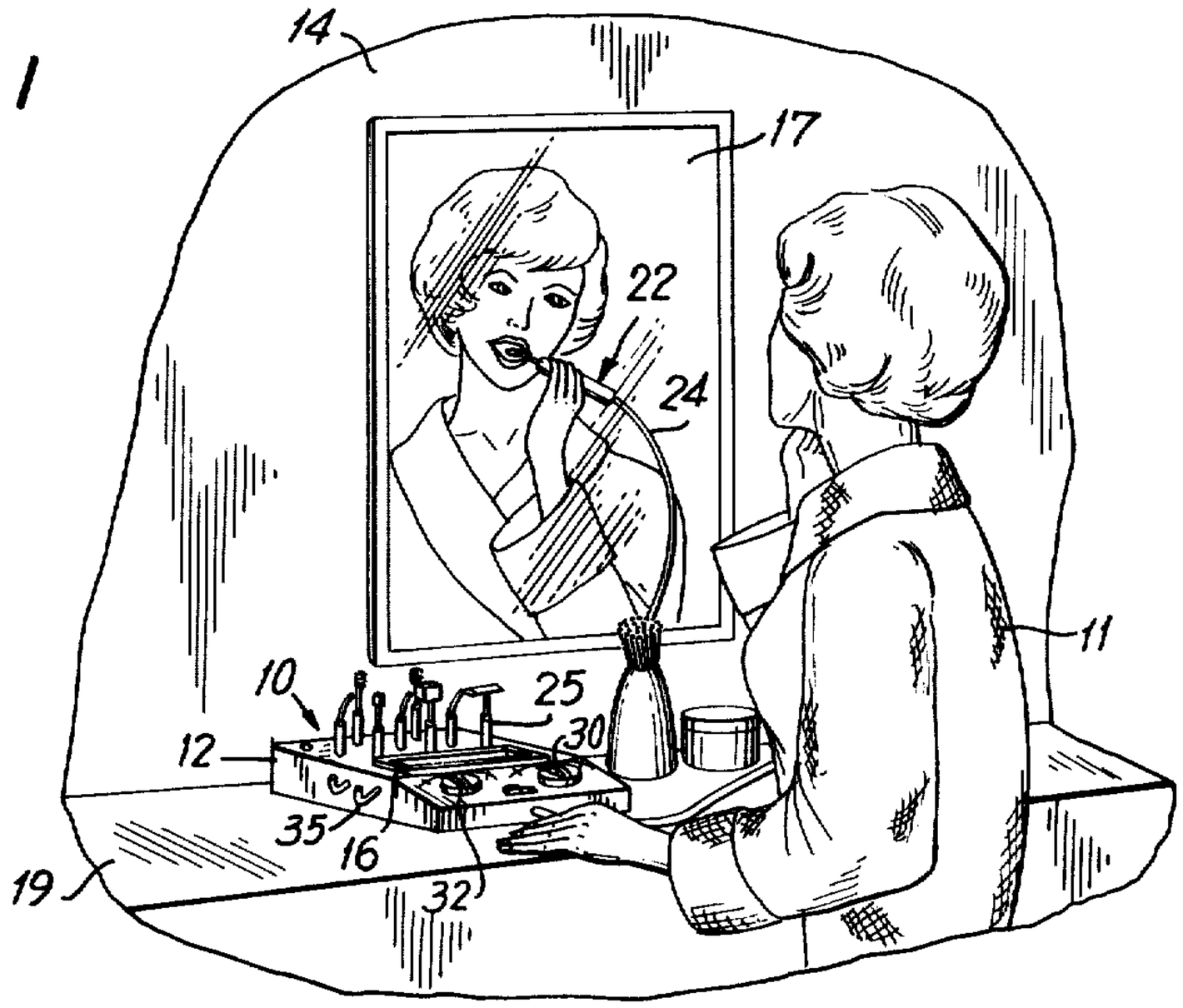
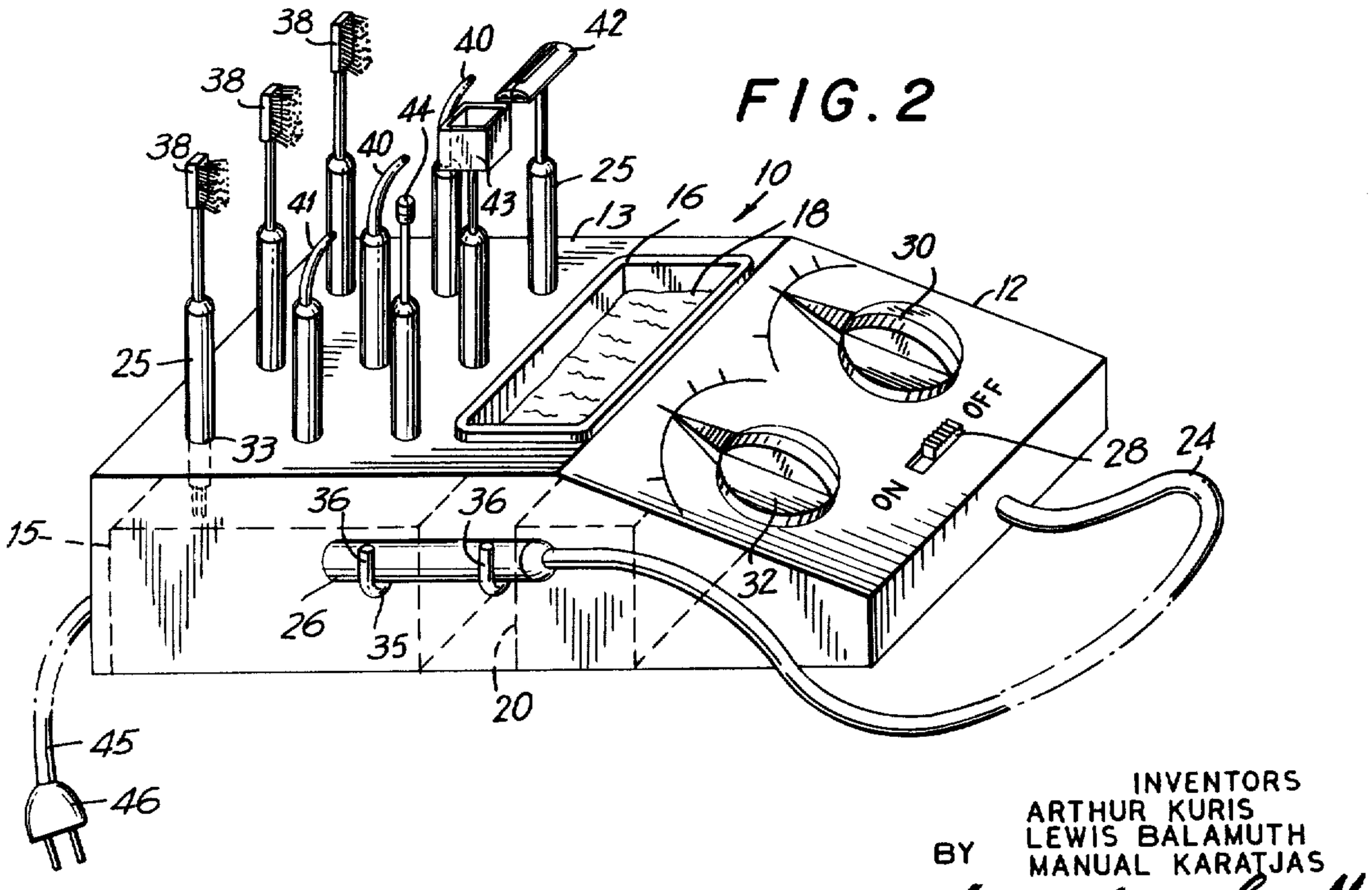


FIG. 2



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BY Leonard W. Senoff
ATTORNEY

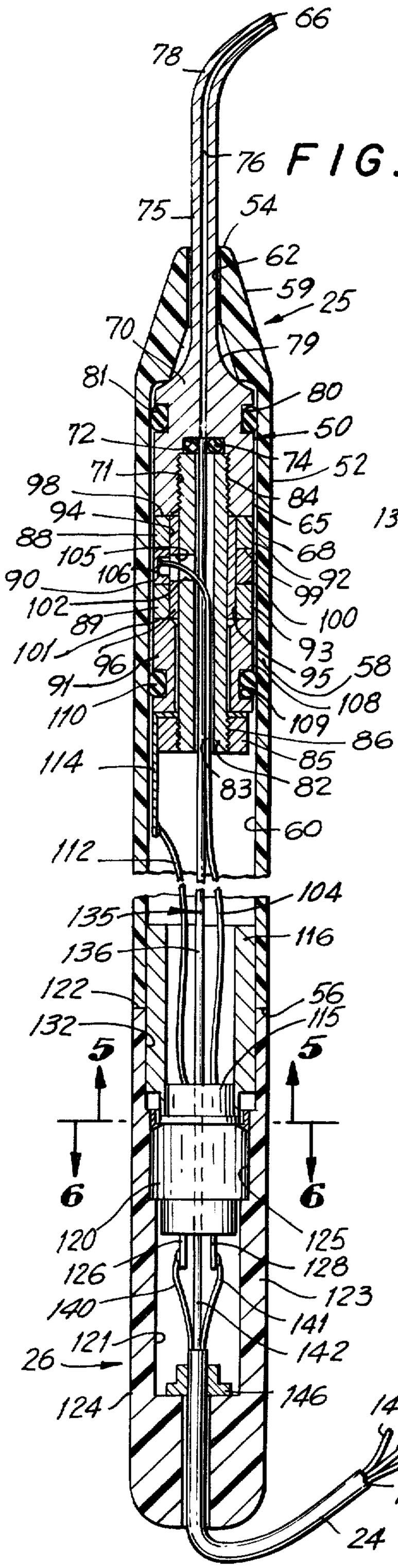


FIG. 4

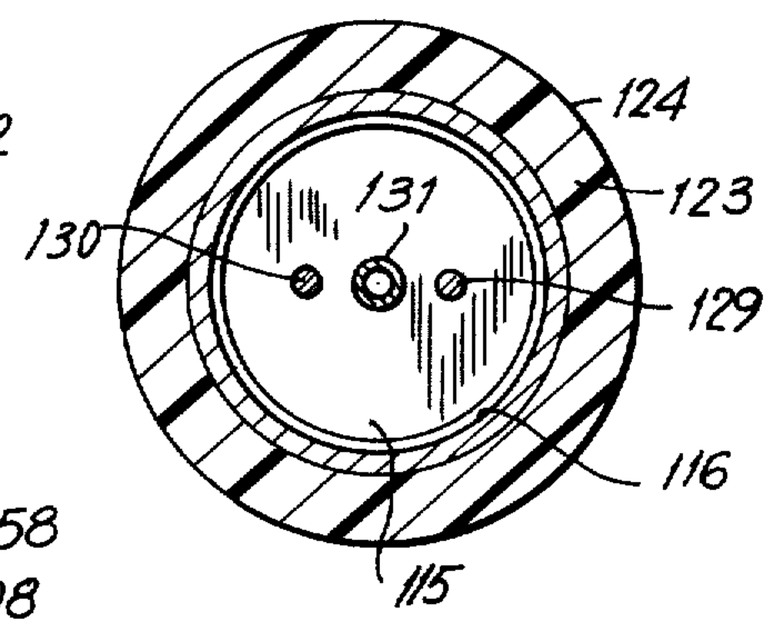
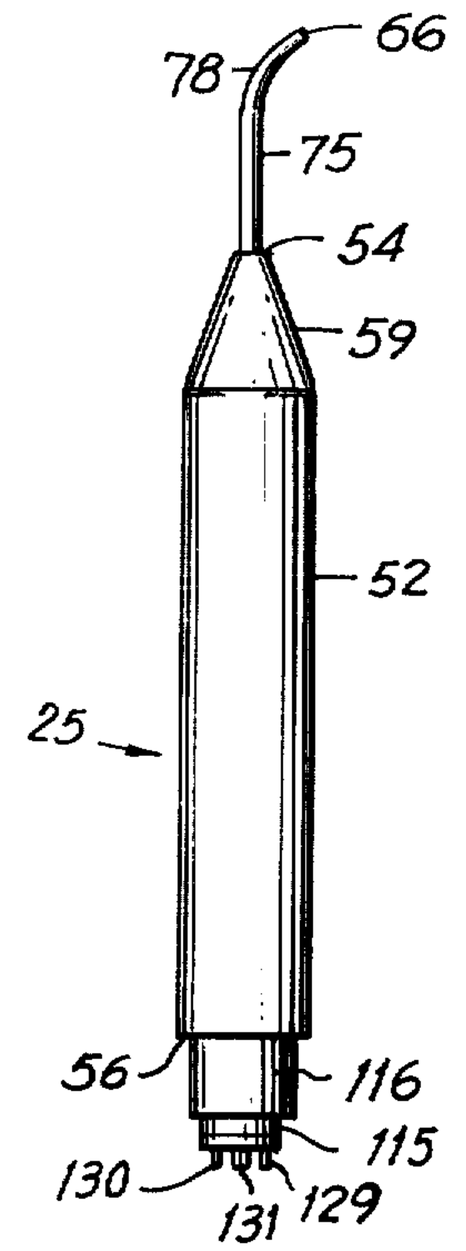


FIG. 5

FIG. 6

FIG. 3



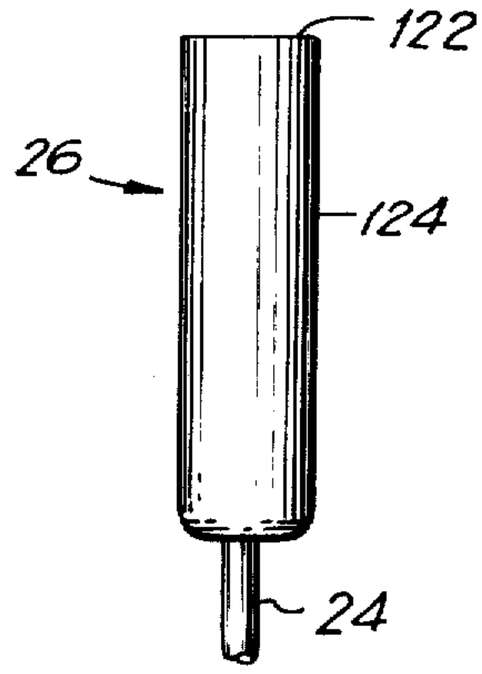
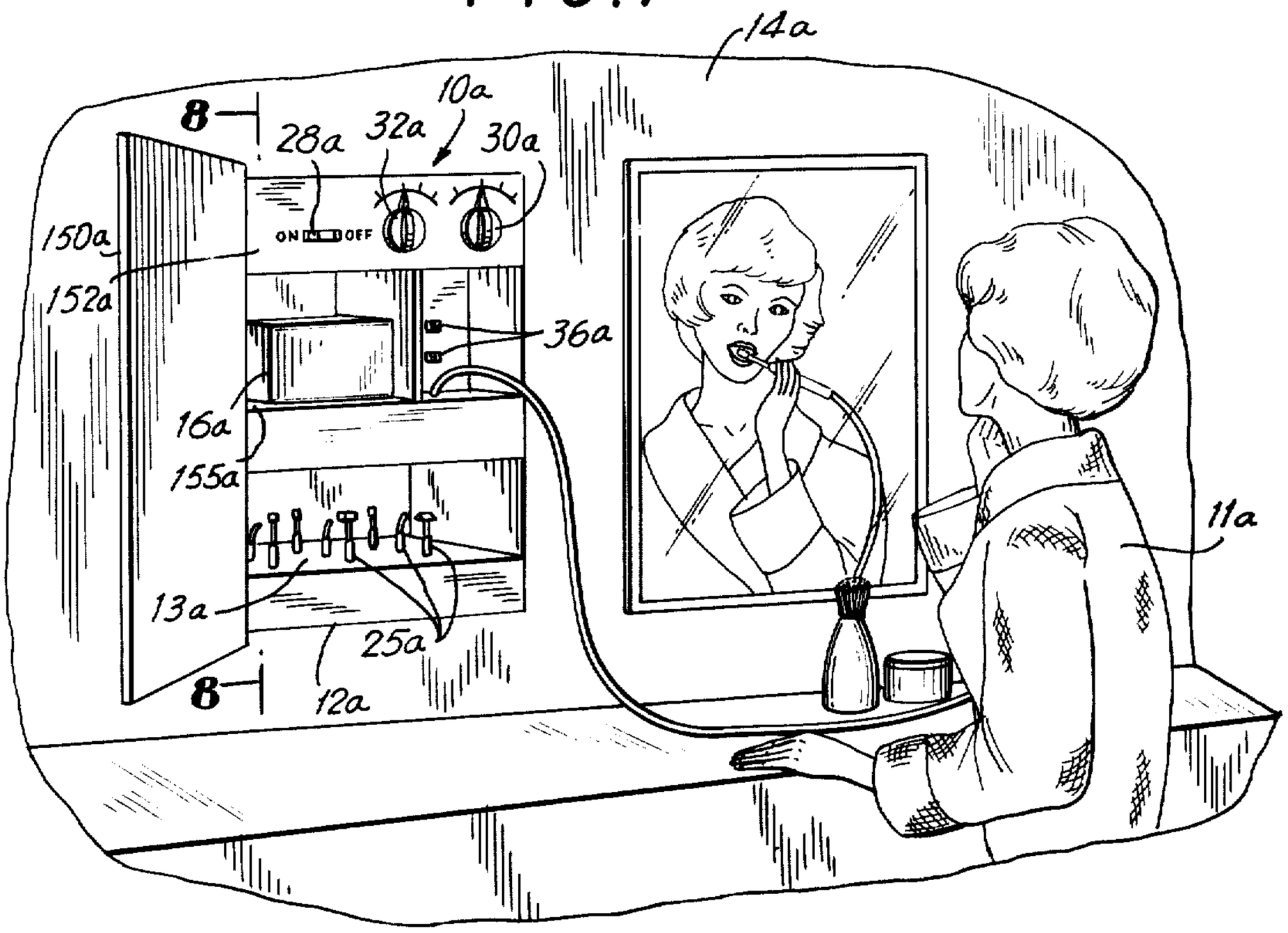


FIG. 7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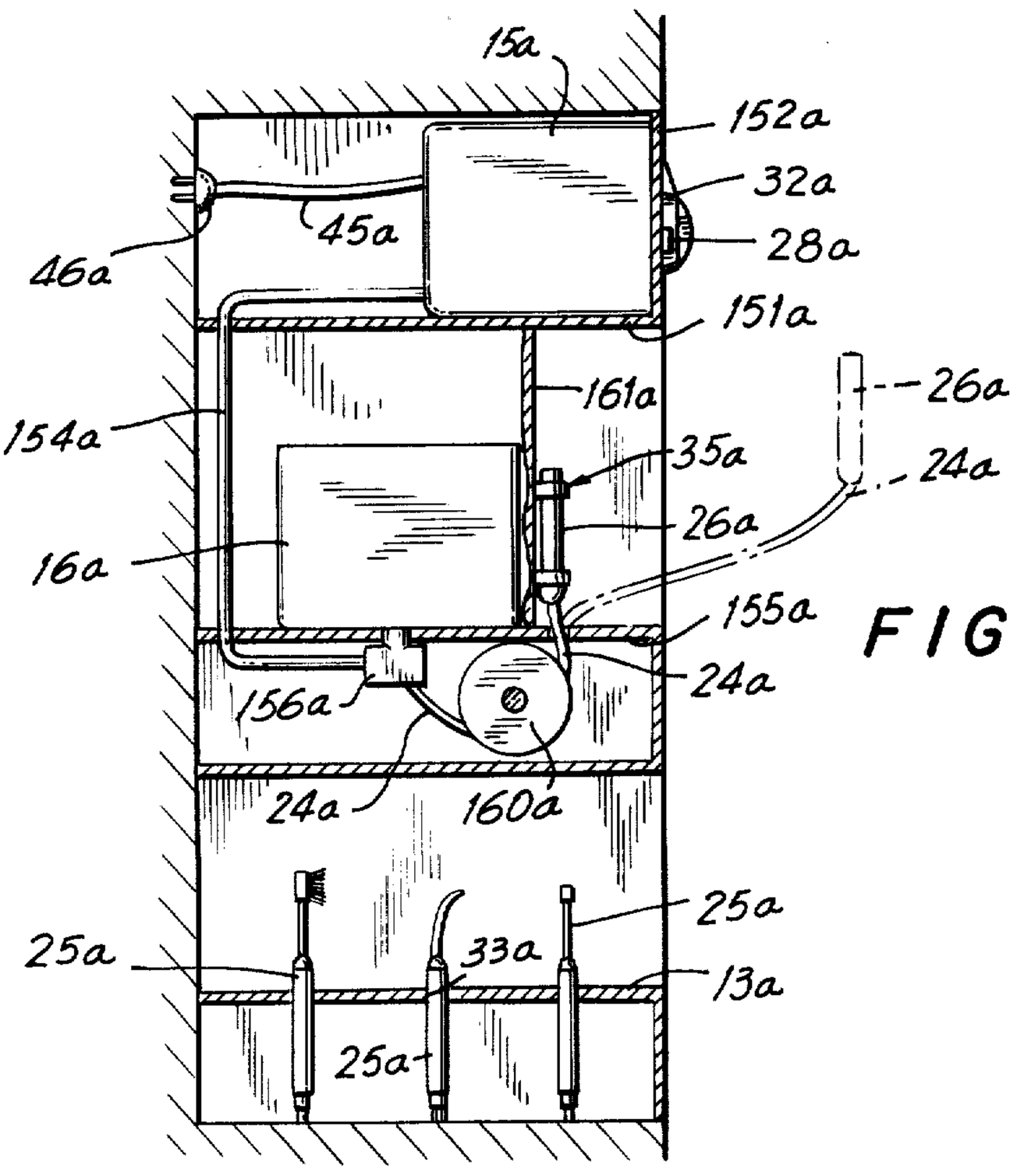
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FIG. 8

FIG. 10

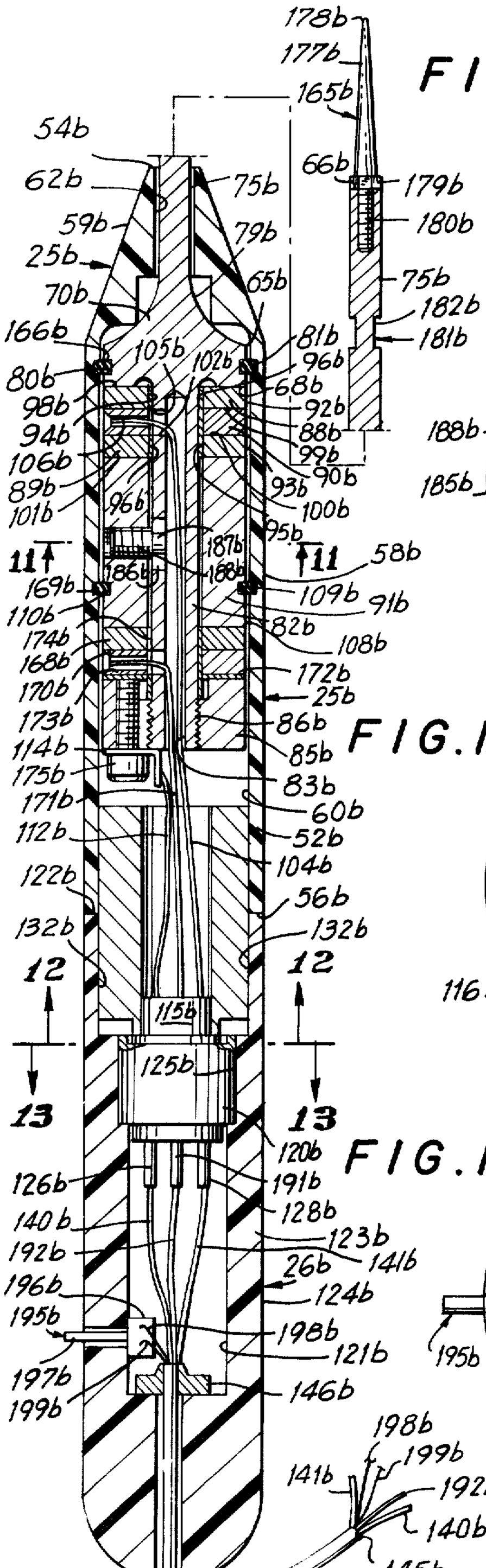


FIG. 11

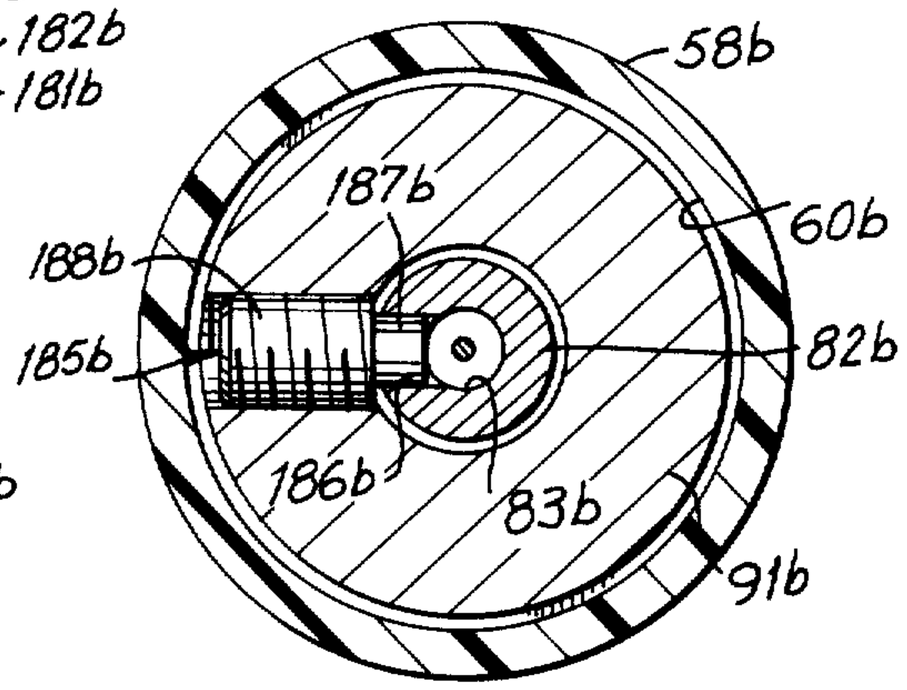


FIG. 12

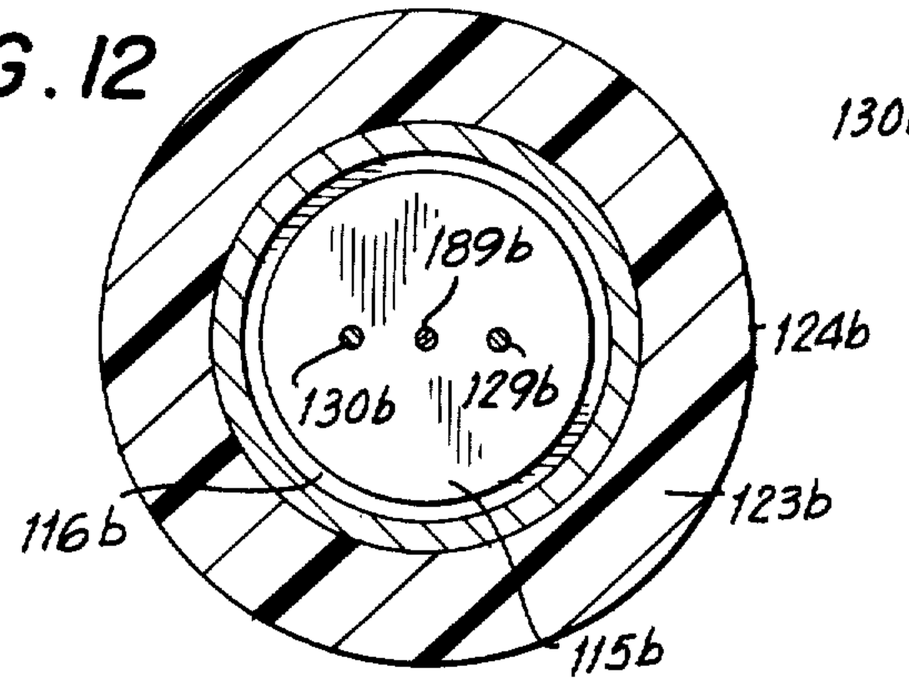
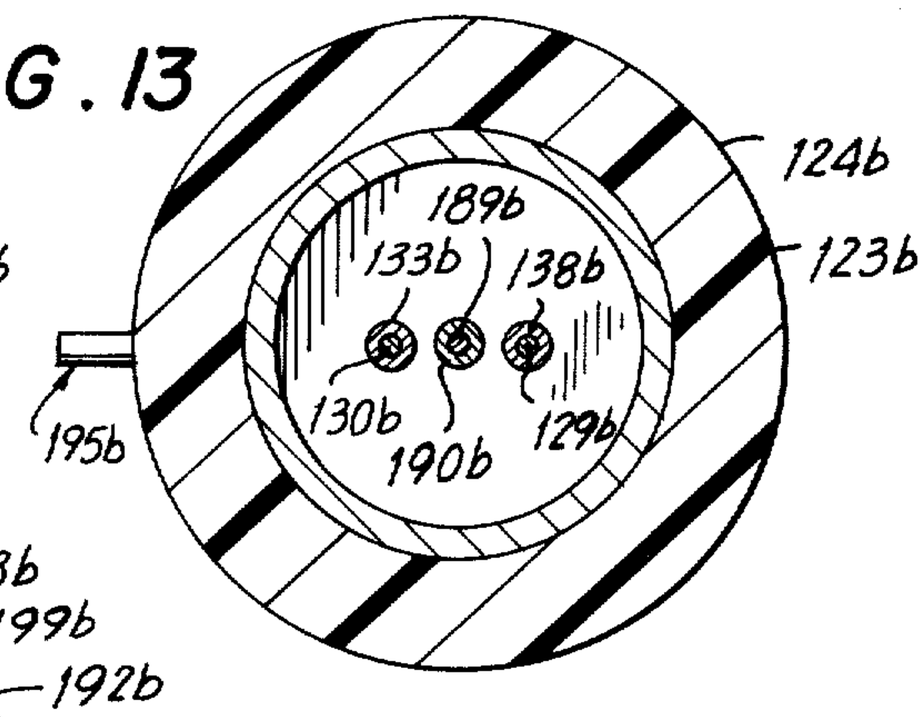


FIG. 13



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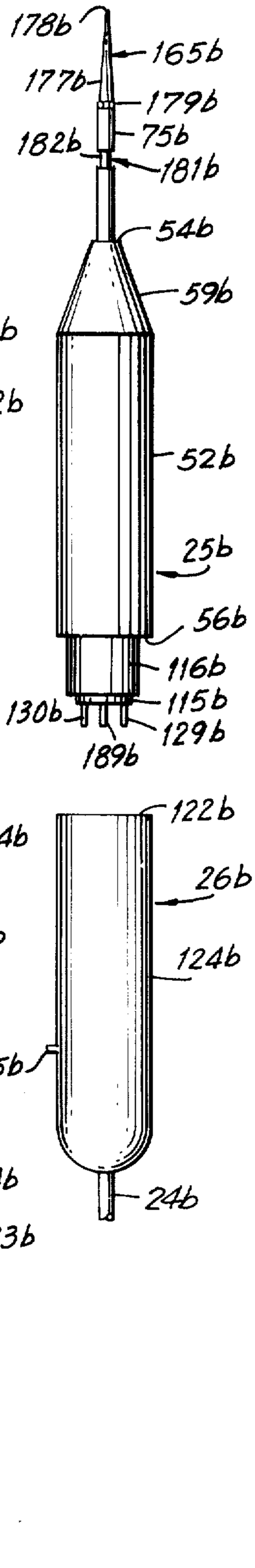
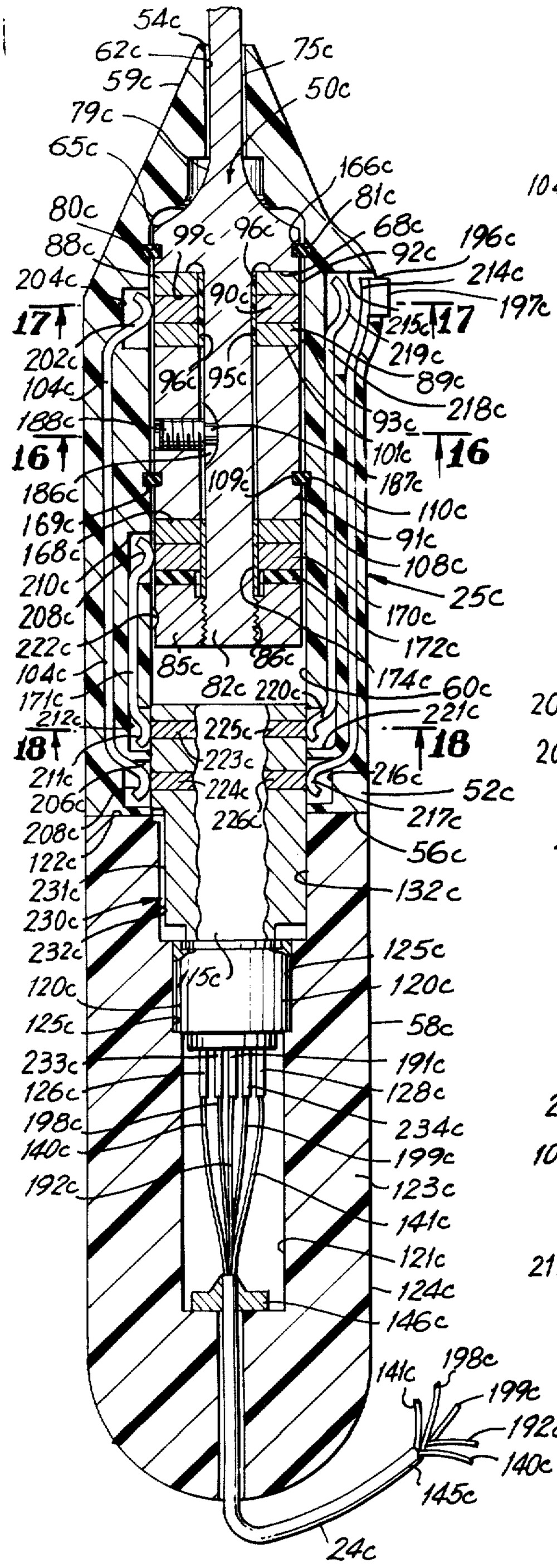


FIG. 15



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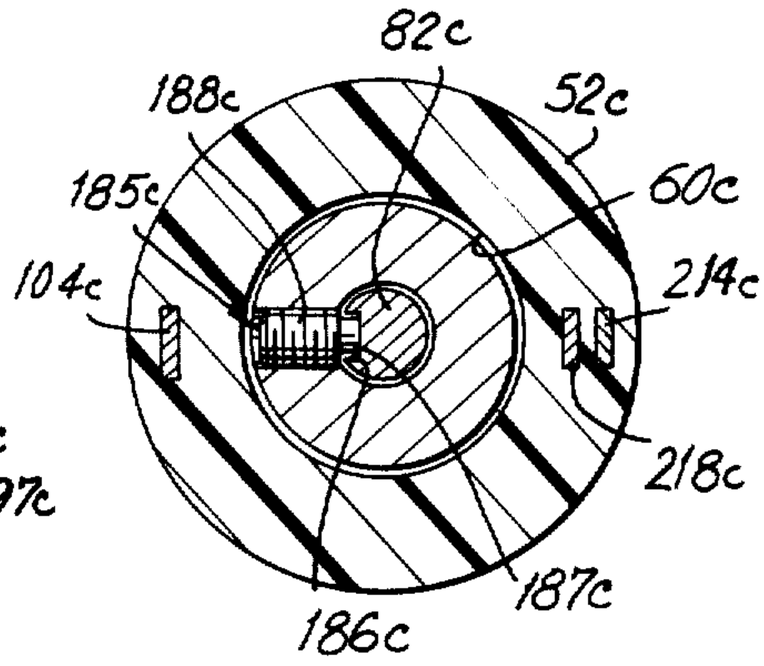
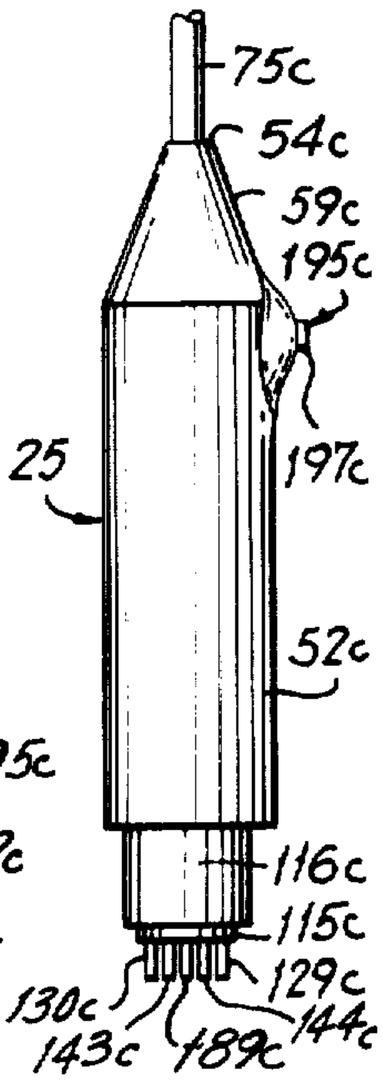


FIG. 14



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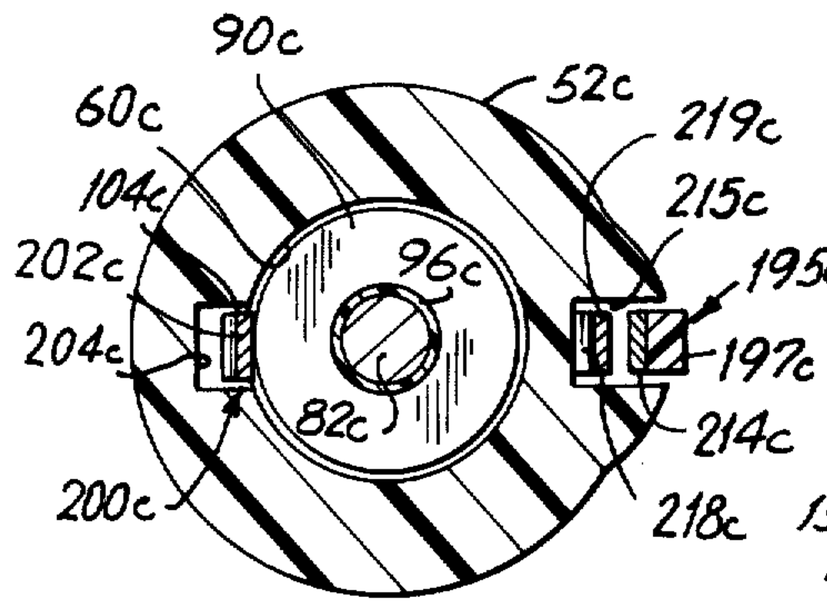
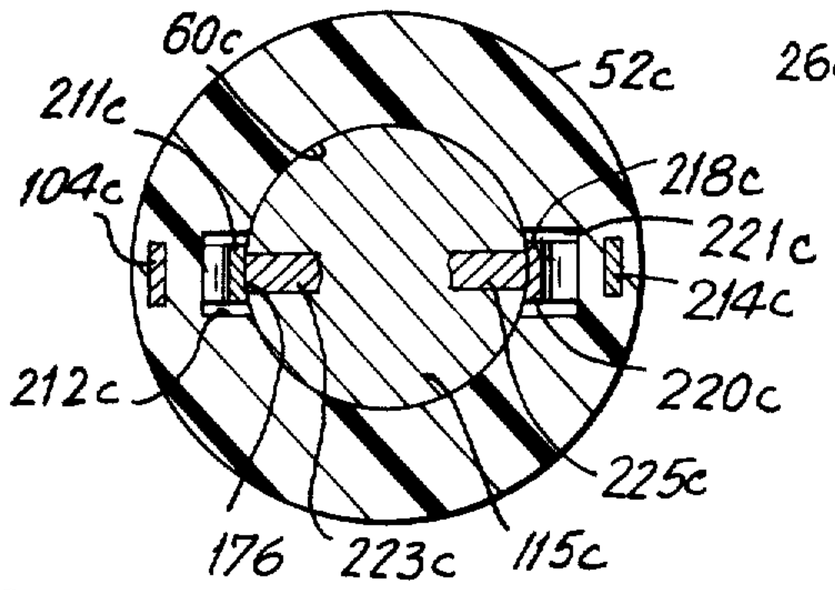


FIG. 18



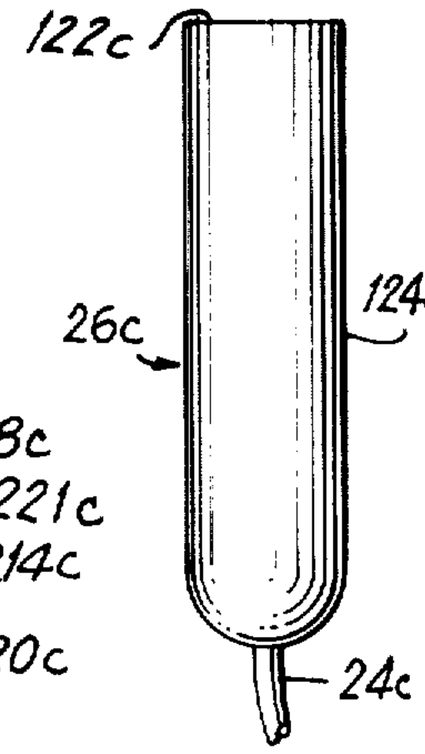
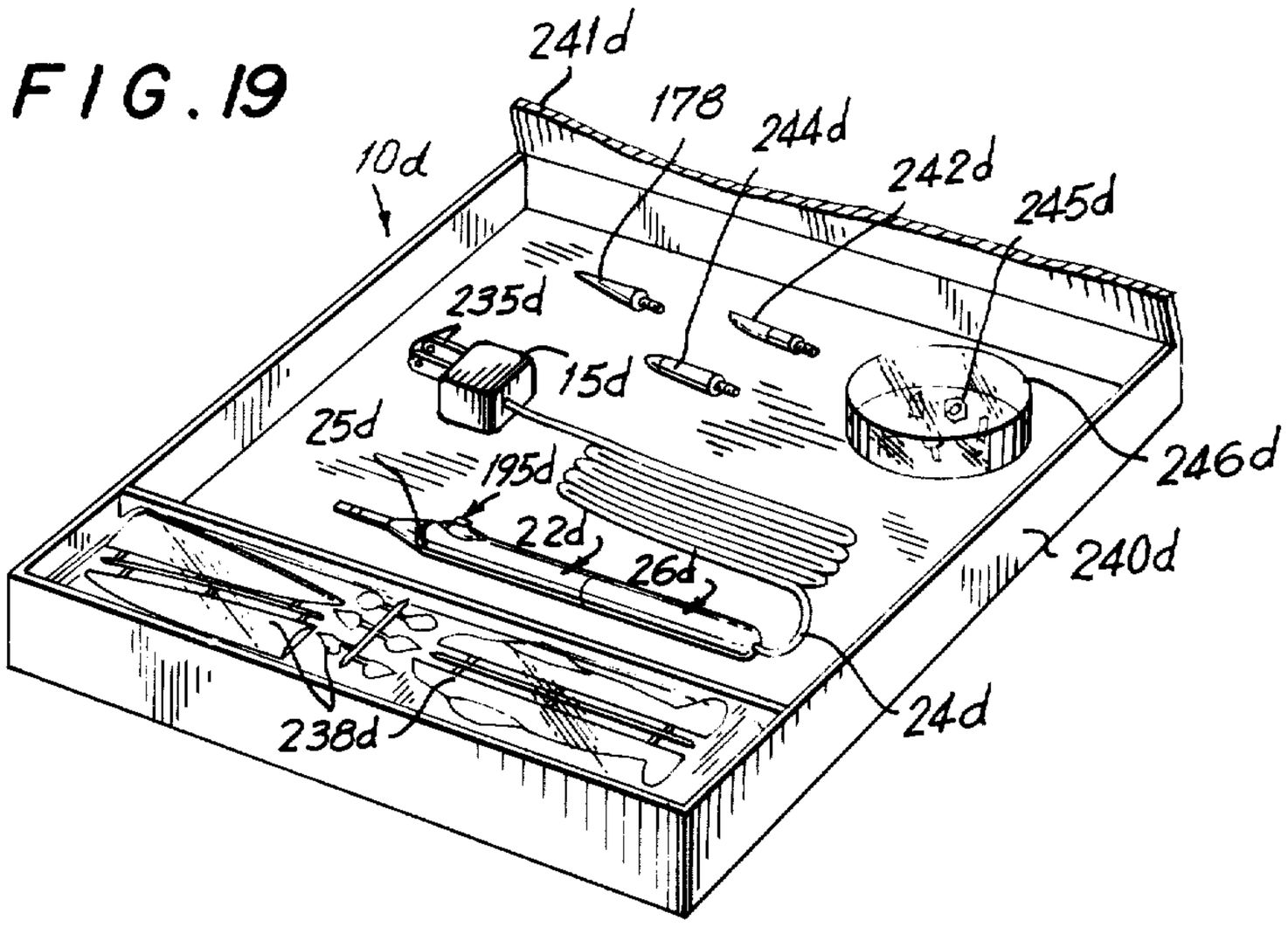


FIG. 19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178
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22d
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FIG. 20

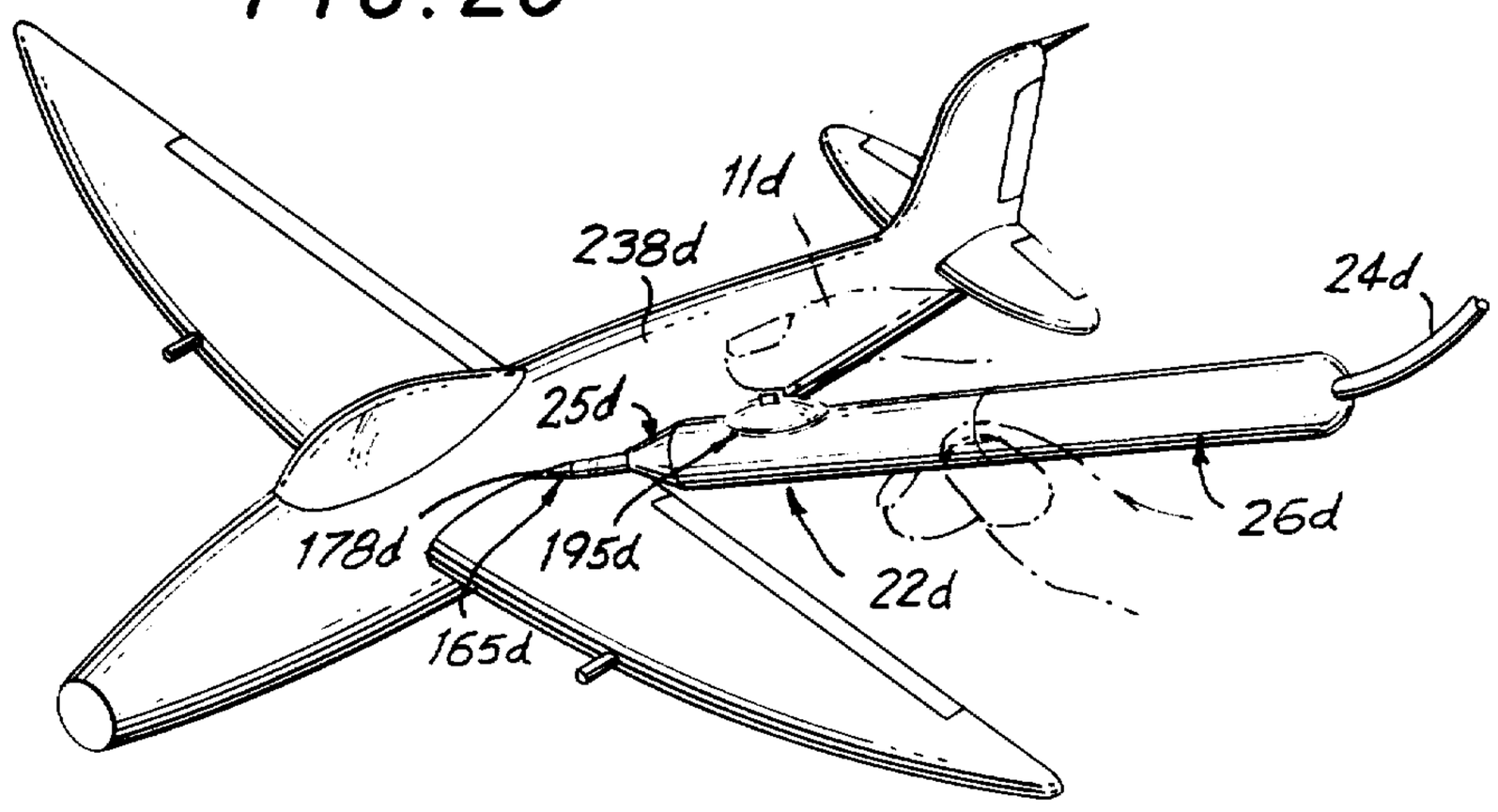
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FIG. 21

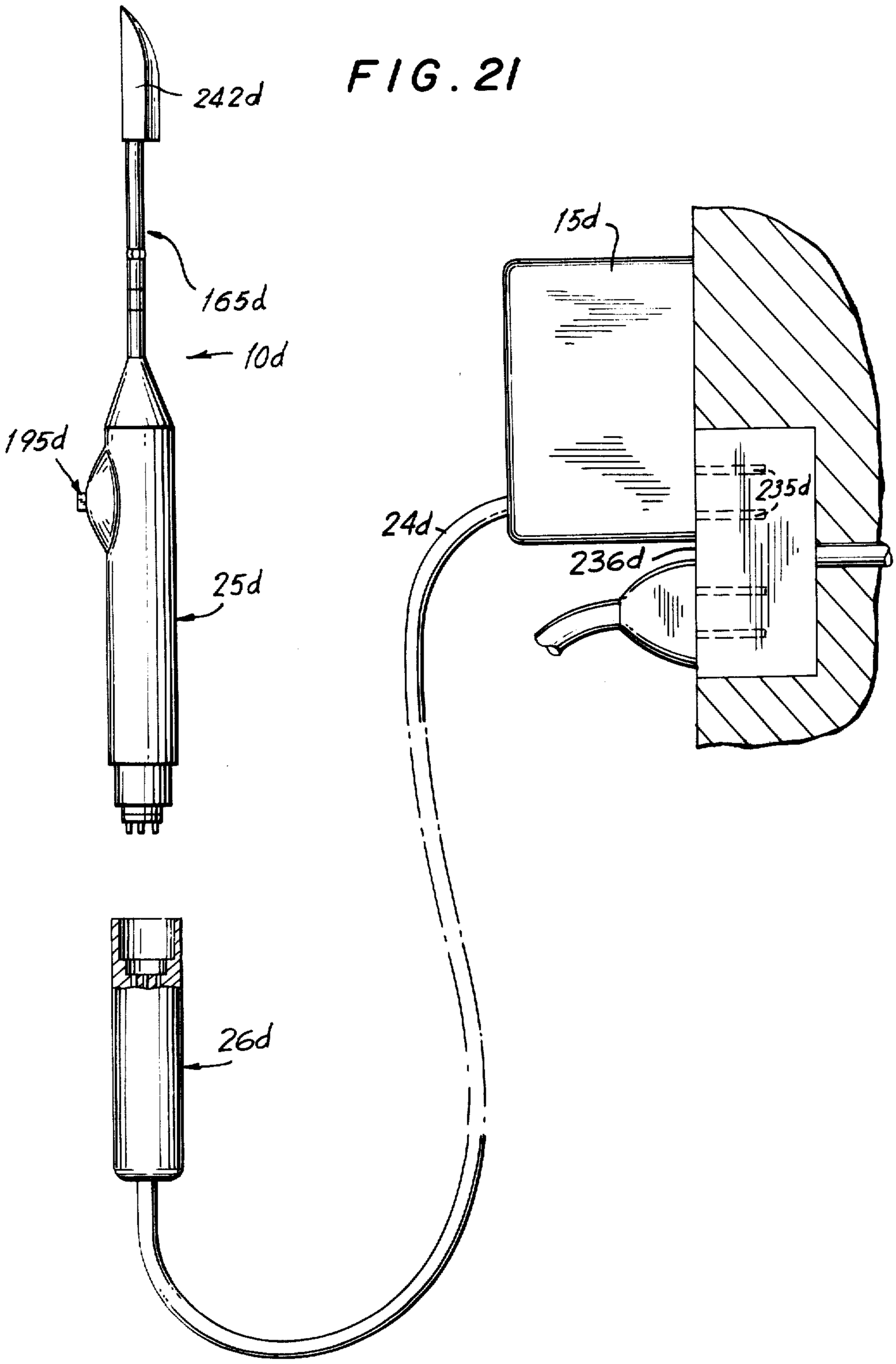

FIG. 22

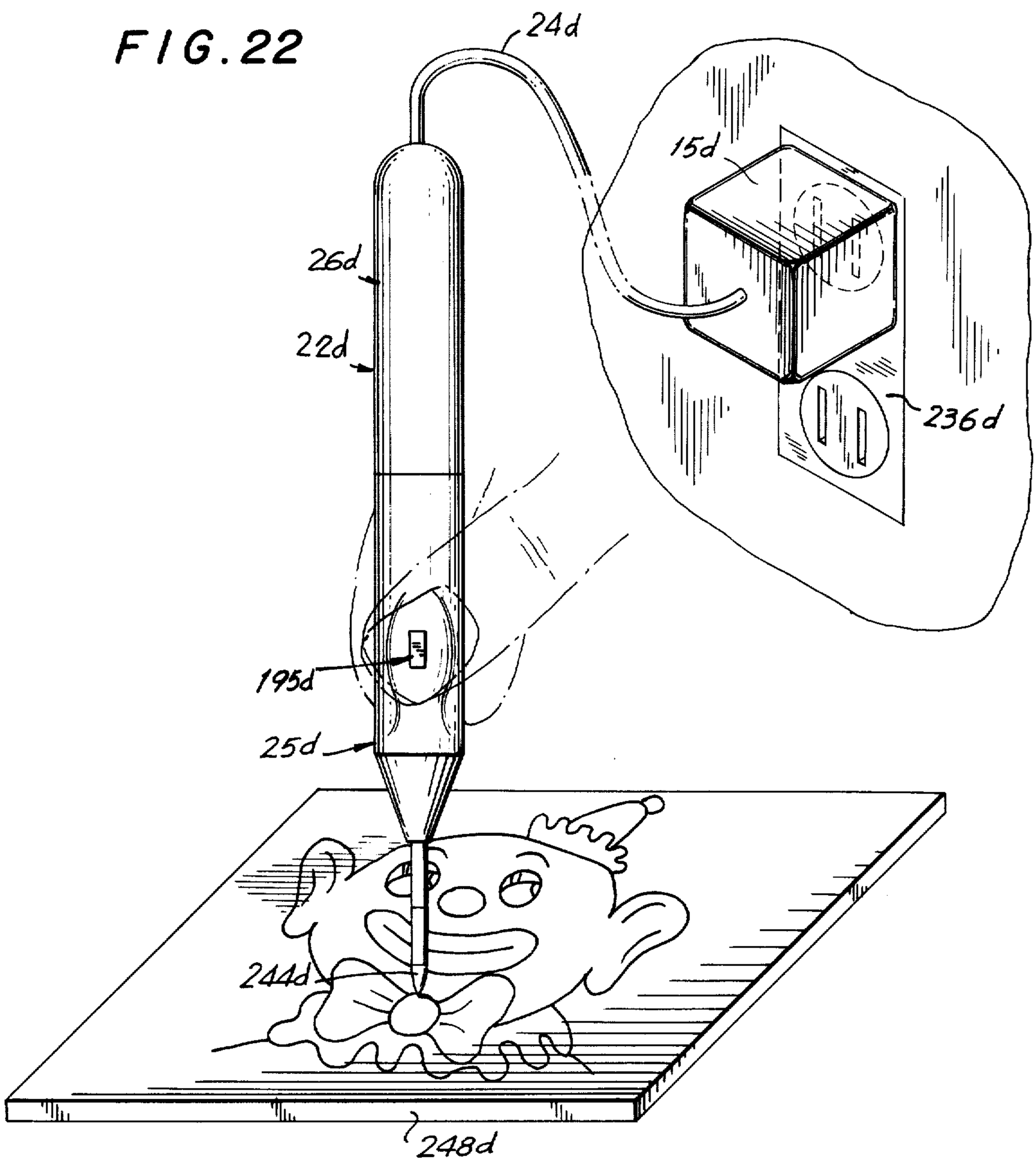

FIG. 23

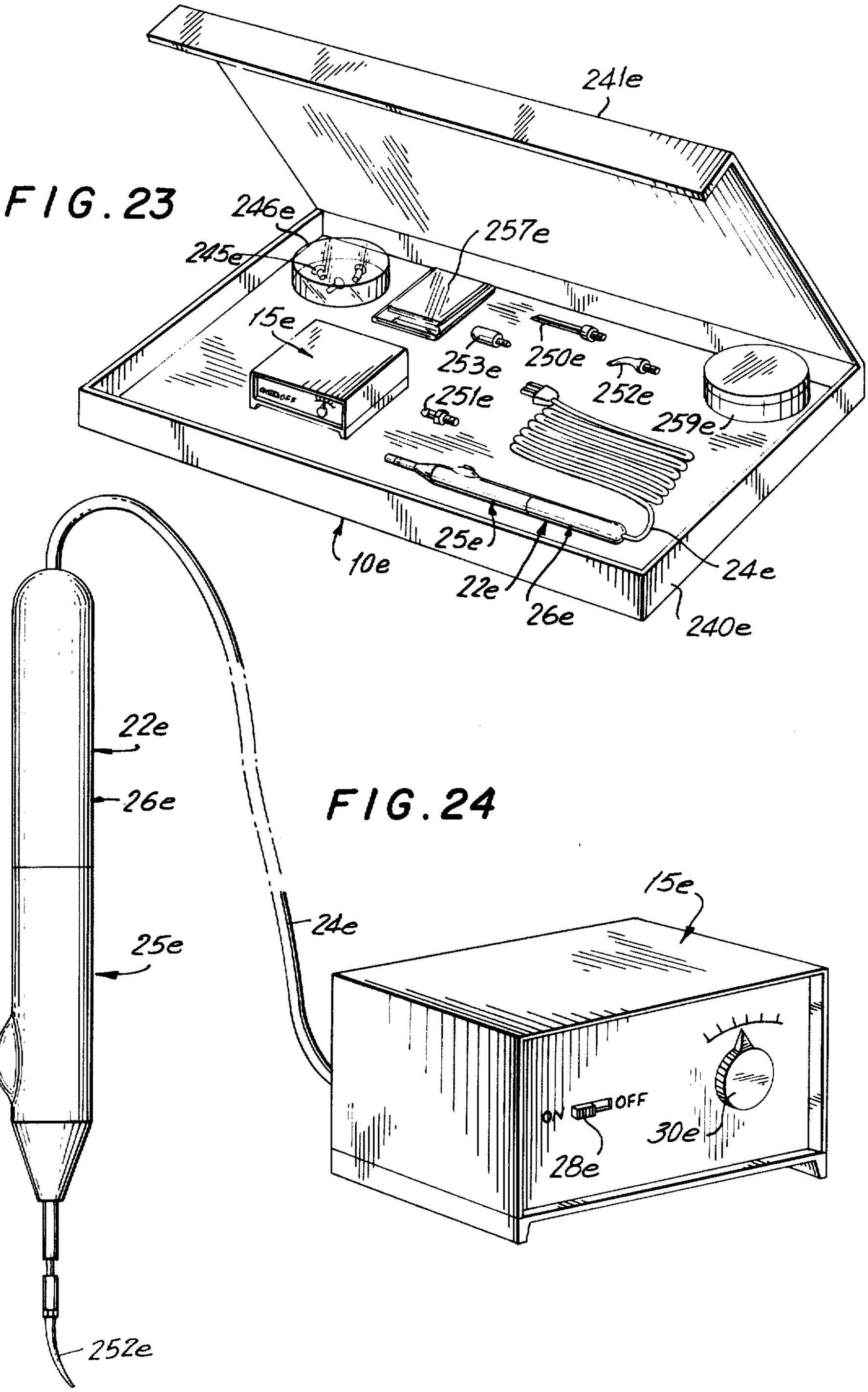
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FIG. 24

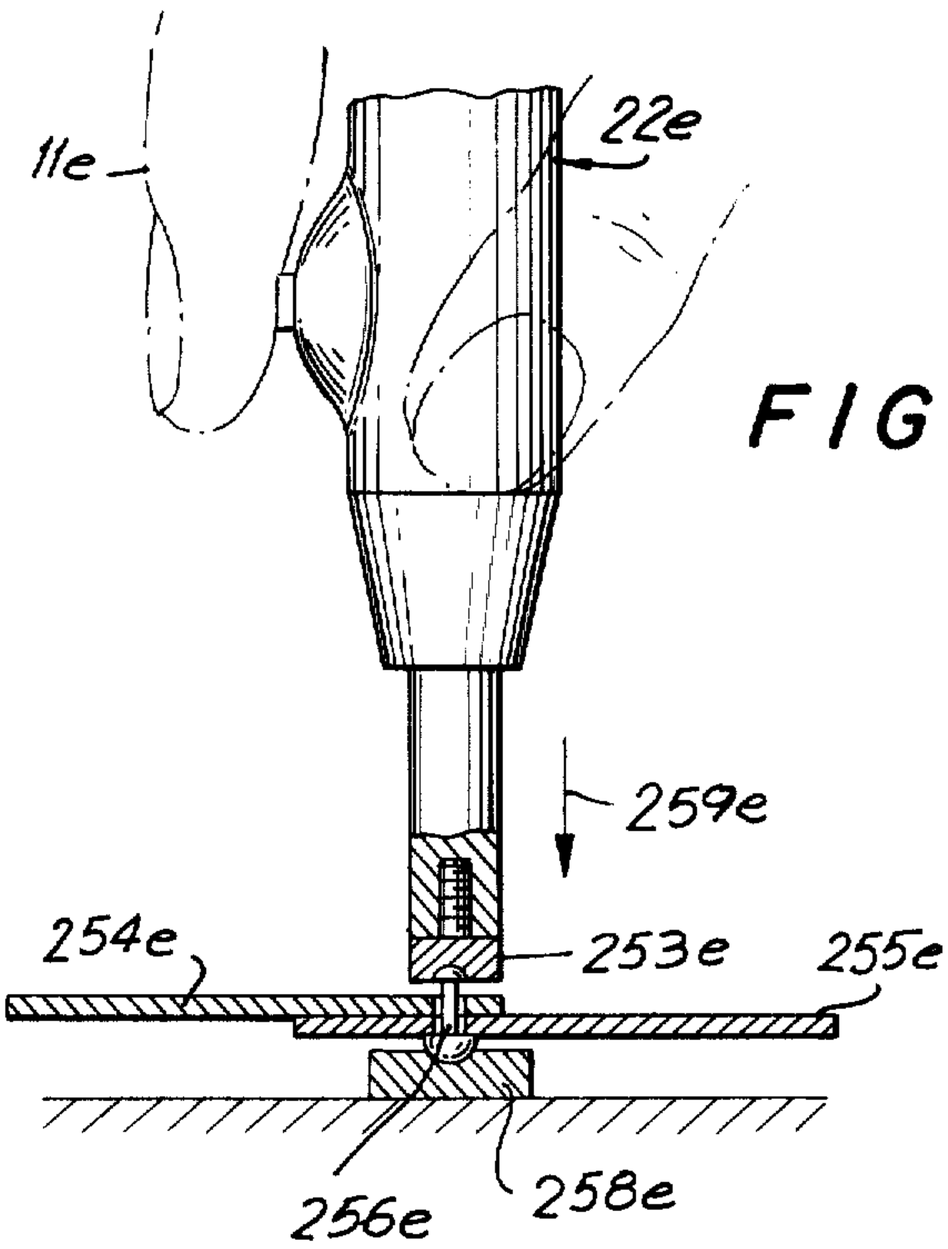

FIG. 25

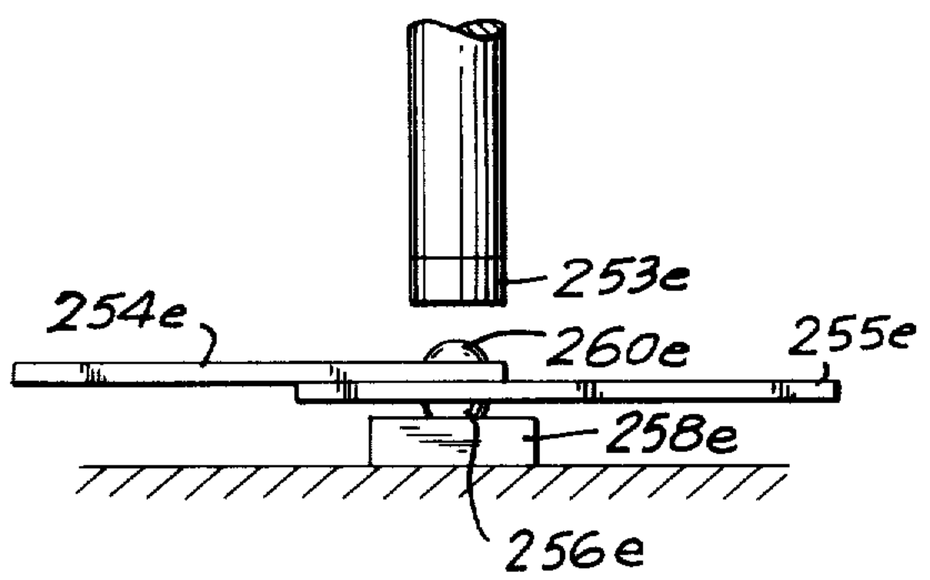

FIG. 26

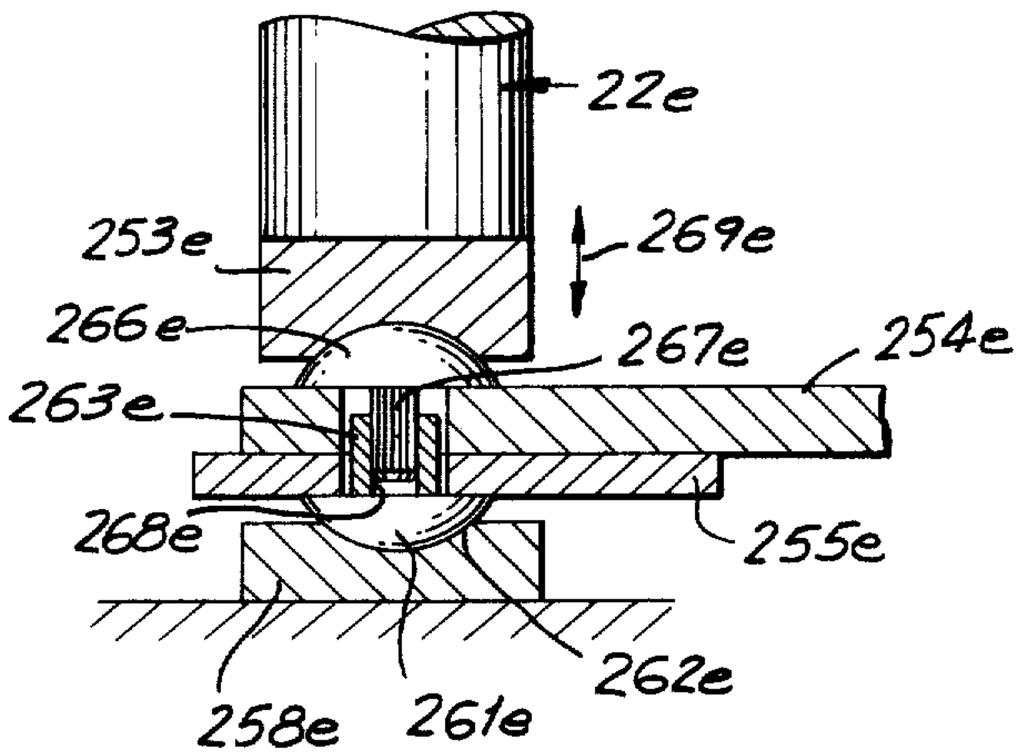

FIG. 27

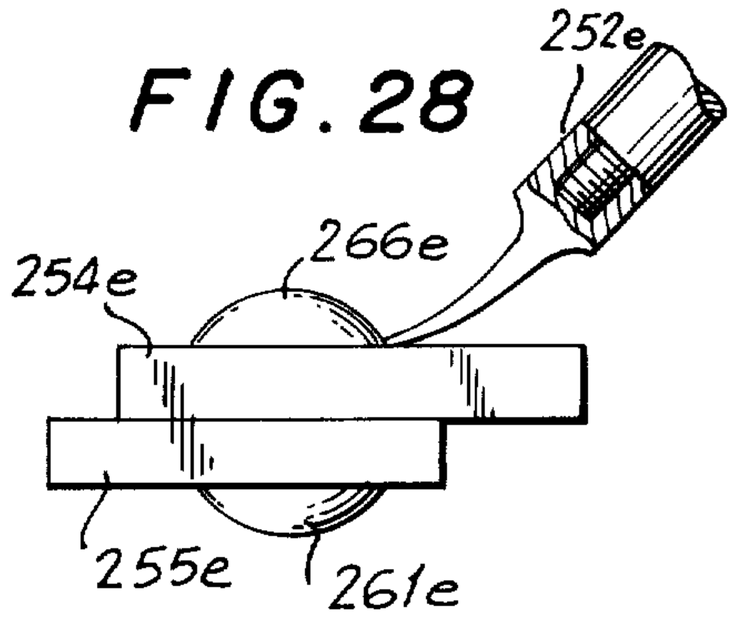

FIG. 28

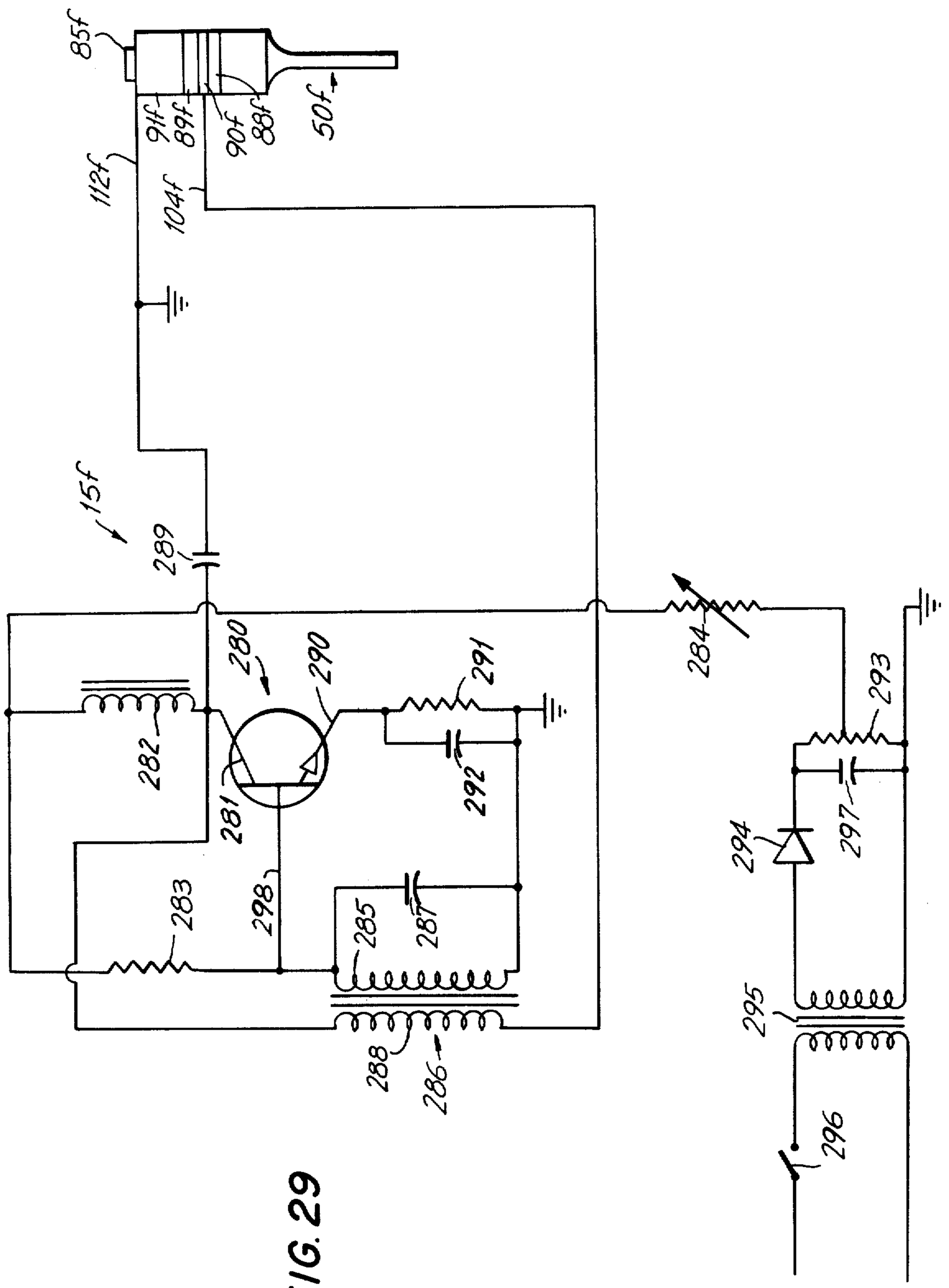
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FIG. 29

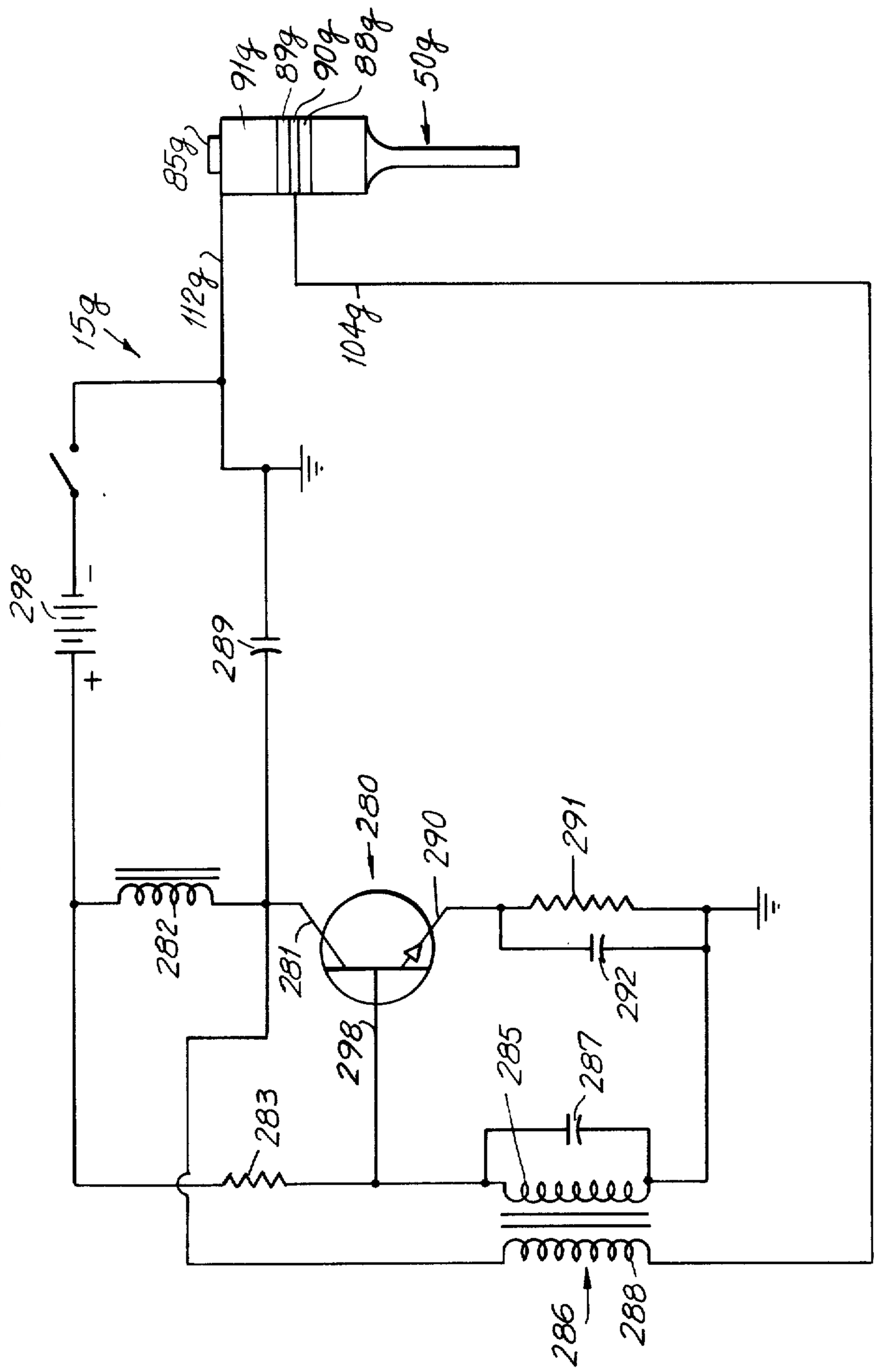
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FIG. 30

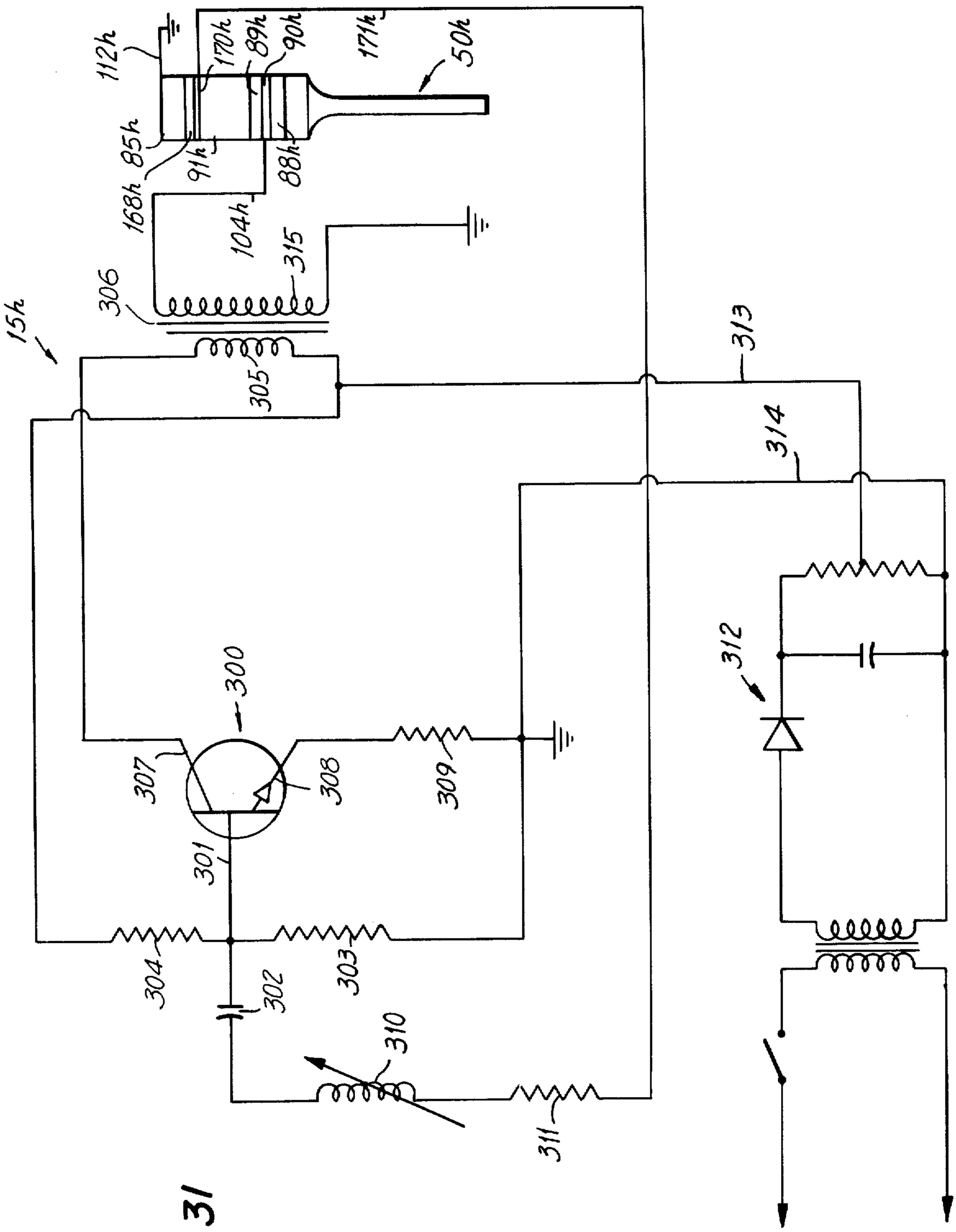
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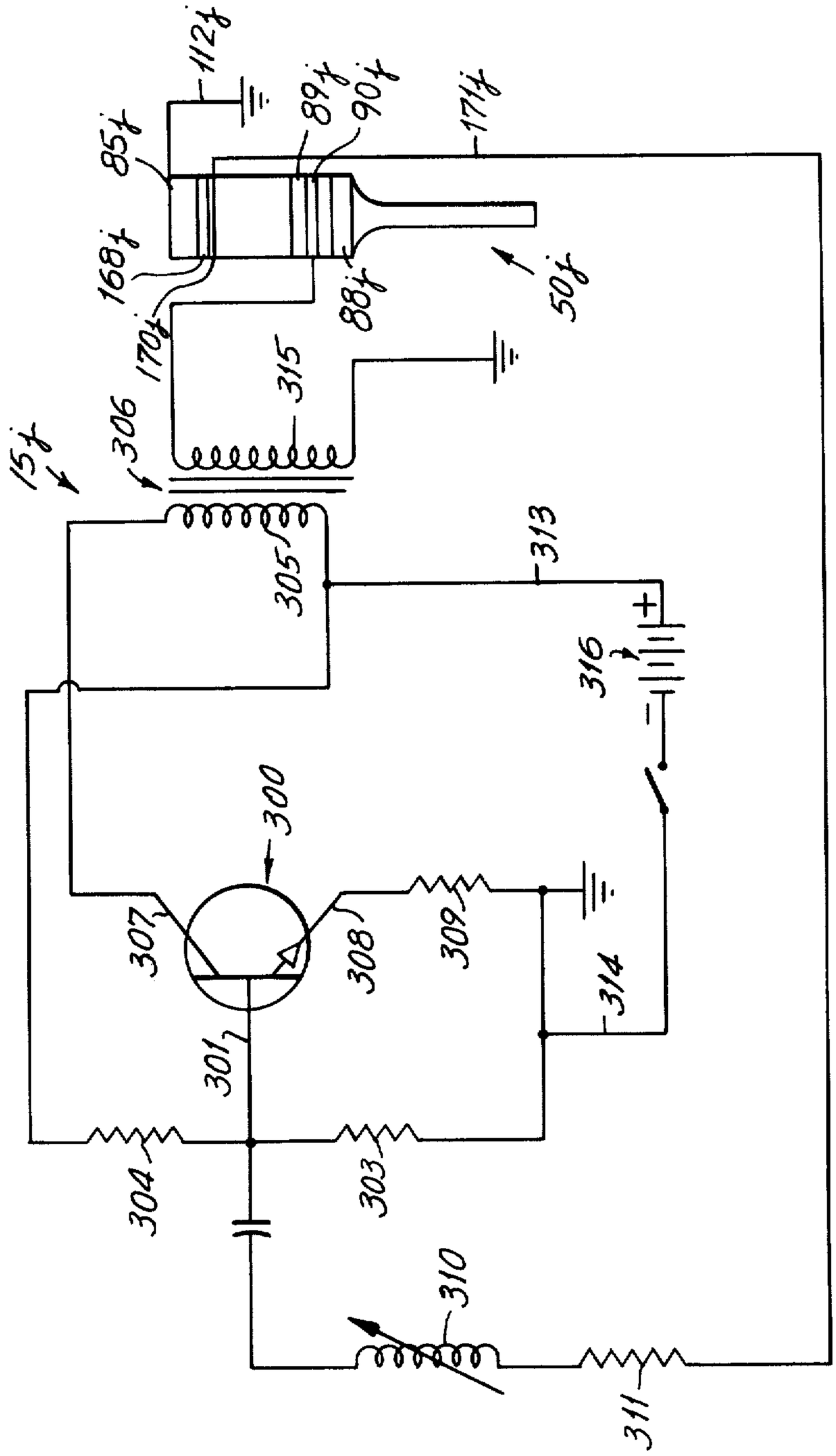
FIG. 31

FIG. 32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ULTRASONIC KITS AND MOTOR SYSTEMS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

The present invention relates to an ultrasonic unit adapted to be used for home, professional and industrial applications to perform a variety of functions, as wall as motor designs and power sources available therefore.

Heretofore, the use of ultrasonic energy has been directed towards the medical and industrial markets without any major attempt to enter the home consumer field via products incorporating an ultraonsic motor adapted to be hand held with a complimentary converter for increasing the normal 60-cycle per second house current to an ultrasonic range, of say 40,000 cyles per second, to energize the motor.

Applicants have now discovered that it is possible to produce home oriented products, by supplying to the consumer a basic kit that permits the user a major degree of flexibility in the application of ultrasonic energy to a number of areas. Accordingly, the present invention comprises one or more kits which may be variously designated as:

1. An ultraonsic hobby kit.
2. An ultraonsic multi-duty home service kit.
3. An ultrasonic universal chores kit.
4. An ultrasonic home workshop and the like.
5. An ultrasonic cosmetic kit which may include a razor, water pick, toothbrush, or prophylaxis unit.

An essential aspect of the ultrasonic motor technology today requires an electrical converter to increase the frequency of the normal house current to an ultrasonic rate, which rate for purposes of this invention is defined within the range of approximately 5,000 to 1,000,000 cycles per second. Accordingly, the present invention in each of its various forms provides a converter, either adapted to be plugged directly into an electrical outlet through an electrical cord or connected to a battery. The converter is electrically connected to the motor which is designed to convert the electrical energy into mechanical vibrations at an ultrasonic rate. The present invention provides various converters adapted to be used in connection with variously housing motors adaptable for a number of applications.

In connection with the home consumer market particularly, the cost to date of the ultrasonic motor-converter systems has hindered the introduction of ultrasonics into the consumer field in any sizeable scale. This invention provides a way for producing the ultrasonic system with the versatility necessary for practical application thereof on an economical basis.

OBJECTS OF THE INVENTION

A primary object of the present invention is to provide a variety of ultrasonic kits adaptable for consumer and commerical use both in the home and industry.

Another object of the present invention is to provide a series of accessories for use with an ultrasonic motor adaptable to be interchangeable so as to produce a series of effects therewith.

Another object of the present invention is to provide a kit including a number of items that may be assembled with ultrasonic energy.

Another object of the present invention is to provide a new and novel ultrasonic motor.

Another object of the present invention is to provide a new and novel ultrasonic motor converter system for multi-purpose use.

Another object of the present invention is to provide a new and novel ultrasonic converter.

Other objects of the invention will be apparent as the description proceeds.

SUMMARY OF THE INVENTION

The apparatus, in accordance with one aspect of the invention, includes a home consumer unit adapted for use for cosmetic purposes, having a plurality of interchangeable accessories to permit the user to carry out various functions with the ability of quick interchangeability and replacement so that various members of the household may have access to the ultrasonic energy imparted to the accessory with a single power source or converter being employed.

In accordance with another aspect of the invention, the ultrasonic instrumentation is contained within a wall unit such that the accessory may be manually withdrawn therefrom during usage and then returned to the wall cabinet when the user has completed such usage.

In accordance with another aspect of the invention, an ultrasonic kit is provided to permit the user to use ultrasonic energy for various hobby purposes; and the kit includes the ultrasonic motor, converter, and a series of interchangeable acceessory elements that function in various manners to carry out the hobbycraft functions. The word "hobbycraft" is used to include various household functions, and is not limited to hobbies per se. The kit further may include various plastic, wood, or metallic parts of various shapes and configurations to be assembled by, or used with, the ultrasonic instrument.

In accordance with another aspect of the invention, a novel ultrasonic motor is disclosed, which provides for the first time an interchangeability within the ultrasonic field of an entire motor that may be plugged or otherwise quickly coupled to a power source such that quick interchangeability is available for various uses.

In accordance with another aspect of the invention, a novel converter design is disclosed that is battery powered so as to be able to drive an ultrasonic motor for a variety of functions.

In accordance with another aspect of the invention, a novel motor-converter system is disclosed in which driving crystals are utilized for powering the motor and a sensing crystal is utilized for monitoring the frequency of the motor.

BRIEF DESCRIPTION OF THE DRAWINGS

Although the characteristic features of this invention will be particularly pointed out in the claims, the invention itself, and the manner in which it may be made and used, may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part hereof, wherein like reference numerals refer to like parts throughout the several views and in which:

FIG. 1, is a perspective view of an ultrasonic hygienic kit in use;

FIG. **2,** is a perspective view of the ultrasonic kit as adapted for use;

FIG. **3,** is a side elevational view of ultrasonic instrument means for use in the present invention;

FIG. **4,** is a side elevational view in cross-section of the instrument means in assembled relationship taken along a medial plane;

FIG. **5,** is a view in cross-section taken along the plane indicated by the line **5—5** in FIG. **4;**

FIG. **6,** is a view in cross-section taken along the plane indicated by the line **6—6** in FIG. **4;**

FIG. **7,** is a perspective view of an ultrasonic hygienic kit in use;

FIG. **8,** is a side elevational view in section of the kit illustrated in FIG. **7;**

FIG. **9,** is a side elevational view of ultrasonic instrument means for use in the present invention;

FIG. **10,** is a side elevational view in cross-secion of the instrument means in assembled relationship taken along a medial plane;

FIG. **11,** is a view in cross-section taken along the plane indicated by the line **11—11** in FIG. **10;**

FIG. **12,** is a view in cross-section taken along the plane indicated by the line **12—12** in FIG. **10;**

FIG. **13,** is a view in cross-section taken along the plane indicated by the line **13—13** in FIG. **10;**

FIG. **14,** is a side elevational view of ultrasonic instrument means for use in present invention;

FIG. **15,** is a side elevational view in cross-section of the instrument means is assembled relationship taken along a medial plane;

FIG. **16,** is a view in cross-section taken along the plane indicated by the line **16—16** in FIG. **15;**

FIG. **17,** is a view in cross-section taken along the plane indicated by the line **17—17** in FIG. **15;**

FIG. **18,** is a view in cross-section taken along the plane indicated by the line **18—18** in FIG. **15;**

FIG. **19,** is a form of kit that is primarily intended for the hobbyist;

FIG. **20,** illustrates the instrument means of the kit used for assembly of a plastic model;

FIG. **21,** illustrates an ultrasonic system having a converter adapted to be plugged into a wall outlet;

FIG. **22,** illustrates the system for use in another hobbycraft;

FIG. **23,** illustrates another form of hobby kit;

FIG. **24,** illustrates the instrument means of the kit in FIG. **23** in assembled relation;

FIG. **25,** is an enlarged view partially in section, of a removable element for use in assembly of component parts;

FIG. **26,** is a view similar to FIG. **25** showing the completed assembly operation;

FIG. **27,** is a view similar to FIG. **25** of a novel fastener being assembled;

FIG. **28,** is a view illustrating the removal of the head formed on the fastener; and

FIGS. **29–32** illustrate various electrical schematics of converters that can be used to drive the various ultrasonic motors described herein.

PREFERRED EMBODMENTS OF THE INVENTION

Turning now to the drawings and particularly to FIGS. **1** and **2** thereof, we have disclosed an ultrasonic system or kit generally indicated by the reference numeral **10,** for use by one or more users **11,** seen to include a cabinet **12,** on table **19,** which contains therein an ultrasonic converter **15,** as well as a tray or

reservoir **16** forming a reservoir on the top **13** thereof, and containing a supply of liquid **18,** which, in a conventional manner, is pumped from the reservoir **16** by pumping means **20** contained within the cabinet **12** and connected to the tray **16** to permit the flow of liquid **18** through the pumping means **20.** Ultrasonic instrument means **22** is coupled to the converter means **15** and pumping means **20** by cable means **24** which contains a current supply line and a liquid supply line. The ultrasonic instrument **22** is comprised of accessory or implement means **25,** that may have various shapes and configurations, and adapted to be removably secured to adapter or coupling means **26.** The cabinet **12** contains power control means in the form of a switch **28** having an "On" and "Off" position and a variable switch **30** to regulate the power of converter **15.** A liquid means regulator includes a switch **32** that contains a dial to vary the rate of the pump **20,** which pumps the fluid from the reservoir **16** through the cable **24** in a manner which is well known in the art.

The cabinet **12** is seen to include support means **35** which may extend from the side wall thereof in the form of bent arms **36** to support the adapter **26** when not in use. The upper surface **13** of the cabinet **12** includes retaining means in the form of a plurality of recesses **33** adapted to receive therein in vertical relationship a plurality of accessories **25,** each adapted to be interchangeable with and readily connected to the adapter **26** as hereinafter more fully described with respect to FIGS. **3–6** and FIGS. **9–18.** The actual accessory **25** may consist of an ultrasonic toothbrush **38,** an ultrasonic water-pick **40,** or an ultrasonic prophylaxis unit **41;** said water-pick, toothbrush and prophylaxis unit may be made in accordance with U.S. Pat. No. 3,547,110 issued Dec. 15, 1970, by Lewis Balamuth and entitled, "Methods and Apparatus for Maintaining Tooth and Gingival Structures with Ultrasonic Energy," and which patent is assigned to the assignee of the present invention. Another accessory in the form of and ultrasonic razor **42** may also be interchangeable with the adapter **26** and said razor may be of the type disclosed in U.S. Pat. application Ser. No. 872,927, filed Oct. 31, 1969, now U.S. Pat. No. 3,610,080, issued Oct. 5, 1971, by Arthur Kuris and entitled, "Ultrasonic Method and Apparatus for Shaving," and assigned to the assignee of the present invention. Another accessory **25** may be in the form of a container **43** adapted to receive therein a fluid which accessory may be used by the user by inserting their finger therein for doing their nails, to perform a cleansing or other operation thereon. Another accessory **44** may be in the form of a polishing head for polishing and performing other beauty care treatments.

The ultrasonic kit **10,** as seen with respect to FIG. **1,** and for which the user **11** is using an ultrasonic toothbrush in the mirror **17** on wall **14,** permits each family to have their own accessory **25** available to them such that it may be readily interchangeable and connected to the adapter **26** so that when the connection is made electrical energy is transmitted to the working end of the accessory which, as indicated above, may take various shapes and forms and there is disclosed herein are only a sampling of those that might be used in accordance with the present invention. The kit illustrated in FIGS. **1** and **2** is seen to include an electrical plug **46** which is in a conventional manner plugged into a wall outlet and connected by cable **45** to the generator or converter **15** that converts the normal 60-cycle house

current to an ultrasonic rate, which as herein designed, is to include the frequency range of 5,000 cycles to 1,000,000 cycles per second. Obviously, the converter **15** may be battery powered as hereinafter described, or the type in which it is battery powered, as hereinafter described, or the type in which it is battery powered for traveling but having a feature in which case a plug would still be utilized.

Accordingly, FIGS. **1** and **2** illustrate a new and novel ultrasonic instrumentation that affords the user, for the first time, to have a variety of ultrasonic implements **25** available to him in a compact manner, to be useable with minimum effort by an entire family in the home. In use, the user **11** merely selects the particular accessory **25** desired for a particular need and then sets out to manually insert the accessory **25** into the adapter **26** in a simple easy manner. The power may then be energized by the "On" and "Off" switch **28** and the amount of liquid **18** from the reservoir **16,** if any is desired, may then be selected by the variable switch **32,** and the power level selected by variable control switch **30.** When the user has completed the use of the accessory **25,** he or she may then remove the accessory **25** from the adapter **26,** replacing it in the selected retaining means **33** provided therefor and return the adapter to its support means **35.**

FIGS. **4–6** illustrate one form of accessory **25,** and adapter **26,** construction that may be utilized in accordance with the embodiments of the invention illustrated in FIGS. **1** and **2.** The accessory **25** includes an ultrasonic motor or transducer means **50** contained in a tubular housing **52** having a front end **54** and a rear end **56** with the outer wall **58** of the housing **52** having any desired contoured shape or configuration to facilitate it being handled by the user, and a tapered section **59** terminating at the front end **54** of the housing **52** with a chamber or cavity means **60** extending from the rear end **56** of the housing **52** and connected to an axial opening **62** which in turn terminates at the front end **54.**

As seen with respect to FIG. **4,** the ultrasonic motor **50** is contained within the housing cavity **60** and the hand piece housing **52** may be of plastic or any other suitable material.

The ultrasonic motor **50** includes a transmission member **65** terminating at a working output end or tip **66** at one end thereof and having a rear surface or face **68** at its opposite end. The transmission member **65** may be designed in the form of an acoustical impedance transformer so that there is an increase in the amplitude of mechanical vibration from its rear face **68** to its front tip **66.** The actual variations of cross sectional area to obtain the amplitude magnification is well known in the art. The transmission member **65** may be made of a metallic or plastic material depending upon its desired use, for example, if the implement as shown in FIG. **4** has a water feed associated therewith then the unit may be used for dentistry in the form of a dental prophylaxis unit by the dentist or in turn may be of a home consumer design to be used by the user in the home for maintaining tooth and gingival surfaces free of deposits normally contained on the teeth of the user. Essentially, the motor construction, as hereinafter described, for professional and home use, may be of similar design except that the relative power for a home consumer unit would be less than that of a prefessional unit which is used by the dentist since in the home the user is in a sense doing over a

6-month period what the dentist might be doing at one sitting in the dentist's office. Accordingly, the tip **66** may be of a plastic or metallic material depending upon the use thereof and the magnitude of ultrasonic mechanical vibrations to be imparted thereto.

The transmission member has a circular rear section **70** and front section **75,** with an internally threaded bore **71** extending from its rear face **68** and terminating in a seat **72** adapted to contain therein sealing means as in the form of an o-ring **74** as hereinafter explained. Communicating with the bore **71** is a longitudinally extending passageway **76** that extends to the front tip **66** of the transmission **65** through the front section **75,** which is illustrated to have a curved or contoured portion **78** to permit ready access within the oral cavity. Obviously, the shape, contour and cross sectional area of the passageway **76** may be designed to obtain various spray patterns or flow rates and further, the tip **66** may be designed so as to obtain flexural, lateral, torsional, elliptical, linear or longitudinal motion, by proper control of the shape of the front section **75** of the transmission member which has the bent tip portion **78** formed therewith.

The transmission member **65** has a contoured radius **79** connecting together the front section **75** and the rear section **70** of the transmission member **65,** which sections may be both of circular cross sectional area such that the front section **75** extends out beyond the front end **54** of the housing **52** a sufficient distance and through the opening **62** provided therefor. The transmission member **65** may contain an annular depression **80** for motor mounting means, illustrated to be in the form of an o-ring **81,** but it may take other forms and shapes as desired. Extending from the rear face **68** of the transmission member **65** is a support member or shaft **82** having a threaded portion **84** which engages the threaded portion **71** of the transmission member **65** and an axially extending passageway or opening **83.** The rear end of the support member **82** also has a threaded portion **86** which receives locking means in the form of a nut **85** threaded thereon and adapted to sandwich therebetween under a selected compressive static load a pair of piezoelectric crystals **88** and **89** that may be of a lead zirconate or lead titanate ceramic crystal material, formed so as to be capable of ultrasonic vibrational acitivity in its longitudinal direction when activated by high frequency electrical impulses delivered to it as will be described. The crystals have an external diameter **92** and **93** respectively, which is smaller than the internal diameter of the chamber **60** such that sufficient clearance therebetween is obtained. The internal diameters **94** and **95** of the respective crystals **88** and **89** have a diameter which permits an insulating tubular sleeve **96** to be positioned in surrounding relationship over the support member **82,** and extends the length from the front face **98** of crystal **88** to the rear face **101** of the crystal **89.** The sleeve **96** is made preferably from an insulative material such as plastic so as to isolate the crystals from the electrode **90** that extends between the rear face **99** of crystal **88** and the front face [of crystals] **100** of crystal **89.**

To permit wiring of the motor, wire lead **104** extends through the passageway **83** with the support member **82** having a longitudinally extending opening **102** through the support member wall and through an opening **105** in the insulator sleeve **96** and terminating in a pocket **106** within the disc shaped electrode **90.** The wire **104** is soldered or otherwise attached to the elec-

trode **90** for electrical purposes. The rear member **91** fits in telescopic relationship to the support member **82** and has an external diameter **108** which is less than the internal diameter of the chamber **60.**

The mounting means for the motor **50** in the housing means **52** consists of spaced apart-o-rings **81** and **110** such that the vibrational energy of the motor when energized, remains substantially isolated therein without the energy being transmitted to the housing **52.** A peripheral o-ring seat **109** is provided for o-ring **110** in the housing **52.**

Locking means in the form of a nut **85** is secured to the rear threaded portion **86** on shat **82** and is tightened to the point where an axial compressive force is sufficient to compress the crystal **88,** electrode **90,** crystal **89,** and rear section **91** with a predetermined amount of torque. Depending upon the size of the crystals and power of the motor, an epoxy material may be used to bond the parts and crystals together and form the locking means.

As part of the electrical connecting means, a ground lead or conductor **112** is connected to a lug **114,** a portion of which extends beneath the nut **85,** such that the power leads **104** and **112** are in turn connected to a power source as hereinafter explained.

The ultrasonic motor **50** although shown as piezoelectric may be one of a variety of electromechanical types, such as electrodynamic, piezoelectric or magnetostrictive, and designed for effecting ultrasonic vibrations through hand directed tools of suitable configuration, or larger ones, which are readily replaceable or inter-changeable with other work performing tools or accessories such as for use as acoustically vibrated material treating devices. The motor **50** has components rigidly joined, in end-to-end relationship to form a unit or assembly which is removably supported in a housing containing electrical coupling means to the transducer and receiving alternating current.

The ultrasonic motor **50** is longitudinally dimensioned so as to have lengths which are generally whole multiples of half-wavelengths of the compressional waves established therein at the frequency of the combined longitudinal length of the components so that longitudinal loops or other components of motion occur at the end **66** of the output surface of the transmission member **65.** Thus, the optimum amplitude of longitudinal vibration and hyper-accelerations of transmission or coupling member **65** is achieved, and such amplitude is determined by the relationship of the masses of the rear section **70** and front section **75** which may be made effective to either magnify or reduce the amplitude of the vibrations received from the transducer crystals. The front section **75** may be permanently attached to the rear section **70,** or the front section **75,** or part thereof, may be provided with a threaded stud adapted to be screwed into a tapped hole in the end of the transmission member **65** for effecting rigid connection of a removable element thereto.

The rear end **56** of the casing of housing **52** has an electric connector or plug **115** connected thereto by means of a bushing **116,** which extends beyond the rear end of the housing **52** and may be secured thereto in any conventional manner. The connector **115** is seated at one end of the bushing **116** and adapted to mate with an opposite type connector **120;** i.e., female, such that electrical energy may be transmitted to the motor **50.**

The adapter **26** is designed to match the rear end of the housing **52** and includes a cavity **121** having a front

end **122** which abuts the rear end **56** with a wall portion **123** having an external diameter **124** that may be of the same outside diameter as the housing **52.** The female connector **120** is contained within a counterbore **125** having electrical contacts **126** and **128** and may be seated therein by a press fit such that the electrical terminals or prongs **129** and **130** and water feed **131** of the connector **115,** as seen in FIGS. **5** and **6,** are adapted to mate with the female receptacle **120** having receiving prongs or contacts **133, 134** and **138.** The terminals **129, 130** and **131** extend from the front of the connector **115** and the two power leads **104** and **112** are connected to **129** and **130** respectively and, in turn, to prongs **133** and **134** which connect to contacts **126** and **128** respectively. The sleeve **116** extends in telescopic relation to the adapter **26** and by a frictional fit extends within a seat **132** on the front of adapter housing **26.** The present embodiment of the ultrasonic motor system is adapted to have a fluid pass therethrough such that the instrument may be used as a water pick or dental prophylaxis unit and accordingly, fluid supply means **135** is provided in the form of a flexible tube or conduit **136** that extends through the sleeve **116** and is coupled to the receptacle **115** which in turn has its prong **131** that mates with prong **134** in receptacle **120** in a conventional manner. The conduit **136** extends from the receptacle **115** and through the axial bore **83** in the shaft **82** to be in axial alignment with the passageway **76** extending from the bottom surface or seat **72** to the tip **66** of the transmission member **65.** The conduit **136** may abut the bottom of the seat **72** and be retained in place by sealing means in the form of an o-ring **137** to afford a structurally fluid tight seal. Other means of coupling the front to the fluid connecting member **136** may be utilized in order to have a continuous flow of fluid, such as water, from a desired source, which may be from a tap or a mechanical pump as discussed with respect to FIGS. **1** and **2,** for maintaining a stream of fluid on a continuous or intermittent basis. The vibratory mechanical energy generated in the motor is in turn transmitted to the fluid through the front member as discussed in accordance with U.S. Pat. No. 3,547,110.

The contacts **126** and **128** have wires **140** and **141** connected thereto and liquid conduit **142** connects to terminal **134,** with all being contained within a flexible sheath **145** and together forming cable **24.** A stop member **146** firmly grips the sheath **145** and members therein.

FIGS. **7** and **8** illustrate an ultrasonic kit **10a** of a similar nature to that illustrated in FIGS. **1** and **2,** except that the entire kit **10a** is situated within a cabinet **12a** that is built within the wall **14a** of the home of the user **11a** and access to the accessories **25a** as well as the power On-Off switch **28a,** power regulation **30a** and fluid regulator switch **32a** are obtained by opening the door **150a** to the cabinet **12a.** As seen in particular with respect to FIG. **8,** the cabinet **12a** contains a lower shelf **13a** or wall having a plurality of openings **33a** and each opening adapted to receive therein an accessory **25a** which may be of the type discussed above with respect to FIGS. **1** and **2.** The upper portion of the cabinet **12a** contains an upper wall **151a** and a front panel **152a** through which the knob control switches **28a, 30a** and **32a** extend with the converter **15a** positioned on the upper wall **151a** and connected to the normal house current via cable **45a** and plug **46a.** An electrical power cable **154a** extends from the converter **15a** through the

upper wall **151a** and through a middle wall **155a,** which latter wall supports the reservoir **16a** which, as seen in FIG. **3** may be readily removed for replenishing the supply of liquid therein. The bottom of the reservoir **16a** is coupled to a fitting **156a** in which the power cable **154a** is connected to, and fluid supply and power supply merge into cable **24a,** and are then wound on a spring loaded or other commercially type available take-up or retracting means in the form of a reel **160a** such that the adapter **26a** from its retracted position as seen in FIG. **8** is retained in place by supporting means **35** with support arms or clips **36a,** mounted on panal **161a** to its extended position as seen in FIG. **7** so that it is ready for use by the user **11a.** The manner of operation is similar to that described in FIGS. **1** and **2,** and by supplying a spring loaded take-up reel **160a,** the problems of a loose cable **24a** are eliminated.

FIGS. **9–13** illustrate another form of accessory **25b** and adapter **26b** that may be utilized in accordance with the embodiments of the invention illustrated in FIGS. **1** and **2,** and **7** and **8,** and having an added feature of a removable element **165b.** The accessory **25b** includes an ultrasonic motor or transducer means **50b** contained in a tubular housing **52b** having a front end **54b** and a rear end **56b** with the outer wall **58b** of the housing **52b** having any desired contoured shape or configuration to facilitate it being handled by the user, and a tapered section **59b** terminating at the front end **54b** of the housing **52b** with a chamber or cavity means **60b** extending from the rear end **56b** of the housing **52b** and connected to an axial opening **62b** which in turn terminates at the front end **54b.**

As seen with respect to FIG. **10,** the ultrasonic motor **50b** in contained within the housing cavity **60b** and the hand piece housing **52b** may be of plastic or any other suitable material. The ultrasonic motor **50b** includes a transmission member **65b** terminating at a working output end or tip **66b** at one end thereof and having a rear surface or face **68b** at its opposite end. The transmission member **65b** may be designed in the form of an acoustical impedance transformer so that there is an increase in the amplitude of mechanical vibration from its rear face **68b** to its front tip **66b.** The actual variations of cross sectional area obtain the amplitude magnification is well known in the art. The transmission member **65b** may be of a metallic or plastic material depending upon its desired use with the removable element **165b** having a water feed through as shown in FIG. **4;** then the unit may be used for dentistry in the form of a dental prophylaxis unit by the dentist or in turn may be of a home consumer design to be used by the user in the home for maintaining tooth and gingival surfaces free of deposits normally contained on the teeth of the user. Essentially, the motor construction, as hereinafter described, for professional and home use, may be of similar design except that the relative poser for a home consumer unit would be less than that of a professional unit which is used by the dentist, since in the home the user is in a sense doing over a 6-month period what the dentist might be doing at one sitting in the dentist's office. Accordingly, the removable element **165b** may be of a plastic or metallic material depending upon the use thereof and the magnitude of ultrasonic mechanical vibrations to be imparted thereto.

The transmission member **65b** has a contoured radius **79b** connecting together the front section **75b** and the rear section **70b** of the transmission member **65b,**

which sections may be both of circular cross sectional area such that the front section **75b** extends out beyond the front end **54b** of the housing **52b** a sufficient distance and through the opening **62b** provided therefor. The transmission member **65b** may contain an annular depression **80b** and casing **52b** with an annular depression **166b,** for motor mounting means, illustrated to be in the form of an o-ring **81,** positioned in each of said depressions. Extending from the rear face **68b** of the transmission member **65b** is a support member or shaft **82b** that may be integrally formed therwith, and having an axially extending passageway or opening **83b.** The rear end of the support member **82b** has a threaded portion **86b** which receives locking means in the form of a nut **85b** threaded thereon and adapted to sandwich therebetween under a selected compressive static load a pair of driving piezoelectric crystals **88b** and **89b** and a third crystal **168b** forming part of the sensing means, that may be of a lead zirconator or lead titanate ceramic crystal material, formed so as to be either capable of ultrasonic vibrational activity in its longitudinal direction when activated by high frequency electrical impulses delivered to it, or detecting the frequency of the motor as will be described. The driving crystals have an external diameter **92b** and **93b** respectively, which is smaller than the internal diameter of the chamber **60b** such that sufficient clearance therebetween is obtained. The internal diameters **94b** and **95b** of the respective crystals **88b** and **89b** have a diameter which permits an insulating tubular sleeve **96b** to be positioned in surrounding relationship over the support member **82b,** and extends the length from the front face **98b** of crystal **88b** to at least the rear face **101b** of the crystal **89b.** The sleeve **96b** is made preferably from an insulative material such as plastic so as to isolate the crystals from the electrode **90b** that extends between the rear face **99b** of crystal **88b** and the front face of crystal **100b** of crystal **89b.**

To permit wiring of the motor, wire lead **104b** extends through the passageway **83b** with the support member **82b** having a longitudinally extending opening **102b** through the support member wall and through an opening **105b** in the insulator sleeve **96b** and terminating in a pocket **106b** within the disc shaped electrode **90b.** The wire **104b** is soldered or otherwise attached to the electrode **90b** for electrical purposes. The rear member **91b** fits in telescopic relationship to the support member **82b** and has an external diameter **108b** which is less than the internal diameter of the chamber **60b.**

A peripheral o-ring seat **109b** is provided on the support member **82b** and an o-ring seat **169b** is provided in the cavity **80b** for o-ring **110b** such that the mounting means for the motor **50b** in the housing means **52b** consists of spaced apart o-rings **81b** and **110b** such that the vibrational energy of the motor when energized, remains substantially isolated therein without the energy being transmitted to the housing **52b.** By providing o-ring seats in the housing **52b** as well as on the motor **50b** axial movement of the motor relative to the housing is substantially prevented when a force is applied to the removable element **165b.**

The motor **50b** illustrated in FIG. **10** has frequency sensing means in the form of a third crystal **168b** which abuts the rear member **91b** on one side thereof and an electrode **170b** on its opposite side with an insulating washer **172b** between the electrode **170b** and locking nut **35b.** A tubular sleeve **174b** of insulating material

extends on the support member **82b** at least the axial length of the crystal **168b,** electrode **170b** and washer **172b.** A wire lead **171b** is connected within a pocket **173b** and in turn is connected to the connector **115b.**

The nut **85b** forming the locking means is secured to the rear threaded portion **86b** on shaft **82b** and is tightened to the point where an axial compressive force is sufficient to compress the crystal **88b** electrode **90b,** crystal **89b,** rear section **91b,** crystal **168b** and electrode **170b,** with a predetermined amount of torque.

As part of the electrical connecting means, a ground lead or conductor **112b** is connected to a lug **114b,** a portion of which extends beneath the head of a screw **175b** that is screwed into nut **85b,** such that the power leads **104b** and **112b** are in turn connected to a power source as hereinafter explained.

The accessory **25b** in this form of the invention is seen to include element means **165b** that is designed to be removable from the front section **75b** of the motor **50b.** Various forms of the attachment may be employed so that the user may conveniently and quickly replace the element **165b** with minimal effort. One such form is shown in FIG. **10** in which the element means **165b** includes a neck portion **177b** terminating in a head portion **178b,** with the neck portion illustrated in the form of a cone. The neck portion may take various forms and shapes to permit the user to perform various jobs with them—such as a knife for cutting materials, a bent tip for various modes of vibration and permitting access to various areas, etc. The neck portion **117b** merges with a body portion **179b,** illustrated in the form of a hexagon nut to permit it to be gripped for tightening and loosening it relative to the motor **50b.** The fastening portion **180b** may be integrally formed with the body portion **179b** and may be in the form of threads to threadably engage a tapped portion in the front section **75b.**

To assist in tightening and loosening the removable element **165b,** securing means **181b** may be employed in the form of a pair of flats or slots **182b** to be gripped by a wrench. In this manner one wrench is applied at body portion **179b** and another at the slots **182b** and turned relative to each other until firmly secured in place.

To aid in assembly of the motor **50b** positioning means **185b** may be provided as seen in FIGS. **10** and **11** to prevent angular rotation, but not longitudinal displacement, of the rear member **91b** relative to the support member **82b** when the nut **85b** is tightened. The positioning means **185b** includes a transverse opening **186b** in the support member **82b** dimensioned to accept the lip **187b,** of a screw **188b** which is threadably engaged in the rear member **91b,** with a minimum of clearance. In this manner, the rear member **91b** moves in the longitudinal direction to compress the crystals **88b** and **89b** when the nut **85b** is rotated. At the completion of the assembly of the motor **50b,** the screw **188b** may be removed or held permanently in place by an epoxy (not shown).

The rear end **56b** of the casing or housing **52b** has an electric connector or plug **115b** connected thereto by means of a bushing **116b,** which extends beyond the rear end of the housing **52b** and may be secured thereto in any conventional manner. The connector **115b** is seated at one end of the bushing **116b** and adapted to mate with an opposite type connector **120b;** i.e., female, such that electrical energy may be transmitted to the motor **50b.**

The adapter **26b** is designed to match the rear end of the housing **52b** and includes a cavity **121b** having a front end **122b** which abuts the rear end **56b** with a wall portion **123b** having an external diameter **124b** that may be of the same outside diameter as the housing **52b.** The female connector **120b** is contained within a counterbore **125b** having electrical contacts **126b** and **128b** and may be seated therein by a press fit such that the electrical terminals or prongs **129b, 130b,** and **189b** of the connector **115b,** as seen in FIGS. **12** and **13,** are adapted to mate with the female receptacle **120b** having received prongs or contacts **133b, 190b,** and **138b.** The terminals **129b, 130b,** and **189b** extend from the front of the connector **115b** and the three power leads **104b, 112b,** and **171b** are connected to **129b, 130b,** and **189b** respectively and, in turn, to prongs **133b, 134b,** and **189b,** which connect to contacts **126b, 128b,** and **191b** respectively, as seen in FIG. **10.** The sleeve **116b** extends in telescopic relation to the adapter **26b** and by a frictional fit extends within a seat **132b** on the front of adapter housing **26b.** The present embodiment of the ultrasonic motor system may be adapted to have a fluid pass therethrough such that the instrument may be used as a water pick or dental prophylaxis unit and accordingly, may be of the design as illustrated in FIGS. **3–6.**

The contacts **126b, 128b** and **191b** have wires **140b, 141b** and **192b** connected thereto, with all being contained within a flexible sheath **145b** and together forming cable **24b.** A stop member **146** firmly grips the sheath **145b** and members therein.

The motor **50b** may have the current thereto controlled from either the convertor as illustrated in FIGS. **1** and **2,** or switching means **195b** may be provided on the instrument means on either the accessory **25b** or on the adapter **26b** as illustrated in FIGS. **9** and **10.** The switching means **195b** may include a switch **196b** contained within the adapter housing **26b** with a push button **197b** extending through the wall **123b** and externally of the adapter. Electrical leads **198b** and **199b** extend from the switch **196b** and are connected to the converter. The switch may be one of a variety of types commercially available.

FIGS. **14–18** illustrate another form of accessory **25c** and adapter **26c** that may be utilized in accordance with the embodiments of the invention illustrated in FIGS. **1** and **2;** and **7** and **8,** and having an added feature of the electrical coupling means **200c** contained within the housing **52c** so that the motor **50c** is coupled to electrical contacts without any wires extending from the motor **50c.** The accessory **25c** includes an ultrasonic motor or transducer means **50c** contained in a tubular housing **52c** having a front end **54c** and a rear end **56c** with the outer wall **58c** of the housing **52c** having any desired contoured shape or configuration to facilitate it being handled by the user, and a tapered section **59c** terminating at the front end **54c** of the housing **52c** with a chamber or cavity means **60c** extending from the rear end **56c** of the housing **52c** and connected to an axial opening **62c** which in turn terminates at the front end **54c.**

The transmission member **65c** has a contoured radius **79c** connecting together the front section **75c** and the rear section **70c** of the transmission member **65c,** which sections may be both of circular cross sectional area such that the front section **75c** extends out beyond the front end **54c** of the housing **52c** a sufficient distance and through the opening **62c** provided therefor.

Extending from the rear face **68c** of the transmission member **65c** is a support member or shaft **82c** that may be integrally formed therewith. The rear end of the support member **82c** has a threaded portion **86c** which receives locking means in the form of a nut **85c** threaded thereon and adapted to sandwich therebetween under a selected compressive static load a pair of driving piezoelectric crystals **88c** and **89c,** and a third crystal **168c** forming part of the sensing means, that may be of a lead zirconate or lead titanate ceramic crystal material, formed so as to be either capable of ultrasonic vibrational activity in its longitudinal direction when activated by high frequency of the motor, as will be described. The driving crystals have an external diameter **92c** and **93c** respectively, which is smaller than the internal diameter of the chamber **60c** such that sufficient clearance therebetween is obtained. The internal diameters **94c** and **95c** of the respective crustals **88c** and **89c** have a diameter which permits an insulating tubular sleeve **96c** to be positioned in surrounding relationship over the support member **82c,** and extends the length from the front face **98c** of crystal **88c** to at least the rear face **101c** of the crystal **89c.** The sleeve **96c** is made preferably from an insulative material such as plastic so as to isolate the crystals from the electrode **90c** that extends between the rear face **99c** of crystal **88c** and the front face of crystal **100c** of crystal **89c.** The rear member **91c** fits in telescopic relationship to the support member **82c** and has an external diameter **108c** which is less than the internal diameter of the chamber **60c.**

The transmission member **65c** may contain an annular depression **166c,** for motor mounting means, illustrated to be in the form of an o-ring **81c,** positioned in each of said depressions. A peripheral o-ring seat **169c** is provided in the cavity **60c** for o-ring **110c** such that the mounting means for the motor **50c** in the housing means **52c** consists of spaced apart o-rings **81c** and **110c** such that the vibrational energy of the motor when energized, remains substantially isolated therein without the energy being transmitted to the housing **52c.** By providing o-ring seats in the housing **52c,** as well as on the motor **50c,** axial movement of the motor relative to the housing is substantially prevented when a force is applied.

The motor **50c** illustrated in FIG. **15** has frequency sensing means in the form of a third crystal **168c** which abuts the rear member **91c** on one side thereof and an electrode **170c** on its opposite side with an insulating washer **172c** between the electrode **170c** and locking nut **35c.** A tubular sleeve **174c** of insulating material extends on the support member **82c** at least the axial length of the crystal **168c,** electrode **170c** and washer **172c.**

The nut **85c** forming the locking means is secured to the rear threaded portion **86c** on shaft **82c** and is tightened to the point where an axial compressive force is sufficient to compress the crystal **88c** electrode **90c,** crystal **89c,** a rear section **91c,** crystal **168c** and electrode **170c** with a predetermined amount of torque.

To aid in assembly of the motor **50c** positioning means **185c** may be provided as seen in FIGS. **15** and **16** to prevent angular rotation, but not longitudinal direction, of the rear member **91c** relative to the support member **82c** when the nut **85c** is tightened. The positioning means **185c** includes a transverse opening **186c** in the support member **82c** dimensioned to accept the lip **187c** of a screw **188c** which is threadably

engaged in the rear member **91c,** with a minimum of clearance. In this manner, the rear member **91c** moves in a linear path to compress the crystals **88c** and **89c** when the nut **85c** is rotated. At the completion of the assembly of the motor **50c,** the screw **188c** may be removed or held permanently in place by an epoxy (not shown).

The adapter **26c** is designed to match the rear end of the housing **52c** and includes a cavity **121c** having a front end **122c** which abuts the rear end **56c** with a wall portion **123c** having an external diameter **124c** that may be of the same outside diameter as the housing **52c.** The female connector **120c** is contained within a counterbore **125c** and may be seated therein by a press fit such that the electrical terminals or prongs of the connector **115c** are adapted to mate with the female receptacle **120c** having receiving prongs or contacts. The connector **115c** extends in telescopic relation to the adapter **26c** and fits within a seat **132c** on the front of adapter housing **26c.** The present embodiment of the ultrasonic motor system may be adapted to have a fluid pass therethrough.

In this embodiment of the invention, electrical coupling means **200c** is utilized such that the motor **50c** is merely placed within the cavity **60c** and held in place by the o-rings, or other mounting means; and complete electrical contact is accomplished such that no actual wiring of the motor takes place. In this manner, for high production quantities particularly, the problem of a soldered lead breaking due to the vibratory stress generated is eliminated. In addition, by molding in the electrical contacts within say a plastic housing, further savings are obtained in manufacturing costs. Essentially the wire leads are incorporated within the housing **52c** as seen in FIGS. **15, 17** and **18.**

The contact lead to the electrode **90c** is a filament **104c** that has a front hooked or bent section **202c** contained in a pocket or recess **204c** that is adapted to engage and transmit pressural contact thereagainst to couple the electrical energy thereto. The filament **104c** may have a rectangular, circular or other cross-section, and extends substantially the length of the housing **52c** and terminates openly in a rear recess **206c** with a contoured portion **208c** contained therein. The rear electrode **170c** has electrical energy coupled thereto by means of filament **171c** embodied in the casing **52c** and having a front contoured portion **208c** contained in a front recess **210c** with a rear portion **211c** in a rear recess **212c.**

Switching means **195c** is contained in the accessory **25c** and adapted to be engaged by the user when operation of the motor is desired. The switching means **195c** includes a switch **196c** having a push button or contact **197c** that extends beyond the housing for finger engagement and is coupled to a contact element **214c** with its free end, contained within a cavity **215c** contained within the housing **52c.**

The switch **196c** has the contact element **214c** embedded within the housing wall and extending therethrough and terminating in a rear cavity **216c** which has therein the bent portion **217c** of the contact element **214c** such that a certain degree of rigidity is provided as hereinafter discussed. The other electrical contact of the switch is provided in the form of a similarly contained electrical element **218c** that terminates in the cavity **215c** in a contoured section **219c** such that, upon depression of the push button **197c,** contact is made between the element **214c** and the curved

portion **219c,** such that in a normal conventional manner the circuit is closed and current from the converter is transmitted to the ultrasonic motor **50c.** The rear of the element **218c** similarly has a curved section **220** which terminates in a pocket on cavity **221c.** The switch may obviously take many forms and is positioned for ready access between the user's finger when in those instances it is desirable to first obtain the output end of the ultrasonic motor and the member to which the ultrasonic energy is to be transmitted. This permits an easier positionment of the motor tip since, upon energizing, there is immediate movement between the tip and the work piece; and, accordingly, there are those instances where the switch is desired to be positioned as illustrated in FIGS. **14–18.** The electrical coupling means **200c** as herein described may be encapsulated within the plastic housing in the manufacturing process thereof, such that in actual assembly the motor **50c** is pre-assembled and need merely be positioned within the housing in a keyed manner. In this manner upon the o-rings being positioned in the seats provided, the electrodes **90c** and **170c** are in relative axial position for contact with electrical elements. This is an important feature of this embodiment of the invention in that it permits mass production of ultrasonic motors in a housing where there is no wiring or solder joints on the respective motor or housing, or therebetween.

Once the motor is contained within the housing **52c,** then the connector **115c** is positioned within the cavity **60c** as disclosed and in this embodiment of the invention electrical contacts are provided to engage the respective electrical contacts described above. Accordingly, electrical contact **223c** meets with electrode **171c,** contact **224c** meets with electrode **104c,** contact **225c** meets with the element **218c,** and contact **226c** meets with **214c.** In turn, the respective contacts are pre-wired or otherwise molded so that their respective pins of connector **115c** meet with the connector **120c** in a conventional manner.

In order to assure proper orientation of connector **115c** relative to the housing **124c,** positioning means **230c** is provided in the form of a keyway or depression **231c** on the connector **115c** and a complimentary nib or tooth **232c** is provided, as seen in FIG. **15,** on the casing **124c,** such that the user may easily orient the connector **115c** relative to the casing **124c.**

The connecting pins on the connector **115c** are wired via **120c.** Five of such connections are shown in that nut **85c** similarly has an electrode portion connecting it via element **222c** partially seen in FIG. **15.** Accordingly, the contact **104c,** through contact **224c,** is wired to contact **128c** and in turn to wire **141c.** Contact **171c** is wired through **223c** to contact **191c** and in turn through wire **192c.** Contact **222c** is wired to contact **126** and in turn to wire **140c.** Contact **225c** is in turn wired to contact **233c** and in turn wire **198c.** Contact **226c** is in turn wired to contact **234c** and in turn **199c.** Accordingly, all the wires fit through sleeve **145c** and are in turn wired to their respected designated positions within the converter.

FIGS. **19–22** illustrate a kit **10d** that includes instrument means **22d** with a plurality of interchangeable elements **165b** adapted to be removably secured to the output section of the accessory **25d** and having a converor **15d** which, as seen in FIG. **21,** is of a size in that the male prongs **235d** will extend outwardly from one edge of the converter **15d** and are adapted to be

plugged into a wall outlet **236d.** In this manner the user essentially does not have to position his convertor on a table or other working area but may merely plug into the wall outlet **236d** the ultrasonic convertor and by means of the cable **24d** operated by switching means **195d,** on the accessory **25d,** may readily perform whatever function he desires. As seen in FIG. **20,** we have a model plastic airplane **238d** that may be included as part of the kit **10d** such that the user **11d,** upon purchase of the kit **10d,** has contained therein one or more models, or other items, to be worked upon utilizing the ultrasonic instrument means **22d** packaged with the kit.

As seen in FIG. **20,** the ultrasonic element **165d** is interposed between the mating joints of the airplane and by moving same at the joint a flow of plastic occurs which is sufficient to cause a fusion of the plastic parts. The kit **10d** further includes in its carton or other packaging means **240d,** with cover **241d,** a number or removable elements in various shapes and forms. Those illustrated are with a pointed tip element **178d** as in FIGS. **9** and **10,** for use as in FIG. **20** for plastic assembly, a knife element **242d** as seen in FIG. **21,** and a round pointed element **244d** as seen in use in FIG. **22.** Accordingly, the kit is adaptable for use in a great variety of hobby-craft applications and as such a supply of disposable parts **245d** may be contained in a container **246d** in the kit **10d.** The disposable parts **245d** may be of plastic, metal or other material.

Accordingly, all types of plastic, glass, metal, wood, leather, and other materials may be worked upon with the kit **10d.** As seen in FIG. **20** the instrument means **22d** is used by the user **11d** to assemble a plastic model and control the power by the finger tip switching means **195d.**

FIG. **21** illustrates the removable element **165d** in the form of a knife element **242d.** Accordingly, a number of accessories **25d** may be purchased by the user, such that even if the elements are removable, the user may have the ones he uses most often already assembled to an accessory **25d** which is quickly and easily removed from the adapter **26d.** This type of system gives the user maximum flexibility between interchangeability of the accessory and the removable elements to be used. Further, the convertor **15d** is plugged directly into the wall outlet **236d** for the convenience of the user.

FIG. **22** illustrates yet another application in which the instrument means **22d,** connected to the power cable **24d** and in turn to the convertor **15d,** is plugged within the wall outlet **236d.** In operation the finger switching means **195d** is used to vibrate the removable element **244d** which is in contact with a wood member **248d** such as for wood burning or other applications.

FIGS. **23** and **24** illustrate another form of kit **10e** that may be used by the hobbyist to perform a series of applications, some of which are hereinafter illustrated in FIGS. **25–28.** In contrast to the kit illustrated in FIG. **19,** the present kit as seen in FIG. **23** includes a container **15e** that could be battery powered or plugged in a wall outlet and having an on/off switch **28e** contained on the cabinet as well as a power control adjustment knob **20e** such that the power to perform a special application may be properly adjusted by the user **11e** as seen in FIG. **25**

The kit includes a converter **15e** contained within packaging means or cartion **240e** having a cover **241e** for shipment. The instrument means **22e** is seen to include an adapter **26e** having the power cord **24e** adapted to be plugged in the convertor **15e** as seen in

FIG. **24.** The accessory **25e** is of the type to be removed from the adapter **26e** and designed to accept a plurality of interchangeable, removable elements illustrated in the form of a bent or shaped tip **252e,** an assembly element **253e** for use as seen in FIGS. **25–27,** an element **251e** which may have a rounded tip, the element **250e** which may be in the form of a thin spatula for mixing, welding or other applications.

To facilitate the use of the kit **10e** by the user, a number of peripheral items may be provided so that the user, upon purchase of the kit may be able to begin use thereof with what is provided in the kit. For example, the container **246e** is provided having a number of clips **245e** that may be in the form of plastic or other type fasteners such as illustrated with respect to FIGS. **25–27.** In addition, plastic sheet material or even wood members or elements **257e** may be provided such as for wood burning or other uses. Container **259e** is provided for various plastic or leather strips or filaments to be used for artistic craft work or other uses that the hobbyist may find.

It will be noted that a finger switch is also provided on the accessory **25e** such that once the user places the power on by switch **28e** the convertor may be in the on position such that instantaneous power will be available at the removable element **252e** upon engagement of the finger switch by the user.

FIGS. **25–28** illustrate further usage of the ultrasonic apparatus. At the present time, erector sets normally utilize metallic nuts and bolts to assemble the respective components thereof. As seen with respect to FIG. **25,** metallic components **254e** and **255e** of the erector set are assembled by using a plastic rivet **256e** having its head at one end thereof in a nest **258e** and the ultrasonic instrument **22e** held by the user **11e** with a removable element **253e** having a pocket for containment of the shaft of the rivet **256e.** In this manner the energy is applied with a static force in the direction of the arrows **259e,** and the kinetic energy imparted to the rivet by the ultrasonic mechanical vibrations effects the flow of the plastic and a head **260e** is formed as seen in FIG. **26.**

FIGS. **27** and **28** illustrate a vel fastener adapted to be jointed with ultrasonic energy and including a first fastening element or portion **261e** having a head portion **262e** in a nest **258e,** and a tubular shaft **263e** with an axial bore **268e** contained therein and a second fastening element **265e** having a head portion **266e** and a shank shaft **267e** adapted to be contained within the axial bore **268e** of the shaft **263e.** As seen, the two elements **261e** and **265e** are to be assembled with one head **262e** resting in the nest **258e** and the second head **266e** coupled to the ultrasonic motor tool with ultrasonic vibrations applied thereto by the instrument **22e** in the direction of the doubleheaded arrow **269e** to assemble parts **254e** and **255e.** The dimensional relationship between the inner bore **268e** and the outer diameter of the shaft **267e** is such that there is a minimal spacing of 0.0005 inches for the diameters of the shaft **267e** in the range of diameter of 0.032 inch to 1 inch such that a flow of the plastic first occurs to form a molecular bond between the respective circular of other cross-sectional areas of the fastening elements **261e** and **265e.**

FIG. **28** shows the removal of a head **266e** of a rivet, either as formed in FIGS. **25** and **26,** or FIG. **27** with an ultrasonic tool **252e** that permits the user to quickly

disassemble his erector set by shearing off the heads of the plastic rivets and separate the parts **254e** and **255e.**

FIG. **29** illustrates one form of electronic converter circuit **15f** that is designed to be used with the type of motor **50f** having two crystals **88f** and **89f** with the electrode **90f** therebetween, and generally illustrated in FIGS. **3–6.** The motor **50f** further includes a rear portion **91f** and locking means in the form of a nut **85f** with a wire **112f** extending from the motor to point of ground or reference potential and a wire **104f** extending from the electrode **90f** and wired to the converter **15f** as hereinafter discussed.

More particularly now, the converter **15f** includes a transistor **280** arranged in a driving circuit to provide an output oscillatory signal coupled to the motor **50f** to drive or induce ultrasonic vibrations in the piezoelectric crystals **88f** and **89f.** The transistor **280** which is shown as an N-P-N type, has its collector electrode **281** connected through an R.F. choke **282** to the junction of a fixed value resistor **283** and a variable resistor **284.** The other end of the resistor **283** is connected to the base electrode **298** of the transistor **280** and one end of a secondary winding **285** of a transformer **286.** The other end of the winding **285** is grounded. A capacitor **287** is connected in parallel with the transformer secondary winding **285** to provide a tank circuit resonant at the desired frequency of oscillation. An output coupling of the developed oscillatory signal is via the transformer primary winding **288** connected between the transistor collector electrode **281** and the motor driving electrode **90f.** The collector electrode **281** is coupled to ground through an isolating capacitor **289.** The emitter electrode **290** of the transistor **280** is coupled to ground through a bias resistor **291.** Resistor **291** is bypassed to ground by a capacitor **292.**

D.C. operating power for the oscillator may be provided by a standard type half wave rectifier power supply circuit, as shown for example in FIG. **29** as comprising a resistor **293** in series with a diode **294** and connected across the secondary winding of a transformer **295.** A filter capacitor **297** is connected across the resistor **293.** The transformer primary is connected through a suitable on-off switch **296** to an A.C. voltage source D.C. voltage is supplied to the oscillator circuit via a lead connection from the variable resistor **284** to a tap on the resistor **293.**

Operation of the driving circuit of FIG. **29** is as follows. The variable resistor **284** is adjusted to provide a suitable operating potential for the transistor collector electrode **281.** When switch **296** is closed to apply power to the driving circuit, piezoelectric crystals **88f** and **89f** start oscillating at the desired frequency and a plurality of harmonic and subharmonic frequencies of said desired frequency. These oscillations are applied through transformer primary winding **286** to the resonant tank formed by capacitor **287** and transformer secondary winding **285.** This resonant tank is designed so as to pass only the desired frequency and to switch transistor **280** "on" and "off" at said desired frequency. In this manner, a driving signal is applied to crystals **88f** and **89f** to sustain the oscillations thereof and the ultrasonic vibrations of motor **50f** at the desired frequency.

FIG. **30** is similar to FIG. **29** except that in the electronic circuit **15g** the A.C. to D.C. power supply circuit has been replaced by a battery **298** or straight D.C. power supply.

Turning now to FIG. **31**, there is illustrated an electronic circuit **15h** adapted for use with the ultrasonic motor **50h** which may be of the type illustrated in FIGS. **9–18**, inclusive, and which includes a pair of driving crystals **88h** and **89h**, with the electrode **90h** therebetween, with a rear member **91h** coupled to an electrode **170h** and a feedback crystal **168h** with a rear locking nut **85h**. Electrode **90h** is connected by wire **104h** to the circuit and electrode **170h** by wire **171h**. The unit is grounded by wire **112h**.

The oscillator circuit for driving the motor **50h** includes a transistor **300**, having its base electrode **301** connected to the junction of a capacitor **302** and resistors **303** and **304**. Resistor **304** is returned via the primary winding **305** of a transformer **306** to the collector electrode **307** of the transistor **300**. The emitter electrode **308** of the transistor **300** is connected to ground through a resistor **309**. The other end of resistor **303** is also connected to ground. The capacitor **302** is series connected to a variable inductor **310** which is tuned with the capacitor **302** to be series resonant at the desired frequency of vibration for the motor driving crystal **90h**. A signal attenuating resistor means **311** series connects the inductor **310** to a feedback crystal **170h** in the motor **50h**. Operating potential for the circuit is supplied from an A.C. to D.C. power supply **312**, similar to that shown in FIG. **29**. Connection of the power supply D.C. output voltage to the oscillator circuit is via lead **313** to the transformer primary winding **305** and ground lead **314**. The oscillator output drive signal is coupled to the motor **50h** and electrode **90h** via the transformer secondary winding **315**.

Operation of the circuit is as follows:

When the circuit **15h** is energized, as by closing of the power supply on-off switch, the sudden surge of current therefrom will drive the crystals **88h** and **89h** into a vibratory mode of operation. The vibrations of crystal **88h** and **89h** will in turn induce vibrations in the feedback crystal **168h** and the vibrations or oscillatory output of crystal **168h** is fed back to the base input of the transistor **300** via the inductor **310** and capacitor **302** network. Since the induced vibrations in the crystal may be harmonic and/or subharmonic of the crystal fundamental frequency, the inductor-capacitor feedback network is turned to be series resonant at the desired frequency of vibration for the motor **50h**. The transistor **300** operates as an amplifier so that at this series resonant frequency, the feedback signal to the base input of the transistor **300** will be at a level to provide a sufficient signal output from the transistor **300** for coupling via the transformer **306** to the crystals **88h** and **89h** to sustain the crystal vibrations at the desired or tuned frequency of the series resonant circuit.

FIG. **32** is similar to FIG. **31** except that in the circuit **15j** the A.C. to D.C. power supply circuit has been replaced by a battery **316**. Operation of the circuit is the same as was heretofore described with respect to FIG. **31**.

CONCLUSION

Applicants have herein disclosed new and novel apparatus and kits to be utilized for the home consumer, professional and industrial markets. The kits of the present invention are multi-functional and provide a major breakthrough into the home consumer field on an economical basis.

Although illustrative embodiments of the invention have been described in detail herein with reference to the accompanying drawing, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein without departing from the scope or spirit of the invention, except as defined in the appended claims.

We claim:

1. An ultrasonic system including

A. a cabinet;

B. driving circuit means for providing an electrical driving signal of a desired ultrasonic frequency including tuned circuit means tuned to said desired frequency for controlling the frequency of said driving signal;

C. adapter means including a first connector coupled to said driving circuit means for transmission of said driving signal;

D. a plurality of means each adapted to be interchangeable with each other and releasably connected to said adapter means and forming part thereof to permit a variety of applications to be performed, said adapter means and interchangeable means when assembled being adapted to be hand held by a user and including:

1. a housing means capable of being hand held,

2. an ultrasonic motor capable of vibration at more than one frequency including said desired frequency mounted within at least a portion of said housing means and having a portion extending outside of said housing means portion for transmission of high frequency mechanical vibrations, said ultrasonic motor including:

a. a transmission member having a rear section and a front section with an output end for transmitting the generated mechanical vibrations,

b. transducer means connected to said rear section, said interchangeable means being in the form of an accessory [forming part of said instrument means when assembled therewith and] including said motor, said housing means portion, and a second connector mounted on said housing means portion adapted to be releasably connected to said adapter means first connector for electrically coupling said driving circuit means and said transducer means when in its assembled position through said connectors,

E. means for applying to said tuned circuit means a detected signal representative of the frequencies of vibration of said motor, said tuned circuit means responding to the desired frequency portion of said detected signal to cause said driving signal means to produce a driving signal of said desired frequency; and

F. a support means associated with said cabinet for holding said assembled adapter means and interchangeable means in fixed position relative to said cabinet when not in use.

2. An ultrasonic system as defined in claim **1**, including a plurality of interchangeable elements adapted to be removably secured to said transmission member front section of at least one of said interchangeable means for transmission of the ultrasonic mechanical vibrations.

3. An ultrasonic system defined in claim **1**, wherein at least one of said interchangeable means includes a

razor connected to said motor for driving said razor at an ultrasonic rate.

4. An ultrasonic system as defined in claim **1**, wherein at least one of said interchangeable means includes a toothbrush connected to said motor for driving said toothbrush at an ultrasonic rate.

5. An ultrasonic system as defined by claim **1**, wherein at least one of said interchangeable means includes an applicator having a passageway extending therethrough for a stream of liquid and adapted for use in the oral cavity for treating the gingival and tooth structures for hygienic control thereof.

6. An ultrasonic system as defined in claim **1**, and further including liquid reservoir means in said cabinet communicating with said adapter means to provide a supply of liquid to the accessory connected to said adapter means.

7. An ultrasonic system as defined in claim **1**, wherein

A. said transmission means is elongated, said front section having a smaller cross-sectional area then said rear section to act as an accoustical impedance transformer to amplify the mechanical vibrations transmitted to said rear section and transmitted by said front section,

B. said ultrasonic motor including support means extending longitudinally from said rear section,

C. said transducer means being piezoelectric, positioned on said support means and electrically connected to said first connector,

D. said ultrasonic motor further including a rear member mounted in telescopic relation to said transducer means, and

E. locking means to maintain said transmission means, transducer means, and rear member under compression.

8. An ultrasonic system as defined in claim **7**, wherein said locking means includes a nut threadably engaged on said support means to compress said transmission means, transducer means and rear member to maintain said compression.

9. An ultrasonic system as defined in claim **8**, and further including mounting means for said motor to maintain said motor in fixed position relative to said housing means.

10. An ultrasonic system as defined in claim **7**:

a. wherein said transducer means includes a pair of piezoelectric discs mounted on said support means,

b. a disc-shaped electrode mounted between said crystal discs, and

c. means for insulating said piezoelectric discs and said electrode from said support means.

11. An ultrasonic system as defined in claim **1**, wherein said driving circuit means includes a power supply for producing a power signal; switch means for controlling the transmission of said power signal as a driving signal to said transducer means; and transformer means having a primary and a secondary winding; said tuned circuit means including capacitor means connected in parallel with said secondary winding; said means for applying said detected signal including said primary winding and means for electrically coupling said power supply through said primary winding to said transducer means.

12. An ultrasonic system as defined in claim **1**, wherein said means for applying said detected signal includes sening means mechanically coupled to said motor for detecting the frequencies of vibration thereof

and producing said detected signal, and electrical conductor means for transmitting said detected signal through said first and second connectors to said driving circuit means, said driving circuit means including amplifier means having an input and an outut, said tuned circuit means being connected intermediate said conductor means and said amplifier means input and being adapted to filter said detected signal and pass to said amplifier means input the component of said detected signal of said desired frequency, said driving circuit means further including means operatively coupling said amplifier means output and said first connector for transmission of said driving signal.

13. An ultrasonic system as defined in claim **1**, and further including power switching means contained on said housing means and adapted to be engaged by a user during operation of the system.

14. An ultrasonic system as defined in claim **13**, wherein said swithcing means is contained on the interchangeable means.

15. An ultrasonic system as defined in claim **13**, wherein said switching means is contained on the adapter means.

16. An ultrasonic system as defined in claim **1**, and further including electrical coupling means extending between said motor and said second connector, said coupling means being at least in part embedded within said housing means wall and exposed at at least one end thereof to engage said motor to make electrical contact therewith.

17. An ultrasonic kit, including:

A. ultrasonic instrument means adapted to be hand held by the user thereof and having an ultrasonic motor capable of vibrating at more than one frequency;

B. driving circuit means for providing an ultrasonic driving signal of a desired frequency for energizing said ultrasonic instruments means, and adapted to be connected to said motor, said driving circuit means including tuned circuit means tuned to said desired frequency for controlling the frequency of said driving signal;

C. means for applying to said tuned circuit means a detected signal representative of the frequencies of vibration of said motor, said tuned circuit means responding to the desired frequency portion of said detected signal to cause said driving circuit means to produce a driving signal of said desired frequency;

D. interchangeable means each adapted to be removably secured to the front end of said ultrasonic instrument means to permit a variety of applications of ultrasonic mechanical vibrations to selected objects for various results, and

E. a container for retaining said ultrasonic instrument means, driving circuit means, and interchangeable means.

18. An ultrasonic kit as defined in claim **17**, including electrical plug means for connection to an electrical outlet, said driving circuit means being mounted in said plug means.

19. An ultrasonic kit as defined in claim **17**, including a battery for powering said [converter] *driving circuit means*, said battery being mounted in said container.

20. An ultrasonic kit as defined in claim **17**, and further including plastic parts to be assembled by said ultrasonic instrument means.

21. An ultrasonic kit as defined in claim **20**, wherein said plastic parts form a plastic hobby model.

22. An ultrasonic kit as defined in claim **20**, wherein said plastic parts are in the form of fasteners.

23. An ultrasonic kit as defined in claim **17**, wherein said ultrasonic instrument means includes manual control switch means for selectively actuating said motor.

24. An ultrasonic kit as defined in claim **17**, wherein said interchangeable means includes a cutting tool.

25. An ultrasonic kit as defined in claim **17**, wherein said interchangeable means includes a heating tool.

26. An ultrasonic kit as defined in claim **17**, wherein said driving circuit means includes a power supply for producing a power signal; switch means for controlling the transmision of said power signal as a driving signal to said motor; and transformer means having a primary and a secondary winding; said tuned circuit means including capacitor means connected in parallel with said secondary winding; said means for applying said detected signal including said primary winding and means for electrically coupling said power supply through said primary winding to said motor.

27. An ultrasonic kit as defined in claim **17**, wherein said means for applying said detected signal includes sensing means mechanically coupled to said motor and electrically coupled to said driving circuit means for detecting the frequencies of vibration thereof and producing said detected signal, said driving circuit means including amplifier means having an input and an output, said tuned circuit means being connected intermediate said sensing means and said amplifier means input and being adapted to filter said detected signal and pass to said amplifier means input the component of said detected signal of said desired frequency, said driving circuit means further including means operatively coupling said amplifier means output and said motor for transmission of said driving signal.

28. A system for use in the home for hygienic purposes, comprising:

A. a housing adapted to be mounted on a wall in the home having an access opening;

B. a door connected to said housing and adapted to close the access opening and being movable to open the access opening;

C. driving circuit means in said housing for converting conventional home electrical current to an electrical driving signal oscillating at a desired ultrasonic frequency, including tuned circuit means tuned to said desired frequency for controlling the frequency of said driving signal; and

D. ultrasonic instrument means in said housing adapted to be hand held by the user, and having an electrical cable connected to said converter, said ultrasonic instrument means being removable through the access opening when said door is opened to permit use of said ultrasonic means with the inner end of the cord being retained within said housing, said instrument means being adapted to

be used for hygienic purposes, and having a motor capable of vibrating at more than one frequency including said desired frequency.

29. The system as defined in claim **28**, and further including a reel on which said cable is wound to provide retractable means therefore.

30. The system as defined in claim **28**, wherein said instrument means includes an adapter having said cable connected thereto and an accessory removably connected to said adapter and having one end thereof for said hygienic purpose, said accessory including:

A. an ultrasonic motor for producing mechanical vibrations;

B. an output section coupled to said motor for transmitting the generated mechanical vibrations;

C. housing means enclosing said motor; [and]

D. electrical connecting means mounted on said housing means and connected to said motor, said connecting means being adapted to be releasably connected to said adapter for the transmission of electrical energy to said motor, when in its assembled position [.] ; *and*

E. means for applying to said tuned circuit means a detected signal representative of the frequencies of vibration of said motor, said tuned circuit means responding to the desired frequency portion of said detected signal to cause said driving circuit means to produce a driving signal of said desired frequency.

31. A system as defined in claim **30**, wherein said accessory is in the form of a razor and includes an ultrasonic motor electrically connected through said adapted to said driving circuit means for driving said razor at the ultrasonic rate.

32. A system as defined in claim **30**, wherein said accessory is in the form of a toothbrush and includes an ultrasonic motor electrically connected through said adapter to said driving circuit means, for driving said toothbrush at an ultrasonic rate.

33. The system as defined in claim **30**, and further including reservoir means contained in said housing for containing a liquid, said reservoir means being coupled to said cable, said cable and adapter including a passageway to supply liquid to said accessory, and pumping means in communicating relationship to said reservoir means for supplying said liquid to said instrument means, said accessory being in the form of an applicator having a passageway extending therethrough for a stream of liquid and adapted for use in the oral cavity for treating the gingival and tooth structures for hygienic control thereof, said accessory containing an ultrasonic motor electrically connected through said adapter to said driving circuit means to inpart vibratory energy to said applicator.

34. The system as defined in claim **28**, and further including power switching means on said instrument means for manual operation by the user during use.

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