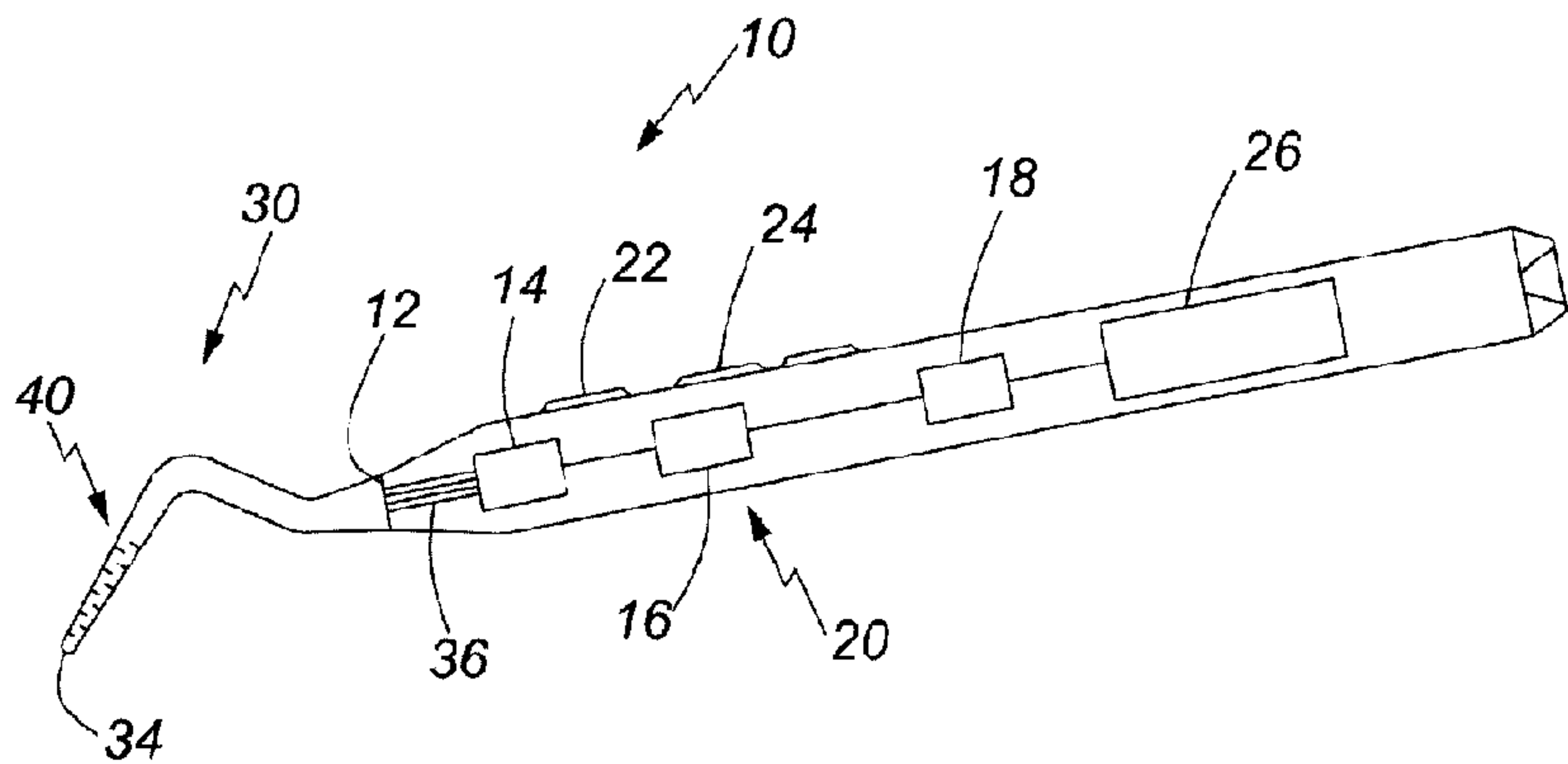




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(57) Abrégé/Abstract:
A periodontal probe is provided for measuring a depth of a periodontal pocket using a touch sensor. The periodontal probe includes a handle with a probe tip for insertion into the periodontal pocket. The probe tip includes a touch sensitive reader located on or near an exterior surface thereof for measuring contact between the exterior surface of the probe tip and the tissue of the periodontal pocket. A touch sensor and a microcontroller are connected to the touch sensitive reader to measure the amount of contact between the touch sensitive reader and the tissue of the periodontal pocket, which corresponds to the depth of the periodontal pocket.

ABSTRACT

A periodontal probe is provided for measuring a depth of a periodontal pocket using a touch sensor. The periodontal probe includes a handle with a probe tip for insertion into the periodontal pocket. The probe tip includes a touch sensitive reader located on or near an exterior surface thereof for measuring contact between the exterior surface of the probe tip and the tissue of the periodontal pocket. A touch sensor and a microcontroller are connected to the touch sensitive reader to measure the amount of contact between the touch sensitive reader and the tissue of the periodontal pocket, which corresponds to the depth of the periodontal pocket.

PERIODONTAL PROBE WITH TOUCH SENSING

FIELD

[0001] This invention relates to the field of dentistry, specifically the periodontal diagnostic area. In particular, this invention relates to a periodontal probe having an electronic recording capability, which accurately measures and records the depth of the periodontal pocket surrounding a tooth.

BACKGROUND

[0002] In the dental field periodontal disease is known to be a progressive, plaque-induced disease. Periodontal disease can cause serious tissue inflammation and even bone loss in the areas surrounding the teeth of those afflicted. To effectively treat periodontal disease it is essential to monitor the progression of the disease in the mouths of patients. To monitor the progression of periodontal disease a dental professional periodically measures the depths of the periodontal pockets surrounding the teeth.

[0003] The periodontal pocket is the physical distance from the top of the gingival tissue surrounding a tooth, to the depth that a probe will physically extend, until contact pressure impedes the probe from entering the pocket any further. This is usually at the level where the epithelial attachment starts between the gum and tooth root. As periodontal changes occur, the relative depth of the periodontal pocket increases. Measurements are usually taken in millimeters.

[0004] In the dental setting, accurately and thoroughly measuring the peridontium can be time consuming and tedious. Conventional probing, still utilized by most dental offices, requires the operator to stop and record the depth of the periodontal pocket at least after the measurement of every tooth, or an assistant is required to record the measurements. Traditionally, the measurements are manually written on the patient's chart. The process of measuring and recording is repeated for each periodontal pocket to be measured.

[0005] Conventional probes have lines, marks or colours to indicate the depth that the probe penetrates into the pocket between the tooth and the gum. The dental professional has to manually read the depth of the probe. Probes are small and such readings are difficult to make accurately. Very small differences can be important in monitoring the progression of periodontal disease. There is also a problem of subjectivity. Different dental professionals may have different techniques or may view the periodontal probe at a different angle when taking measurements on different days. Different measurement techniques are a significant problem in offices with multiple hygienists or dentists, as each practitioner could employ a different measuring technique for the same patient during different visits.

[0006] Aside from conventional graduated probes, many instruments exist to measure the depth of the periodontal pocket. One of these devices is the electronic periodontal probe with a constant force applier, also known by the trademark FLORIDA PROBE™, which is described in U.S. Patent No. 4,791,940, and Canadian Patent No. 1,282,236 to Hirschfeld et al. This probe and recording apparatus uses a spring tension device electronically connected by a transducer to the recording apparatus. The probe tip, attached to a movable or mechanical arm,

moves within a narrow sleeve fixed to a probe handle. When the probe tip rests at the bottom of the pocket, the probe handle is pressed until the sleeve end touches the gingival margin. The subsequent exposed length above the sleeve represents the depth of the pocket. A foot switch triggers electronic measurement from the mechanical displacement of the transducer to the recording apparatus. This probe has several disadvantages. First, the mechanical moving parts in the narrow sleeve, arm, handle and spring are all subject to loss of integrity that may change the consistency of the force required to allow spring tension transduction. Second, the probe tip needs to be removed for sterilization. Third, the height from probe tip to the top of the mechanical moving arm may make it difficult to obtain readings in the back of the mouth where there is less room. Furthermore, the size may make it difficult to get proper readings in patients with limited opening ability.

[0007] U.S. Patent No. 4,995,403 to Beckman et al. describes a periodontal probe with a retractable fiber element for measuring. Again, there are movable parts that are subject to frictional inaccuracies in measurement. Also, a large portion of the instrument is not sterilizable and needs to be disposed of, making the overall length of the device substantial. The large length can create issues in positioning the probe for measuring and can be cumbersome and uncomfortable for a dental professional to use.

[0008] Another example of a movable sleeve and tip is described in U.S. Patent No. 5,993,209 to Matoba et al. This device detects positional differences between the tip of the probe and the tip of the sleeve when the tip of the probe is inserted into the bottom of the pocket and the sleeve is at the top of the gingiva. Again, movable parts are a disadvantage and all the

components comprising the apparatus that move could add to inaccuracies due to friction during movement of the probe within the sleeve, at the elbow, or along the terminal sleeve.

[0009] In the past, to reduce time and produce consistency with periodontal probing examinations, attempts have been made to produce periodontal probes that will electronically record the depth of periodontal pockets. One disadvantage of these probes is that they have movable parts that can lead to difficulties with sterilization, and inconsistency in the overall measurements. Moreover, these probes tend to be large and bulky.

[0010] The prior art lacks probes that can quickly and easily determine the depth of the periodontal pocket by measuring the amount of marginal tissue without relying on the dental professional's technique. The prior art also lacks a probe that compiles electronic measurements, is lightweight, provides consistent accuracy, and is easy to sterilize.

SUMMARY

[0011] The present periodontal probe with touch sensing addresses the major shortcomings of the prior art.

[0012] The present periodontal probe described herein seeks to provide a probe that can quickly and accurately measure and record the depth of a patient's periodontal pockets. The present periodontal probe seeks to eliminate operator subjectivity when taking measurements and seeks to eliminate possible inaccuracies that may occur as a result of having moving parts. The periodontal probe described herein seeks to reduce significantly the

amount time required for recording measurements, and to eliminate operator subjectivity when reading the probe markings.

[0013] It is an aspect of the periodontal probe described herein to provide a probe that accurately and quickly measures a patient's periodontal pockets using a touch sensor. The marginal tissue of the gingival will cause an electronic signal to be produced that relates to the depth to which the periodontal probe has been inserted into the periodontal pocket.

[0014] A further aspect relates to a periodontal probe with a touch sensor that is in communication with a computer. The computer records the different depths of the patient's periodontal pockets.

[0015] Another aspect relates to a periodontal probe that has no moving parts, and can be sterilized without the possibility of misalignment of any moving parts due to temperature cycling.

[0016] In accordance with one aspect then, there is provided a periodontal probe for measuring a depth of a periodontal pocket, the periodontal probe comprising: a handle; a probe tip having a proximal end connected to the handle and an opposite distal end for insertion into the periodontal pocket, the probe tip including multiple capacitive touch sensitive readers located on an exterior surface of the probe tip for measuring contact between the exterior surface of the probe tip and tissue of the periodontal pocket, each capacitive touch sensitive reader comprising an electrically conductive band or ring arranged around a circumference of the probe tip; a corresponding capacitive touch sensor connected to the capacitive touch sensitive readers for measuring contact between the electrically conductive bands or rings on

the probe tip and the tissue of the periodontal pocket; and a microcontroller connected to the capacitive touch sensor, wherein the depth of the periodontal pocket is determined by a number of electrically conductive bands or rings for which a capacitance reading generated by the corresponding capacitive touch sensor increases above a pre-determined threshold capacitance as a result of the contact between the exterior surface of the probe tip and the tissue of the periodontal pocket.

[0017] In accordance with another aspect, there is provided a method for using the periodontal probe described above, comprising inserting the distal end of the probe tip into the periodontal pocket until the distal end of the probe tip contacts a bottom of the periodontal pocket and the exterior surface of the periodontal probe makes contact with the tissue of the periodontal pocket.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Referring to the drawings wherein like reference numerals indicate similar parts throughout the several views, several aspects of the periodontal probe with touch sensing are illustrated by way of example, and not by way of limitation, in detail in the figures, wherein:

[0019] Figure 1 is a partial cutaway side view of a wireless version of the present periodontal probe;

[0020] Figure 2 is a partial cutaway side view of the present periodontal probe periodontal for wired connection to a computer;

[0021] Figure 3 is a schematic view of a computer used to connect to the present periodontal probe.

[0022] Figure 4 is a cutaway side view of a probe tip of the present periodontal probe having one embodiment of a capacitive touch reader;

[0023] Figures 5a and 5b are cross sectional views of periodontal probe tips having the capacitive touch reader shown in Figure 4;

[0024] Figure 6 is a cutaway side view of a probe tip having a capacitive touch reader with a single conductive band;

[0025] Figure 7 is a cutaway side view of a probe tip having a capacitive touch reader with variable sized conductive bands;

[0026] Figure 8 is a cutaway side view of a probe tip having a capacitive touch reader arranged in a grid pattern;

[0027] Figure 9 shows one example of a circuit for a resistance touch reader for the present periodontal probe;

[0028] Figure 10 shows a cutaway side view of a probe tip having one version of a resistance touch reader.

[0029] Figure 11 shows a cutaway side view of a probe tip having another version of a resistance touch reader;

[0030] Figure 12 shows a cutaway side view of a probe tip having yet another version of a resistance touch reader;

[0031] Figure 13 shows a periodontal probe tip having a pressure sensitive switch for activating the periodontal probe to take a reading;

[0032] Figure 14 shows a periodontal probe tip having a flex switch for activating the periodontal probe to take a reading

[0033] Figure 15 shows a cutaway side view of a periodontal probe tip having a resistive switch mechanism at the tip end for activating the periodontal probe to take a reading;

[0034] Figure 16 shows a partial cutaway side view of a periodontal probe equipped with a thermo electric coupler (TEC) for powering the probe;

[0035] Figure 17 shows a cutaway side view of a periodontal probe equipped with a power transfer coil (PTC) for powering the probe

DETAILED DESCRIPTION

[0036] Various embodiments of the applicant's periodontal probe with touch sensing will now be discussed in detail.

[0037] Figure 1 shows a cutaway side view of a periodontal probe **10** comprising a handle **20** and a probe tip **30**. The handle **20** is substantially hollow and longitudinally extending. The periodontal probe tip **30** extends from a distal tip end **34**, which is inserted into the periodontal pocket, to a proximal end **12** for connection to the handle **20**. The probe tip **30** may include a bend at about 15-20 millimeters from the tip end **34**, forming a probe elbow **32**. The probe tip **30** may be tapered toward the tip end **34** and the tip end **34** may be rounded. The probe tip **30** may be hollowed throughout its length to allow insulated wires **36** (see Figure 4) to travel through from the probe tip **30** to the handle **20**. Probe tip **30** may also include traditional increment markings on the outside surface as shown in Figures 1 and 2.

[0038] The entire periodontal probe **10**, including probe tip **30**, and handle **20**, is preferably made of a material that can be sterilized, namely a plastic, or lightweight, non-corrosive metal, and has no moving parts. This advantageously allows the entire probe **10** to be sterilized. In the alternative, the periodontal probe **10** may have a detachable interface where tip **30** connects to handle **20** at the proximal end **12**. The connection at proximal end **12** may be a snap or a twist connection, although other suitable connections are envisioned. This allows the probe tip **30** to be removed from handle **20** and sterilized or disposed. Alternatively, probe tip **30** may be permanently attached to handle **20**.

[0039] The probe tip **30** includes a touch sensitive reader **40** located on or near the exterior surface of the probe tip **30** that is in communication with a touch sensor **14**, that is in turn in communication with a microcontroller **16**. The touch sensor **14** may be located in the handle **20** or elsewhere. The touch sensitive reader **40** measures physical contact between the exterior surface of the probe tip **30** and the human tissue

comprising the periodontal pocket. The amount of the contact between the exterior surface of the probe tip **30** and the tissue of the periodontal pocket is determined by the touch sensor **14** and the microcontroller **16** and corresponds to the depth of the periodontal pocket.

[0040] The handle **20** may also contain an activation button **22**, a display **24** and a rechargeable battery **26**. In one embodiment, the handle **20** also houses a wireless receiver/transmitter **18** (see Figure 1). Alternatively, the handle **20** may be hard-wired to a computer through a wire **28** (see Figure 2). In this embodiment, the handle would not require a receiver/transmitter or a battery. The activation button **22** is preferably located so that it may be easily pressed by the operator. When the activation button **22** is pressed, a signal is sent to the microcontroller **16** to take a reading and record the current input state of the touch sensor **14**.

[0041] As will be explained in greater detail below, the touch sensor **14** receives electric signals from the touch reader **40** and sends these readings to the microcontroller **16**, which converts the readings into a numerical depth measurement of the periodontal pocket. The display **24** may be used to display the measurement. The rechargeable battery **26** is used to supply power to the components of the periodontal probe, including the touch sensor **14**, the microcontroller **16** and the wireless receiver/transmitter **18**. If the periodontal probe **10** is hard-wired to a computer the power necessary to run these components may be delivered through the wire **28**.

[0042] The microcontroller **16** may also be configured to detect operator input from secondary buttons for any other user features that may be included in the present periodontal

probe, such as skipping a tooth, adjusting pressure sensitivity for recording, and control of a possible light source (not shown) to improve visibility.

[0043] Probe tip **30** may be pivotal with respect to handle **20** at the proximal end connection point **12**. This would allow the probe tip **30** to be rotated at varying angles relative to the handle **20**, to permit taking measurements in areas that may be difficult to otherwise access.

[0044] Figure 3 is a schematic diagram showing a computer **50**, which may be used to receive and record information regarding the depth of the periodontal pocket from the microcontroller **16**. Computer **50** is in communication with the periodontal probe **10**, either via a wireless receiver/transmitter **54** for receiving and transmitting wireless signals from and to the wireless transmitter/receiver **18**, or by being directly connected to the periodontal probe **10** by wire **28**. Computer **50** may be attached to a foot pedal **52** that can be used to activate the periodontal probe **10** for taking a measurement reading.

[0045] In one embodiment, as shown in Figure 4, the touch sensitive reader **40** is a capacitive touch reader **40a** and the touch sensor **14** is a capacitive touch sensor **14a**. The capacitive touch sensor **14a** is comprised of one or more individual capacitive touch sensing circuits (not shown), each individual sensing circuit being connected to an individual insulated wire **36**. In this description, the individual capacitive touch sensing circuits and the collective capacitive touch sensor are referred to using reference number **14a**. An example of one such capacitive touch sensor that may be used is Texas Instruments™ MSP430G2452. The specific capacitance measurement methodology to be used may vary and could be oscillator-based

measurement or resistor-based measurement, or any other suitable methodology that will be familiar to those skilled in the art.

[0046] Figure 4 illustrates an enlarged cutaway side view of the probe tip **30** of the periodontal probe **10**. The tip **30** includes capacitive touch reader **40a**, which in this embodiment includes of a plurality of thin electrically conductive bands **42**, or wire rings **44**, placed at one-millimeter increments along the length of the probe tip **30** as shown. The number of conductive bands **42** or wire rings **44** may be varied from one to preferably at least 8 to 10. Each band **42** or wire ring **44** is attached by a selected individual insulated wire **36**, to a corresponding individual capacitive sensor circuit **14a**. In Figure 4, only four of the bands or wire rings are shown as being connected with wires **36** to sensor circuit **14a**. These conductive bands **42** or wire rings **44** comprise the capacitive sensor elements for the capacitive touch sensor **14a** and represent the location where the capacitance reading is taken. Figure 5A is a cross section of the probe tip **30** taken at the location of one of the conductive bands **42** shown in Figure 4. One of the insulated wires **36** is shown connecting to the band **42**.

[0047] In an alternative arrangement shown in Figure 5B, the electrically conductive bands **42** on probe tip **30** are replaced by wire rings **44**. Each insulated wire **36** exits onto the outer surface **38** of the probe tip **30**, and forms a conductive wire ring **44** that wraps around the probe tip **30**.

[0048] Each insulated wire **36** extends upwards through the shaft of the periodontal probe tip **30**, along the probe elbow **32**, and attaches to a separate capacitive sensor circuit **14a**, which is in turn connected to microcontroller **16**. A capacitance reading on each band **42** or

wire ring **44** is measured by the corresponding capacitive sensor circuit **14a** and sent to the microcontroller **16**. Capacitive sensor circuit **14a** is constantly monitoring the capacitance of the conductive wire band **42** or ring **44**. Each wire band **42** or ring **44** has a base capacitance reading when not in contact with tissue. When the conductive band **42** or wire **44**, comes in contact with tissue in the periodontal pocket, the capacitance reading of the corresponding capacitive touch sensor circuit **14a** will change. Once the change in capacitance reaches a pre-determined threshold, determined by the type of tissue, moistness and salt content, the sensor circuit **14a** will register a reading. The location of the change in capacitance above the pre-determined threshold is detected by determining which wire band **42** or ring **44** has been triggered. This location is translated into a corresponding depth measurement in millimeters by the microcontroller **16**. For example, when the probe tip **30** is not in contact with tissue, all of the insulated wires **36** will transmit the same base capacitance reading to their corresponding capacitive touch sensor circuit **14a**. As the probe tip **30** is inserted into the periodontal pocket, successive bands **42** or wire rings **44** will come into contact with tissue surrounding the pocket, commencing from the probe tip end **34** upward toward the probe elbow **32**. The contact with tissue will cause a change in capacitance reading from each successive corresponding capacitive sensor circuit **14a**. The number of bands **44** or wire rings **42** for which the capacitance reading changes above a pre-determined threshold will correspond in millimeters to the depth of the periodontal pocket.

[0049] Figure 6, shows an alternative arrangement where the capacitive touch reader **40a** comprises a single conductive band **46**. In this arrangement, capacitive touch sensor **14a** is configured to provide a quantitative reading of the capacitance of the conductive band **46**, rather than to detect a change in capacitance above a certain threshold. As the probe

tip **30** is inserted into the periodontal pocket contact is made between the exterior surface of the probe tip **30** and the moist tissue, which creates a specific capacitance reading on band **46**. As the probe tip **30** is inserted further into the periodontal pocket, the capacitance reading increases due to increased contact between the probe tip **30** and the tissue of the periodontal pocket. The increase in capacitance of the band **46** corresponds to the amount of tissue that has come into contact with the exterior surface of probe tip **30**, which corresponds to the depth of the periodontal pocket.

[0050] As shown in Figure 7, there may be multiple conductive bands **46** of equal or unequal width, each separated by an insulating ring. Figure 7 shows three bands **46**, each connected to a separate capacitive touch sensor circuit **14a**.

[0051] Figure 8, shows a further alternative arrangement, where the capacitive touch reader **40a** comprises a wire grid formed by one or more conductive wire rings **42** that wrap around the outside circumference of probe tip **30** and one or more conductive wire strips **48** that run longitudinally on the outside surface of the probe tip **30**. The wire rings **42** are electrically insulated from the wire strips **48**. Each of the wire rings and wire strips is connected to a separate capacitive touch sensor circuit **14a** by wires **36** and comprise the capacitive sensor element for that sensor circuit. In Figure 8, only two of the multiple wire strips making up the grid are illustrated, and only four of the wire rings are shown as being connected by wires **36**. In this arrangement, capacitive touch sensor **14a** is configured to provide a detailed pattern of capacitance readings at various locations circumferentially around and longitudinally along the exterior surface of probe tip **30**. In this way, more detailed information can be provided, such as the depth, shape and the three-dimensional structural integrity of the periodontal pocket.

[0052] One method of using the periodontal probe shown in Figure 4 is for the operator to grip the periodontal probe **10** by the probe handle **20**. The probe tip **30** is inserted into the periodontal pocket, in the area between the gingival margins and the tooth root. The probe tip **30** is gently guided into the periodontal pocket until resistance is met at the base of the pocket. Tissue surrounding the periodontal pocket comes in contact with the outside surface of the probe tip **30**. At this time, the operator depresses the activation button **22** on the probe handle **20** or depresses the foot pedal **52**, thereby signaling the microprocessor **16** to take a reading. The microprocessor **16** records the amount of contact between the exterior surface of the probe tip **30** and the tissue of the periodontal pocket by measuring the changed capacitance readings, above a pre-determined threshold, from the individual capacitive sensor circuits **14a**, thus registering how many millimeters of the probe tip **30** has been inserted into the periodontal pocket. This depth information is then displayed on the display **24**. The depth information may also be sent to the computer **50** where it may be displayed, processed by software and recorded. The information can be used to keep records of patient history for assessing and keeping track of the patient's periodontal health.

[0053] The periodontal probes shown in Figures 6 and 7 work in the same way, except that when a capacitance reading is taken a quantitative value of capacitance above the base capacitance is obtained, which correlates to the amount of tissue that is in contact with the exterior surface of probe tip **30**, which in turn corresponds to the depth the probe tip **30** has been inserted into the periodontal pocket.

[0054] In another embodiment, as shown in Figures 10-12, the touch reader **40** is a resistance touch reader **40b** and the touch sensor **14** is a resistance touch sensor **14b**. The resistance touch sensor **14b** is comprised of one or more individual resistance touch sensing circuits **60**, like the one shown in Figure 9, which illustrates a basic resistance touch switch. A resistance touch switch is based on the fact that human tissue (like the skin) contains a great amount of water and salt, which makes it conductive. In the sample resistance touch circuit **60** shown in Figure 9, a transistor **61** is used as a switch. A resistor **62** is provided to protect the transistor from an over-current situation in the event of a short circuit. Conductive electrodes **64** and **66** are included in the circuit **60**, separated by an insulating gap **65**. If one of the electrodes **66**, **64** is touched, nothing happens. However, if both electrodes **64** and **66** are touched in such a manner that the insulating gap **65** is bypassed, as shown in Figure 9, human skin acts like a resistor and a slight amount of current will flow between electrodes **64** and **66** and to the base of transistor **61**. The state of transistor **61** will change from cut-off to saturation, and current will flow to the LOAD, thus triggering the sensor. Those skilled in the art will appreciate that many other configurations of resistance touch circuit **60** are possible.

[0055] Figure 10 illustrates one example of periodontal probe tip **30** with a resistance touch reader **40b**. Pairs of conductive bands or wires **64**, **66** located on or near the outer surface of probe tip **30** correspond to electrodes **64**, **66** in resistance touch sensing circuit **60** of resistance touch sensor **14b**, and are separated by an insulating gap **65**. Wires **36** connect the electrodes **64**, **66** to resistance touch sensor **14b**. When the probe tip **30** is inserted into the periodontal pocket, the surrounding tissue will come in contact with the outside surface of the probe tip **30**. If the tissue bridges the insulated gap **65** between conductive bands **64**, **66**, the corresponding resistance touch sensing circuit **60** will record a positive reading. When the

operator depresses the activation button **22** on the probe handle **20** or depresses foot pedal **52**, the microprocessor **16** records how many of the sensing circuits **60** have been triggered, thus registering the amount of contact between the exterior surface of the probe tip **30** and the tissue of the periodontal pocket, thereby measuring how many millimeters the probe tip **30** has been inserted into the periodontal pocket. The depth information may be displayed on the display **24** and/or sent to the computer **50**.

[0056] Figure 11 illustrates another example of a periodontal probe tip **30** having a resistance touch reader **40b** configured in a slightly different manner. In this example, probe distal tip end **34** functions as one of the electrodes **64** in all of the resistance touch sensing circuits **60** of resistance touch sensor **14b**. Conductive bands **66** function as the second electrode. The two conductive bands/electrodes **64** and **66** are separated by insulated, non-conducting gaps **65**. Wires **36** connect the tip end **34** and conductive bands **66** to resistance touch sensors **14b**. The wire **36** connecting tip end **34** is shared by all of the touch sensing circuits **60** of resistance touch sensor **14b**. When the probe tip **30** is inserted into the periodontal pocket, the surrounding tissue will come in contact with the outside surface of the probe tip **30**. If the tissue bridges the insulated gaps **65** between conductive tip end **34** and conductive bands **66**, the corresponding resistance touch sensing circuit **60** will record a positive reading. As the tissue bridges each successive gap **65** to the next conductive band **66**, the next corresponding sensing circuit **60** will record a positive reading. When the operator depresses the activation button **22** on the probe handle **20** or depresses foot pedal **52**, the microprocessor **16** records how many of the sensing circuits **60** have been triggered, thus registering the amount of contact between the exterior surface of the probe tip **30** and the tissue of the periodontal pocket, thereby measuring how many millimeters of the probe tip **30** has been

inserted into the periodontal pocket. The depth information may be displayed on the display **24** and/or sent to the computer **50**.

[0057] Figure 12 illustrates a further example of a periodontal probe tip **30** having a resistance touch reader **40b** configured in a slightly different manner. In this example, the outside surface of probe tip **30** is divided into wide conductive bands **64** and narrow conductive bands **66**, that function as the electrodes **64**, **66** in the resistance touch sensing circuit **60** of resistance touch sensor **14b**. The two conductive bands/electrodes **64** and **66** are separated by an insulated, non-conducting gap **65**. Wires **36** connect each pair of electrodes **64**, **66** to resistance touch sensor **14b**. A second insulating gap **65'** separates each pair of electrodes **64**, **66** from the next adjacent pair of electrodes **64**, **66**. When the probe tip **30** is inserted into the periodontal pocket, the surrounding tissue will come in contact with the outside surface of the probe tip **30**. If the tissue bridges the insulated gap **65** between the first pair of conductive bands **64**, **66**, the corresponding resistance touch sensing circuit **60** will record a positive reading. If the tissue bridges the next insulated gap **65** between the next pair of conductive bands **64**, **66**, a second sensing circuit **60** will record a positive reading. When the operator depresses the activation button **22** on the probe handle **20** or depresses foot pedal **52**, the microprocessor **16** records how many of the sensing circuits **60** have been triggered, thus registering the amount of contact between the exterior surface of the probe tip **30** and the tissue of the periodontal pocket, thereby measuring the depth to which the probe tip **30** has been inserted into the periodontal pocket. The depth information may be displayed on the display **24** and/or sent to the computer **50**.

[0058] Two methods for activation of the periodontal probe **10** to record a reading have been described. One is by pressing the activation button **22** on the probe handle **20**, and the second is by depressing the foot pedal **52** attached to computer **50**. The skilled reader will appreciate that there are numerous other possibilities for activation of the periodontal probe **10** to take a reading. In one example (not shown), voice recognition circuits could be included on the probe **10** or attached to computer **50**, which would permit the user to activate the probe using voice commands. In another example, shown in Figure 13, probe tip **30** may be fitted with a pressure sensitive switch or sensor **70**, which activates when tip end **34** comes in contact with the base of the periodontal pocket. Triggering of the pressure switch or sensor **70** will automatically activate the probe's touch sensor **14** causing it to send the current readings to the microprocessor **16**. In a further example, shown in Figure 14, a flexible pressure switch or sensor **74** may be used on the probe tip **30**. In this case, once the tip end **34** comes in contact with the base of the periodontal pocket, the probe tip **30** will flex, bringing switch plates **76** and **78** into contact to complete the circuit and trigger the switch/sensor **74**. Activation of flex switch/sensor **74** will automatically activate the probe's touch sensor **14** causing it to send readings to the microprocessor **16**. Yet another example is shown in Figure 15. In this example, probe tip **30** is provided with a resistive switch or sensor mechanism **80** at the tip end **34**. Resistive switch/sensor **80** consists of two wire mesh plates **81** and **82**. When tip end **34** comes in contact with the base of the periodontal pocket, pressure is applied causing the two palates **81** and **82** to come into contact, triggering the switch/sensor **80** and automatically activating the probe's touch sensor **14**, causing it to send readings to the microprocessor **16**.

[0059] Pressure switch/sensor **70**, flex switch/sensor **74**, and resistive switch/sensor **80** may have adjustable pressure threshold settings to suit the comfort needs of the patient. Each

switch or sensor can be set to activate at specified pressure settings, which can be stored in the microprocessor **16** or the computer **50** for each patient. The pressure settings may be set to different threshold levels based on standardize averages for healthy versus diseased tissue.

[0060] Two options have been discussed for powering the periodontal probe **10**. One option is to use a rechargeable battery **26** located in the handle **20** as shown in Figure 1. Another option is to directly power the probe using a wired connection **28** to the computer **50** as shown in Figure 2. Two other options are shown in Figures 16 and 17. Figure 16, shows a thermo electric coupler (TEC) **90** and TEC controller **91** located in the handle **20**. TEC **90** is used to generate electricity to charge battery **26** when the probe is heated up and cooled down during the sterilization process. Electricity is generated by the TEC **90** whenever there is a temperature difference between the inside and outside of the probe handle **20**. Such temperature differences are created whenever the probe is placed into or removed from an autoclave for sterilization.

[0061] Figure 17, shows a power transfer coil (PTC) **100** and PTC controller **101** located in the handle **20**. PTC **100** generates electricity to charge battery **26** whenever it is placed in close proximity to another energized power transfer coil. This could take place when the probe is swiped for RFID identification, or the probe could be stored next to an energized PTC.

[0062] Of course, the reader will appreciate that other options are available for powering and charging the probe **10**, such as using a solar panel to charge the battery **26**, or to use a vibration generator such as the type found in wristwatches. In addition, combinations of the above-mentioned power generation and supply techniques may be used.

[0063] The inventors anticipate that there will be multiple periodontal probes **10** in use in a single dental office, all attached or communicating wirelessly with a single computer **50**. In a wireless environment, there is the problem of identifying which probe is being used. One solution is to embed a radio frequency identification (RFID) chip into the handle **20** of each probe **10**. The chip can be swiped over an RFID reader attached to computer **50** to identify which probe is being used. In a situation where there are one or more probes **10** and multiple computers **50**, an RFID reader can be embedded in the handle **20** of each probe **10** and an RFID chip can be attached to each computer **50**. In this situation, the probe handle would be swiped against the RFID chip on the desired computer to identify which computer is being used. Of course, one skilled in the art will understand that numerous other methods of verification are possible. For example, one or two dimensional bar codes and bar code readers could be employed. In the alternative, software could be used on the wireless transmitter/receiver **18** to send identification codes to the computer **50** to identify which of the probes is being used.

[0064] The previous detailed description is provided to enable any person skilled in the art to make or use the present periodontal probe. Various modifications to those embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the scope of the periodontal probe as defined by the appended claims. Thus, the present periodontal probe is not intended to be limited to the embodiments shown herein, but is to be accorded the full scope consistent with the appended claims, wherein reference to an element in the singular, such as by use of the article "a" or "an" is not intended to mean "one and only one" unless specifically so stated, but rather "one or more". All structural and functional equivalents to the elements of the various

embodiments described throughout the disclosure that are known or later come to be known to those of ordinary skill in the art are intended to be encompassed by the elements of the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims.

CLAIMS

1. A periodontal probe (10) for measuring a depth of a periodontal pocket, the periodontal probe comprising:

a handle (20);

a probe tip (30) having a proximal end (12) connected to the handle and an opposite distal end (34) for insertion into the periodontal pocket, the probe tip including multiple capacitive touch sensitive readers (40a) located on an exterior surface (38) of the probe tip for measuring contact between the exterior surface of the probe tip and tissue of the periodontal pocket, each capacitive touch sensitive reader comprising an electrically conductive band or ring (42, 44) arranged around a circumference of the probe tip;

a corresponding capacitive touch sensor (14a) connected to the capacitive touch sensitive readers for measuring contact between the electrically conductive bands or rings on the probe tip and the tissue of the periodontal pocket; and

a microcontroller (16) connected to the capacitive touch sensor,

wherein the depth of the periodontal pocket is determined by a number of electrically conductive bands or rings for which a capacitance reading generated by the corresponding capacitive touch sensor increases above a pre-determined threshold capacitance as a result of the contact between the exterior surface of the probe tip and the tissue of the periodontal pocket.

2. The periodontal probe as defined in claim 1, wherein the touch sensitive readers are positioned at selected incremental distances from the distal end of the probe tip.

3. The periodontal probe as defined in claim 1, further including at least one additional capacitive touch sensitive reader connected to a separate corresponding touch sensor, the at least one additional capacitive touch sensitive reader comprising an electrically conductive strip (48) oriented longitudinally on the exterior surface of the probe tip, wherein the at least one electrically conductive strip is electrically insulated from the electrically conductive bands or rings.
4. The periodontal probe as defined in any one of claims 1 to 3, including an activation switch (80, 70, 74) for activating the periodontal probe to make a reading of the depth of the periodontal pocket once the distal end of the probe tip makes contact with a bottom of the periodontal pocket.
5. The periodontal probe as defined in claim 4, wherein the activation switch is a pressure sensitive sensor (70, 74) located on the probe tip to automatically activate the periodontal probe to make a reading of the depth of the periodontal pocket once the distal end of the probe tip makes contact with a bottom of the periodontal pocket.
6. The periodontal probe as defined in any one of claims 1 to 5, including a rechargeable battery (26) for providing electric power to operate the periodontal probe, and a thermo electric coupler (90) for generating electricity to re-charge the battery when the periodontal probe is heated or cooled.

7. The periodontal probe as defined in any one of claim 1 to 5, including a rechargeable battery for providing electric power to operate the periodontal probe, and a power transfer coil (100) for generating electricity to re-charge the battery.

8. The periodontal probe as defined in any one of claims 1 to 7, including a means for individually identifying the periodontal probe in situations where multiple periodontal probes are being used in close proximity.

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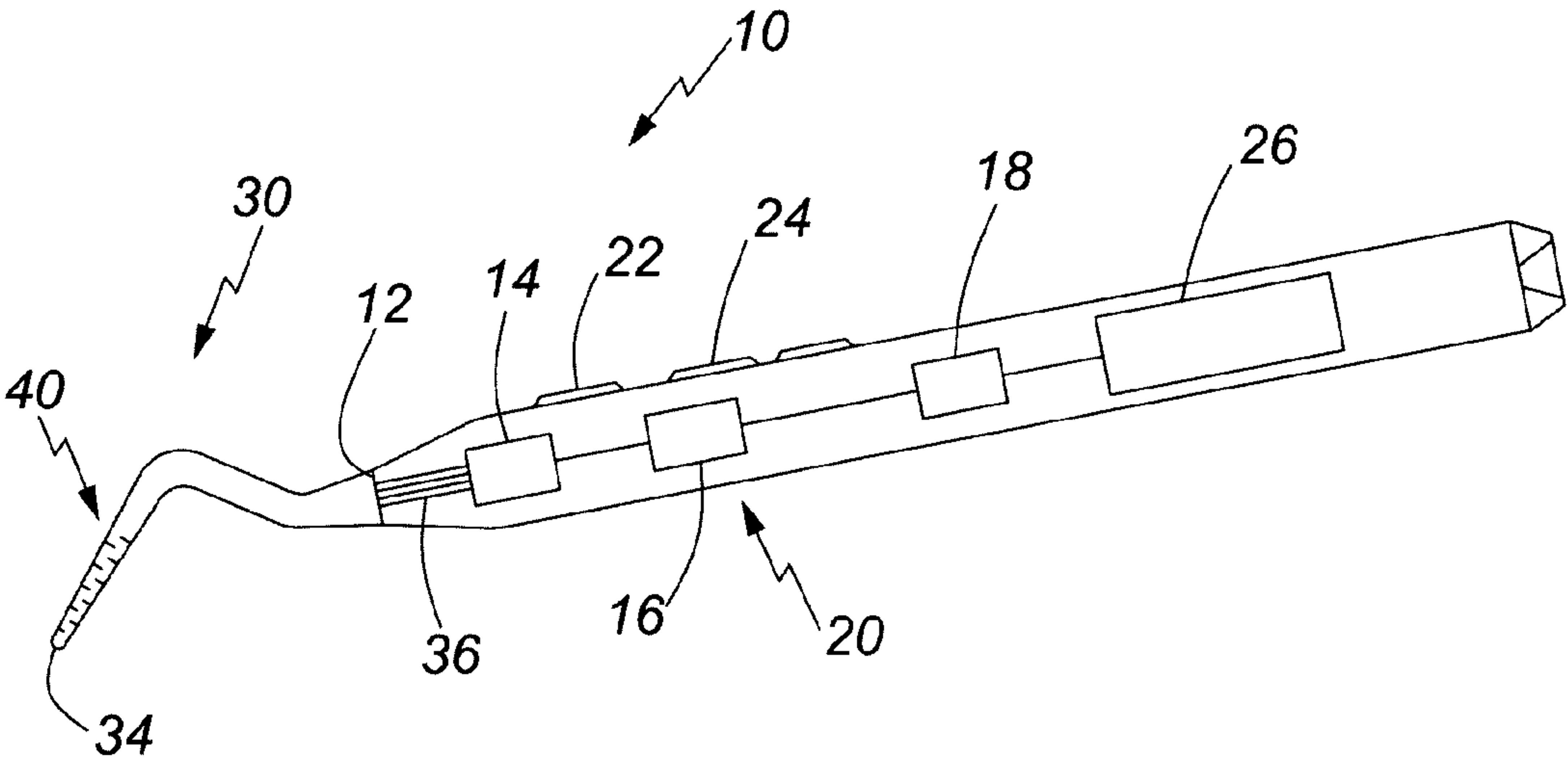


FIG. 1

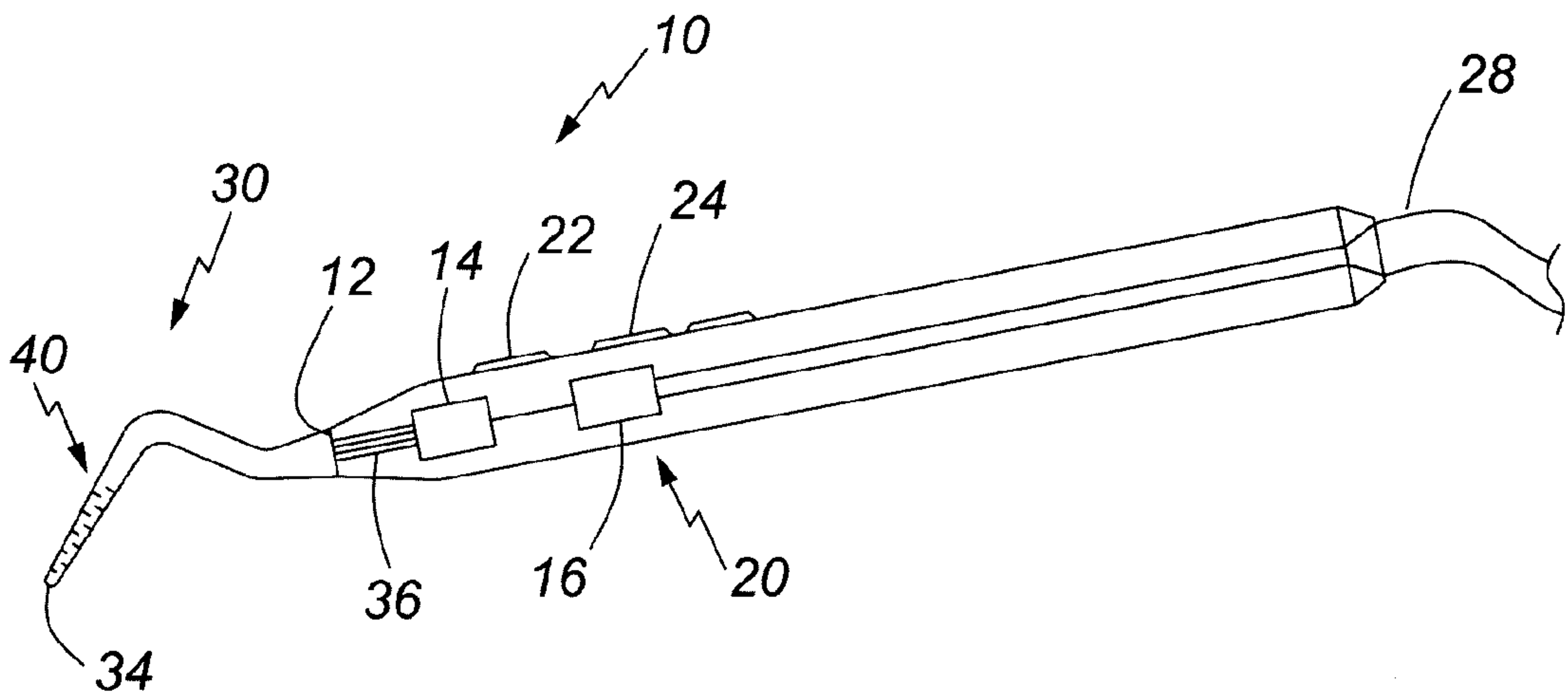


FIG. 2

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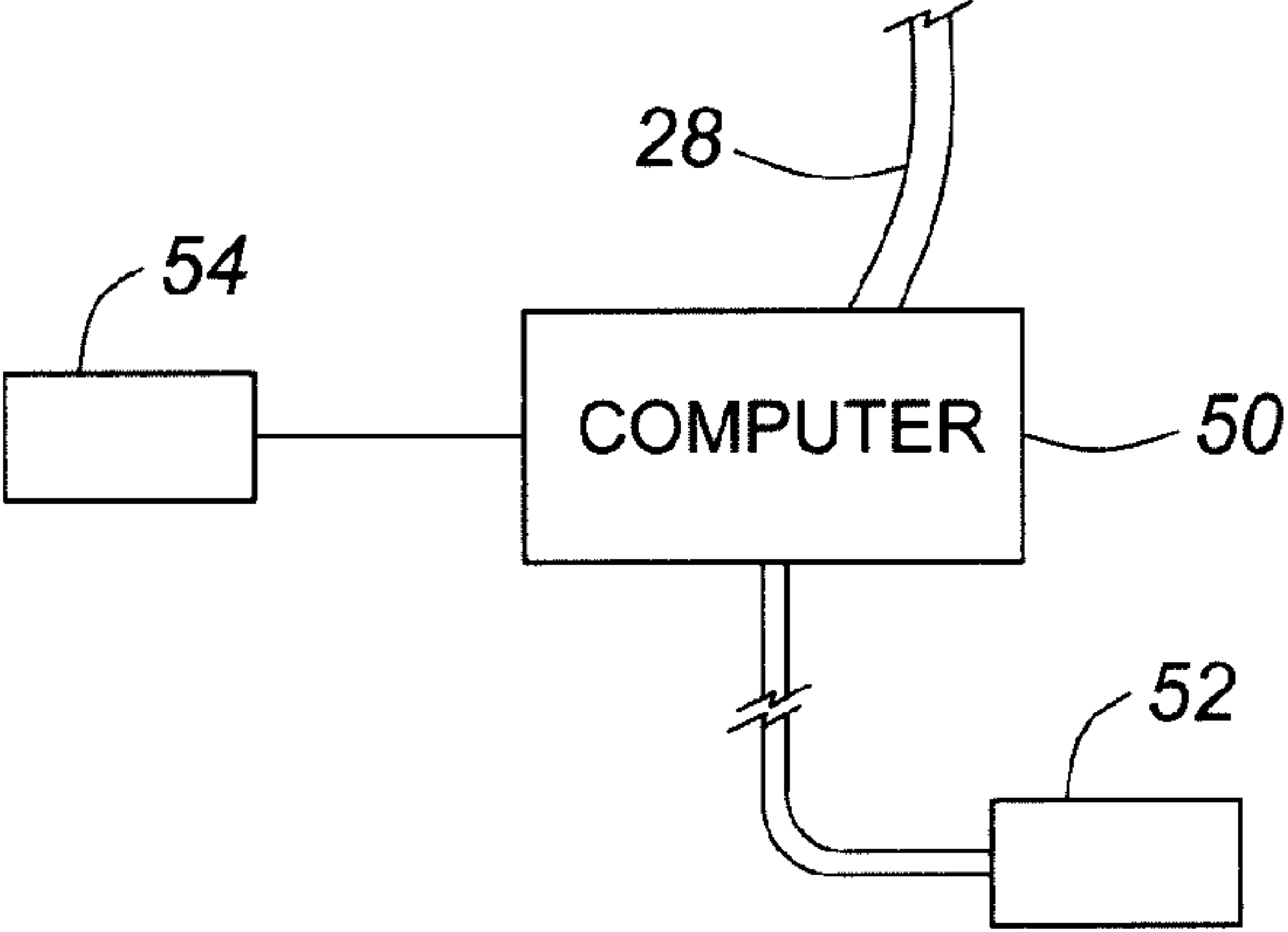


FIG. 3

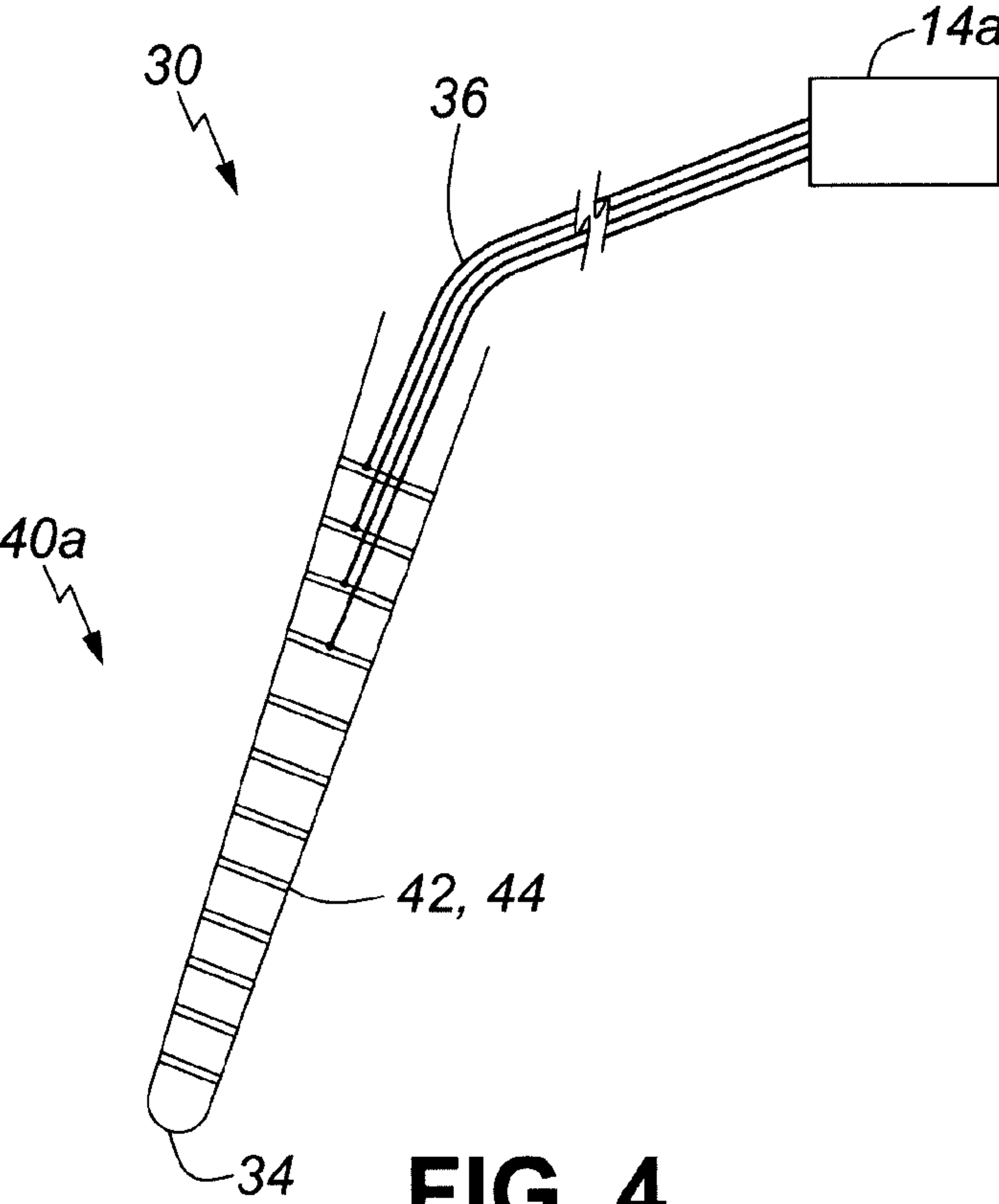


FIG. 4

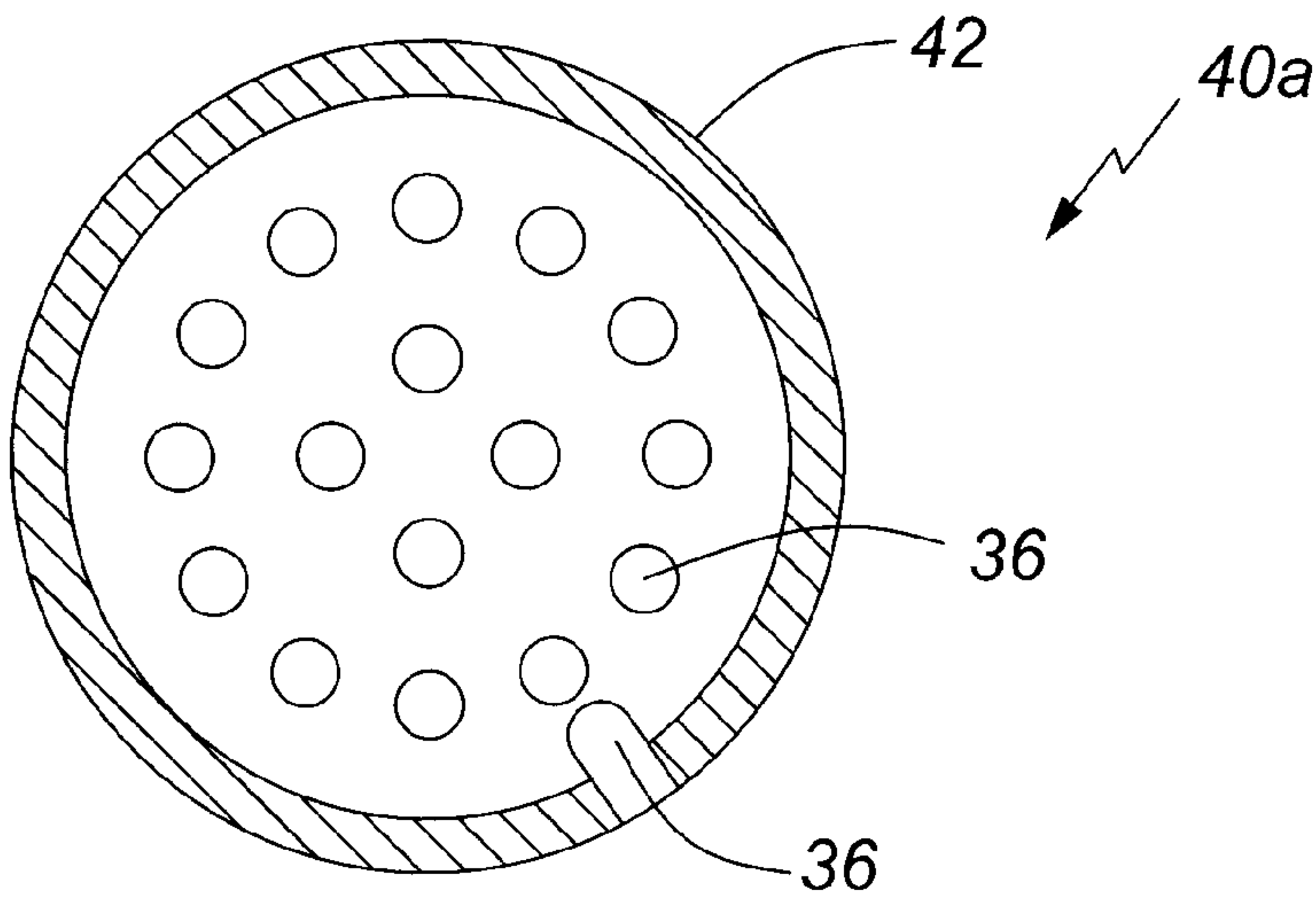


FIG. 5A

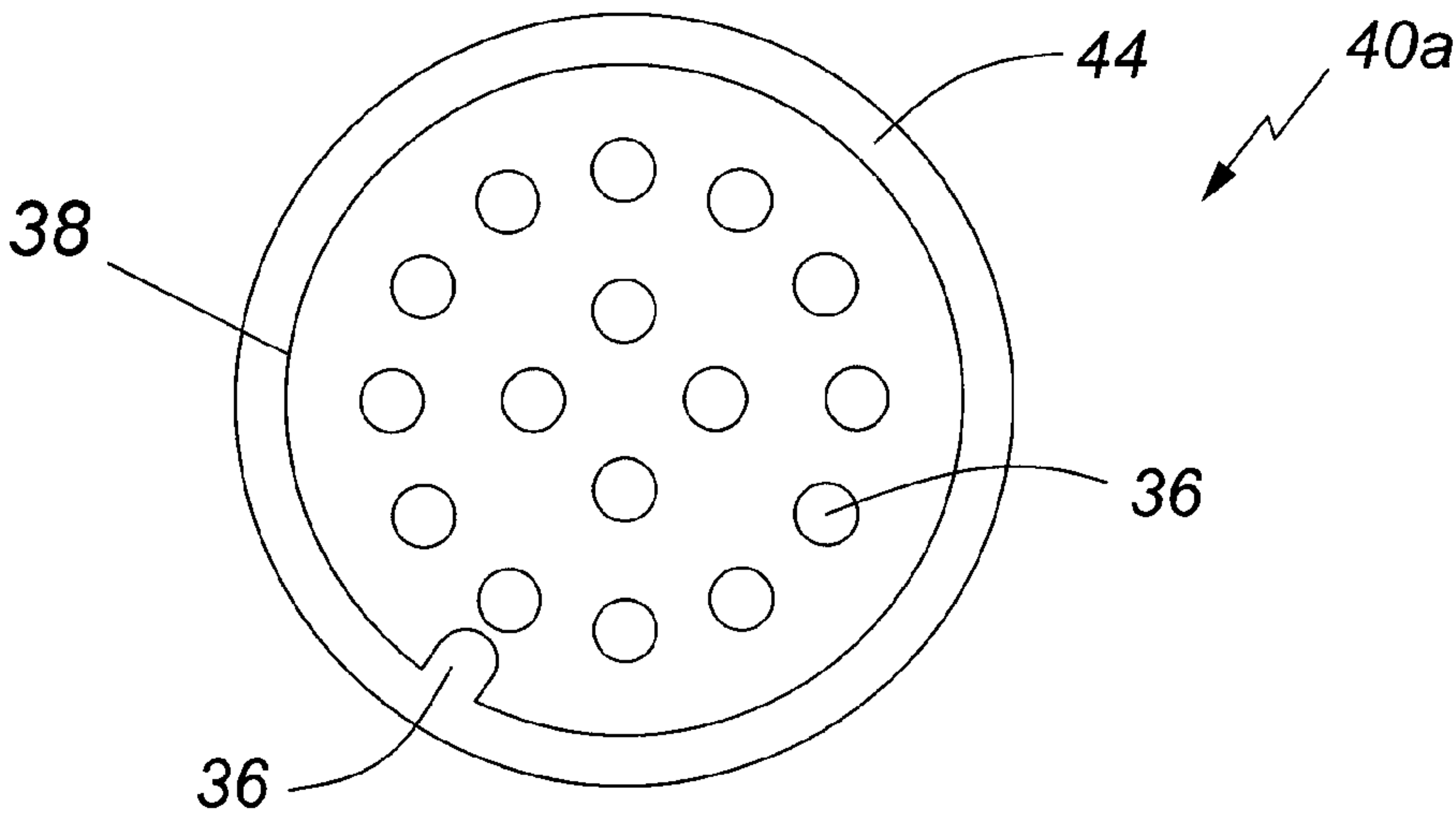


FIG. 5B

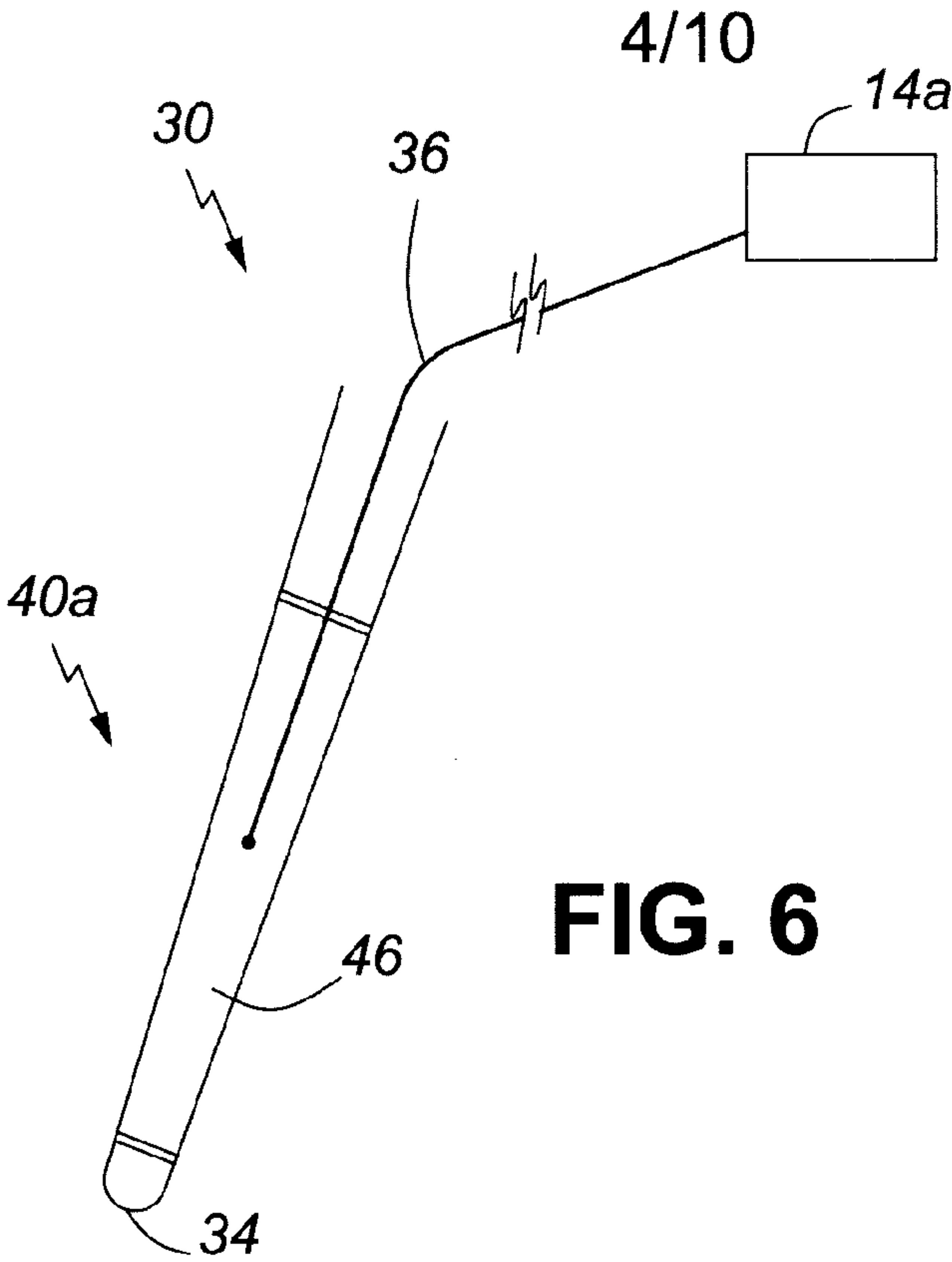


FIG. 6

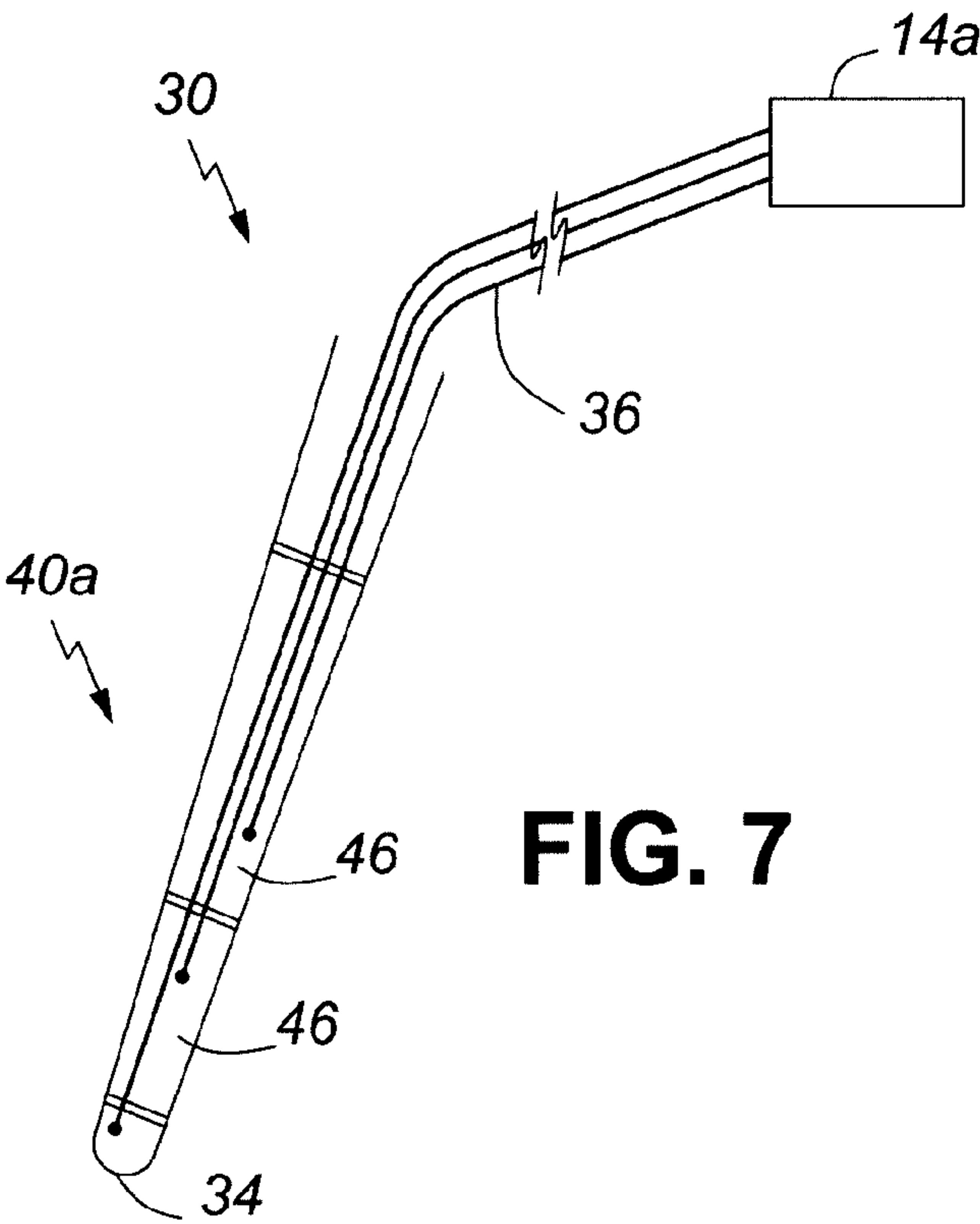


FIG. 7

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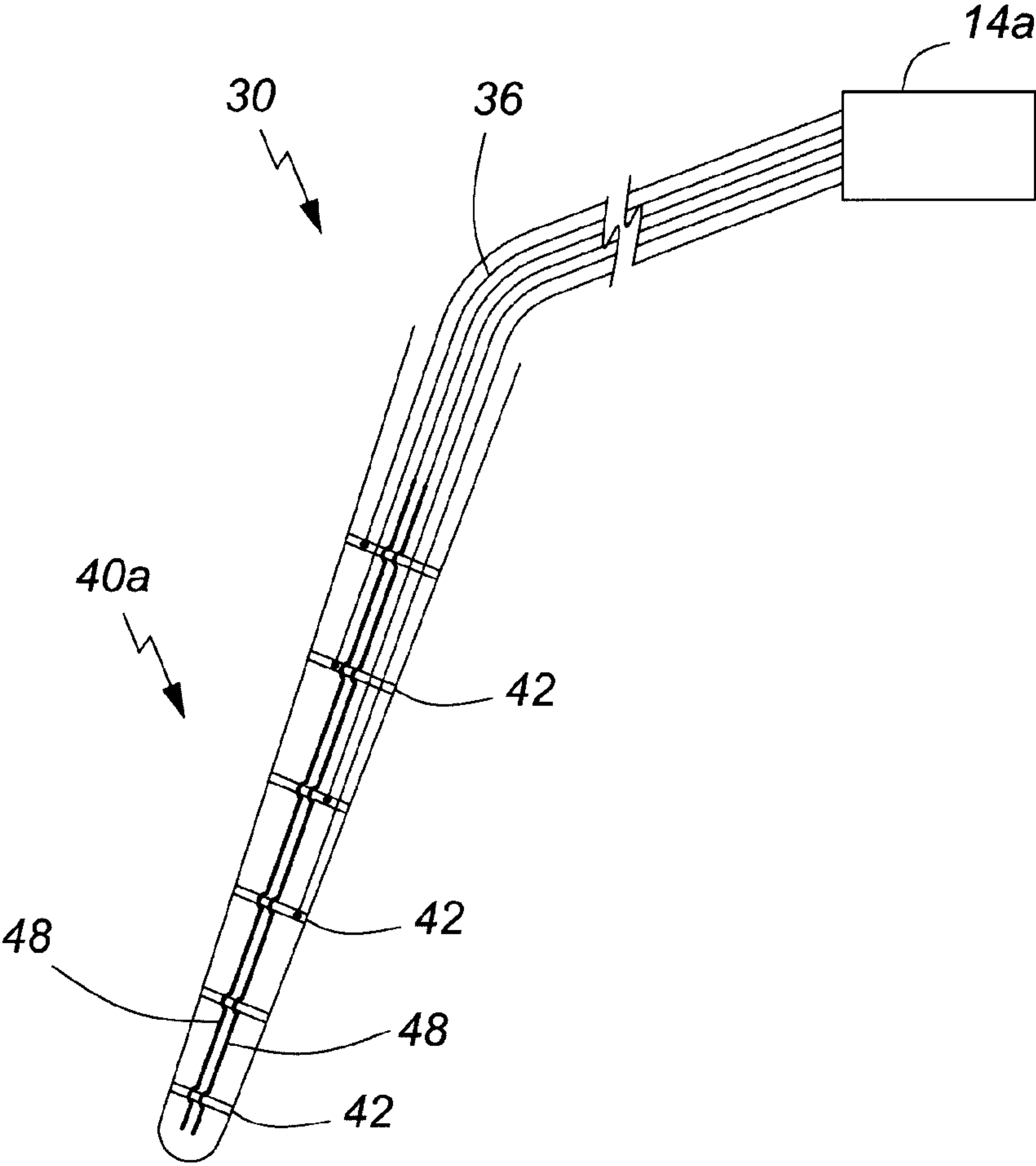


FIG. 8

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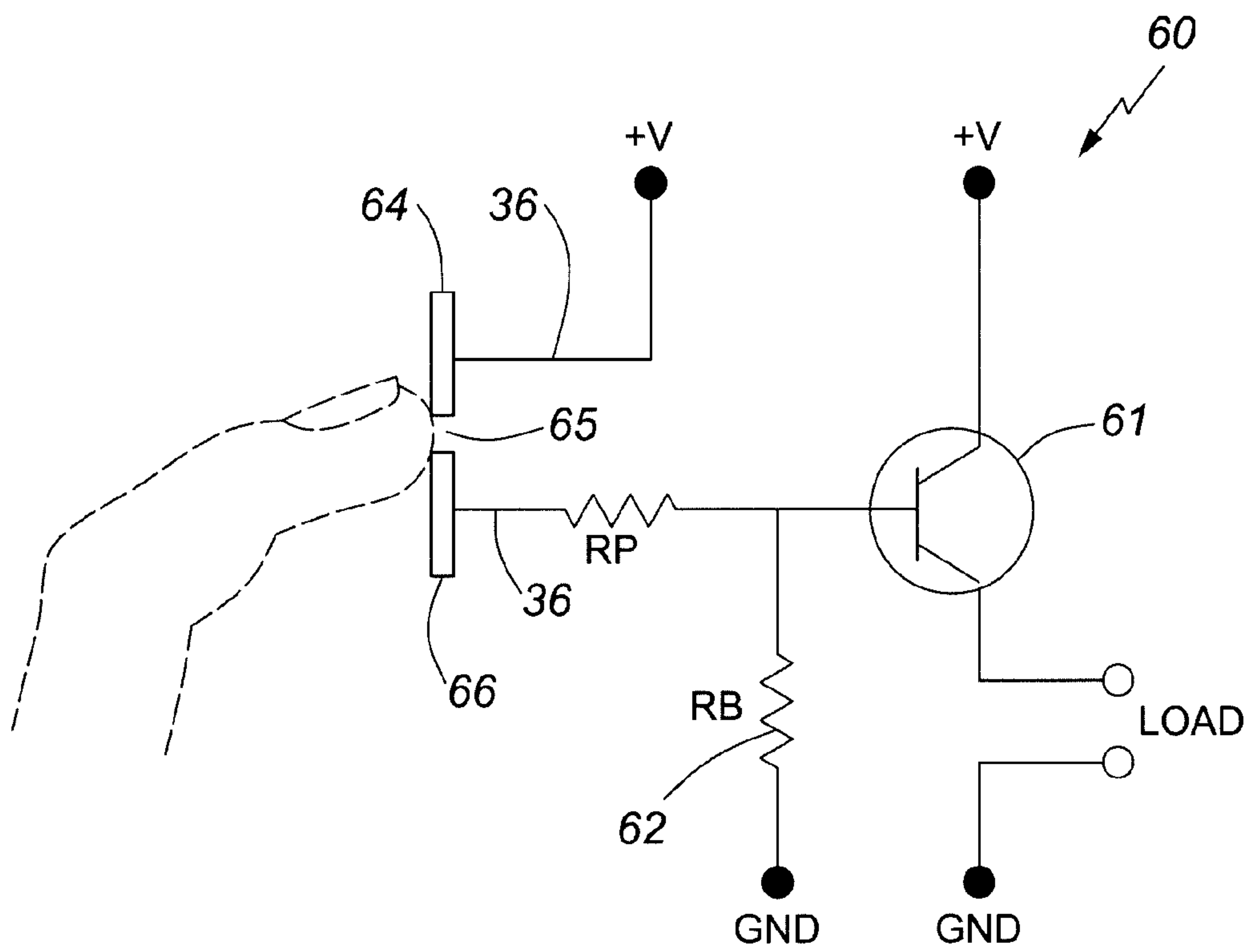


FIG. 9

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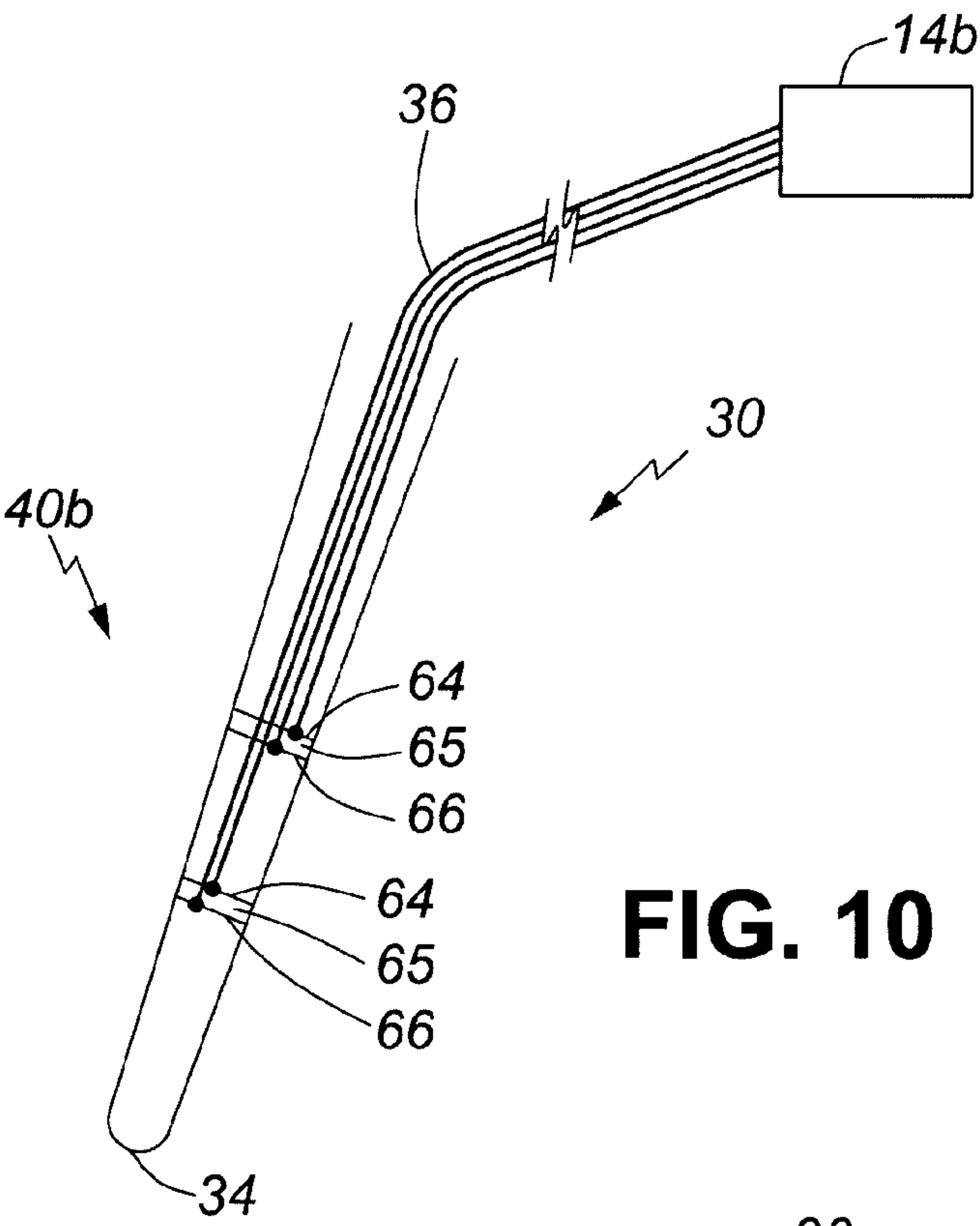


FIG. 10

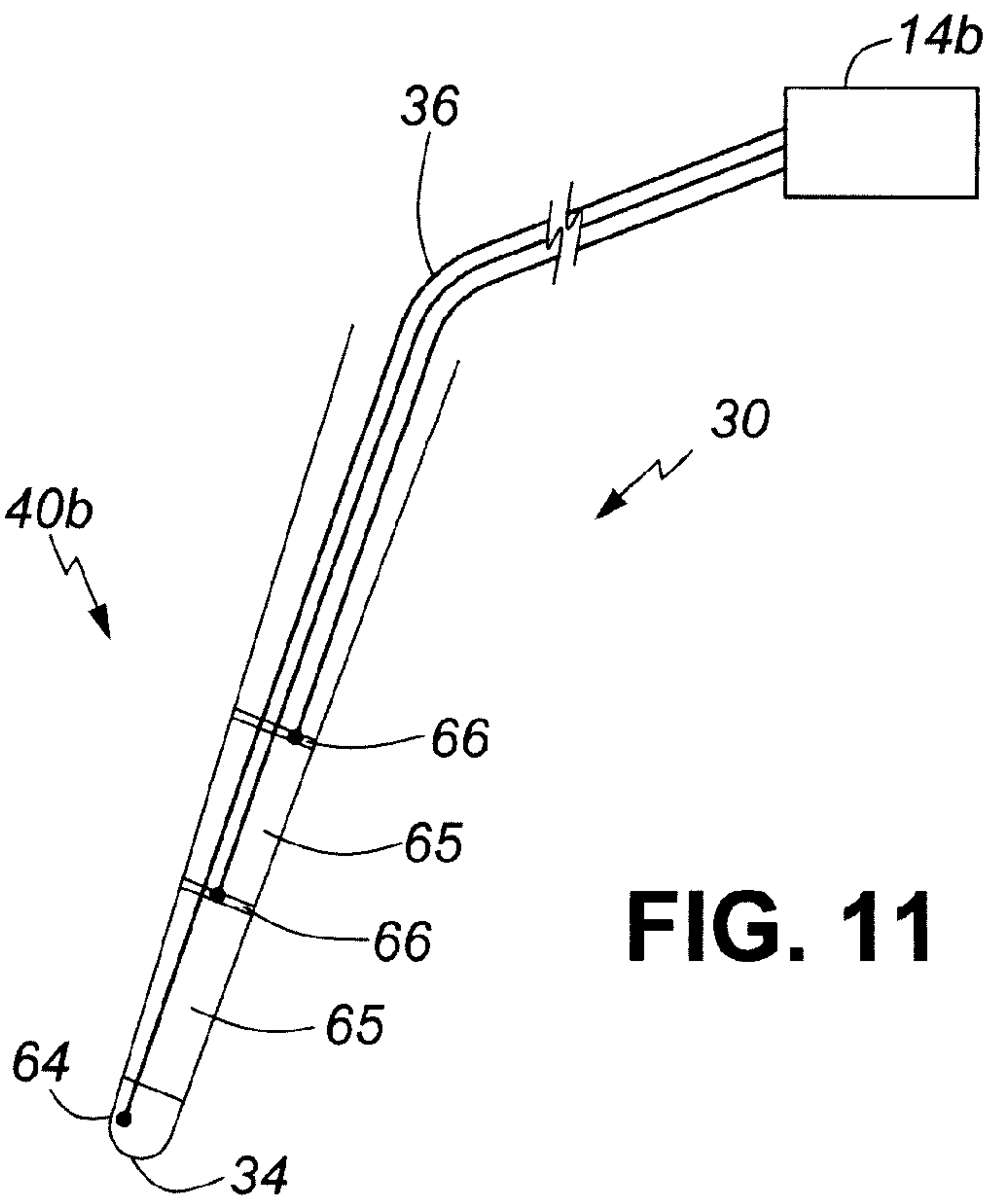
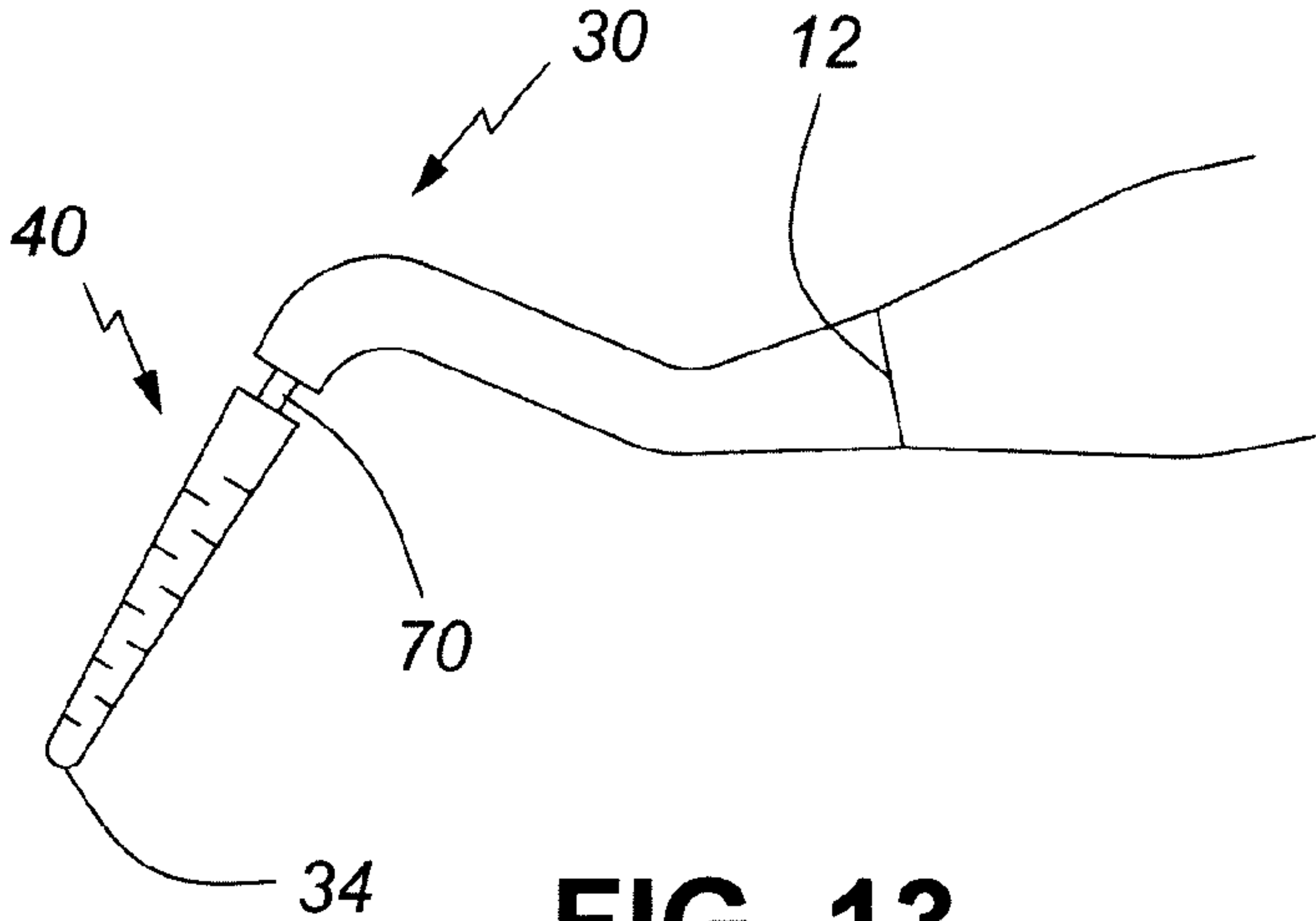
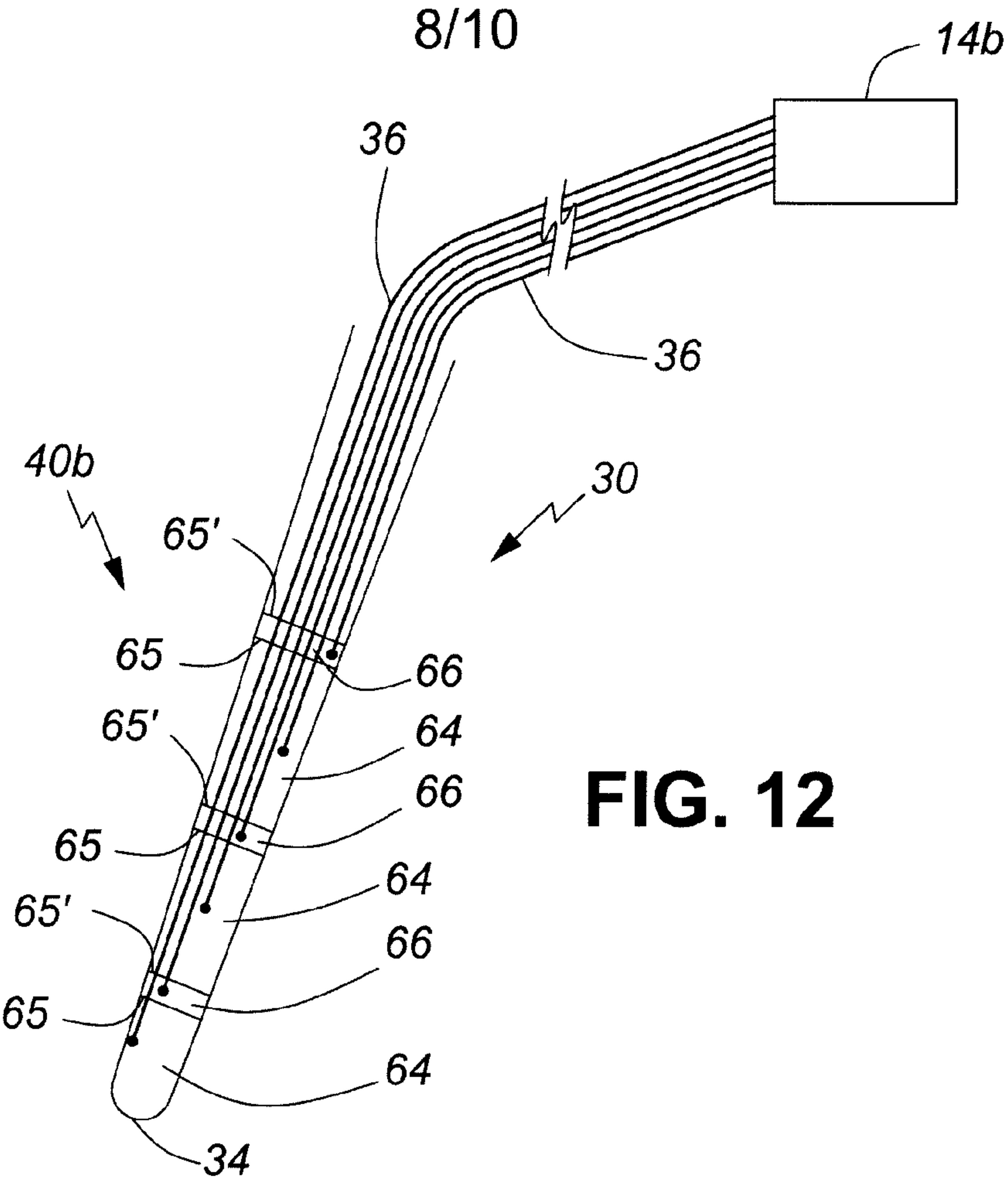


FIG. 11



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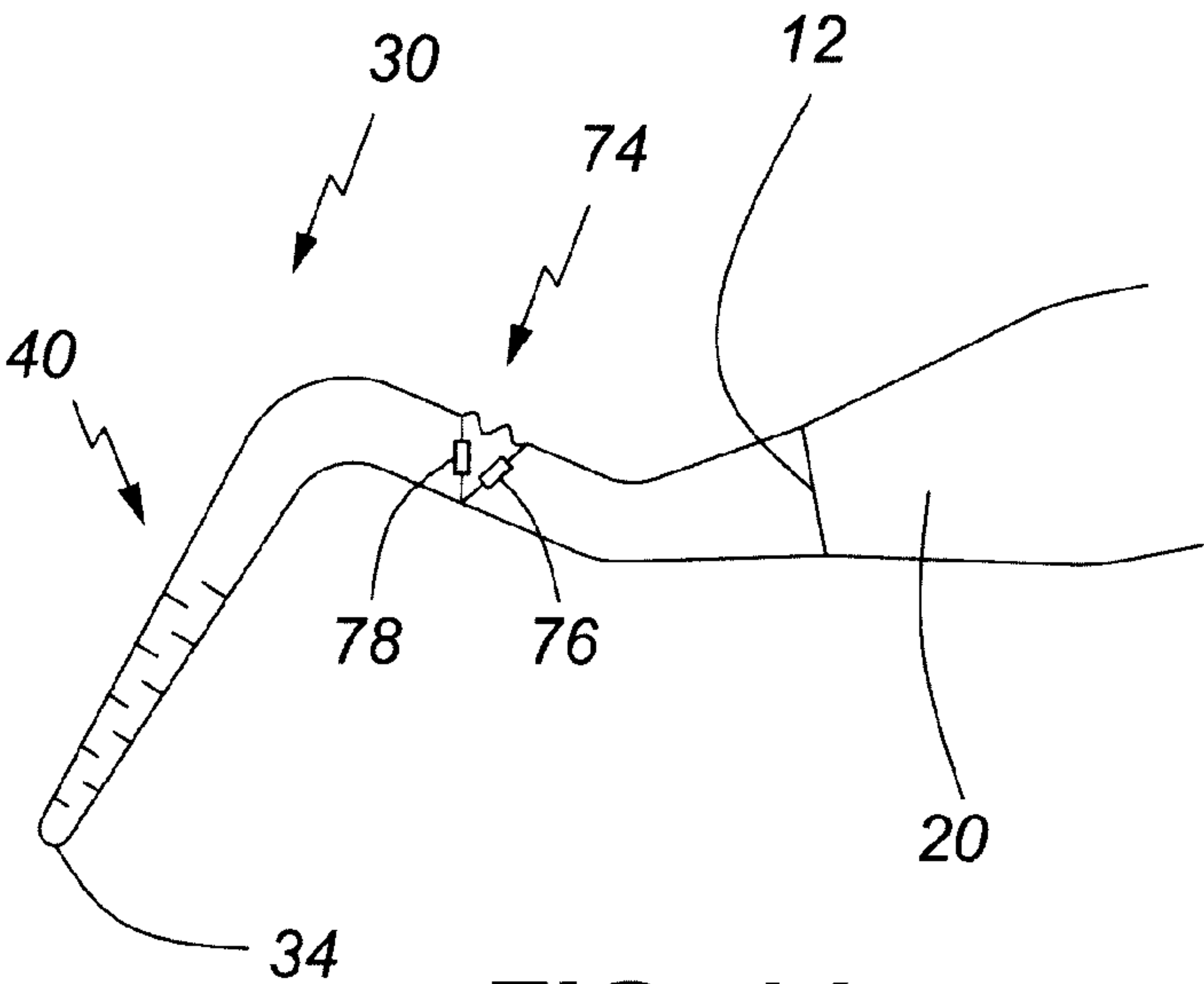


FIG. 14

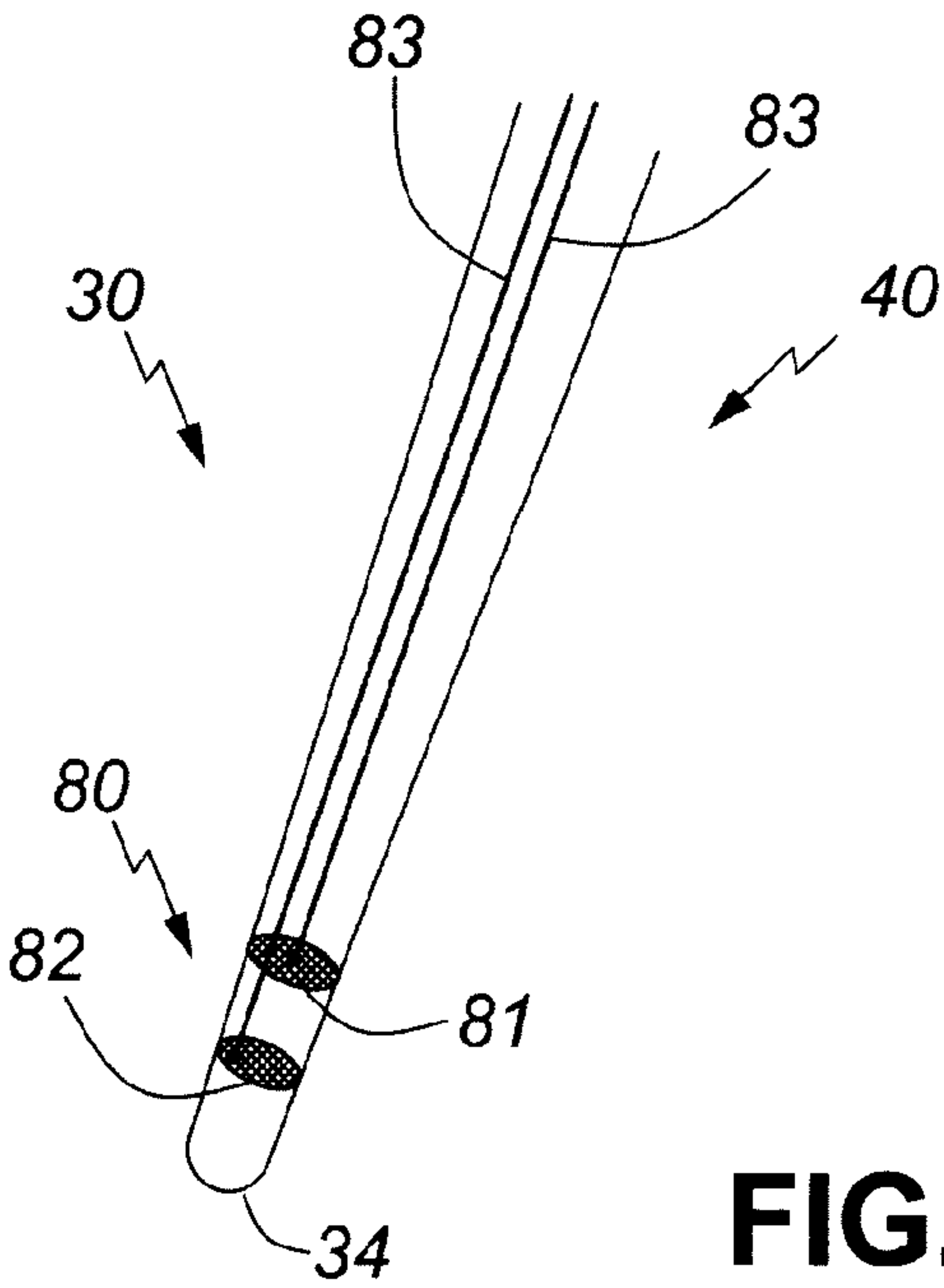


FIG. 15

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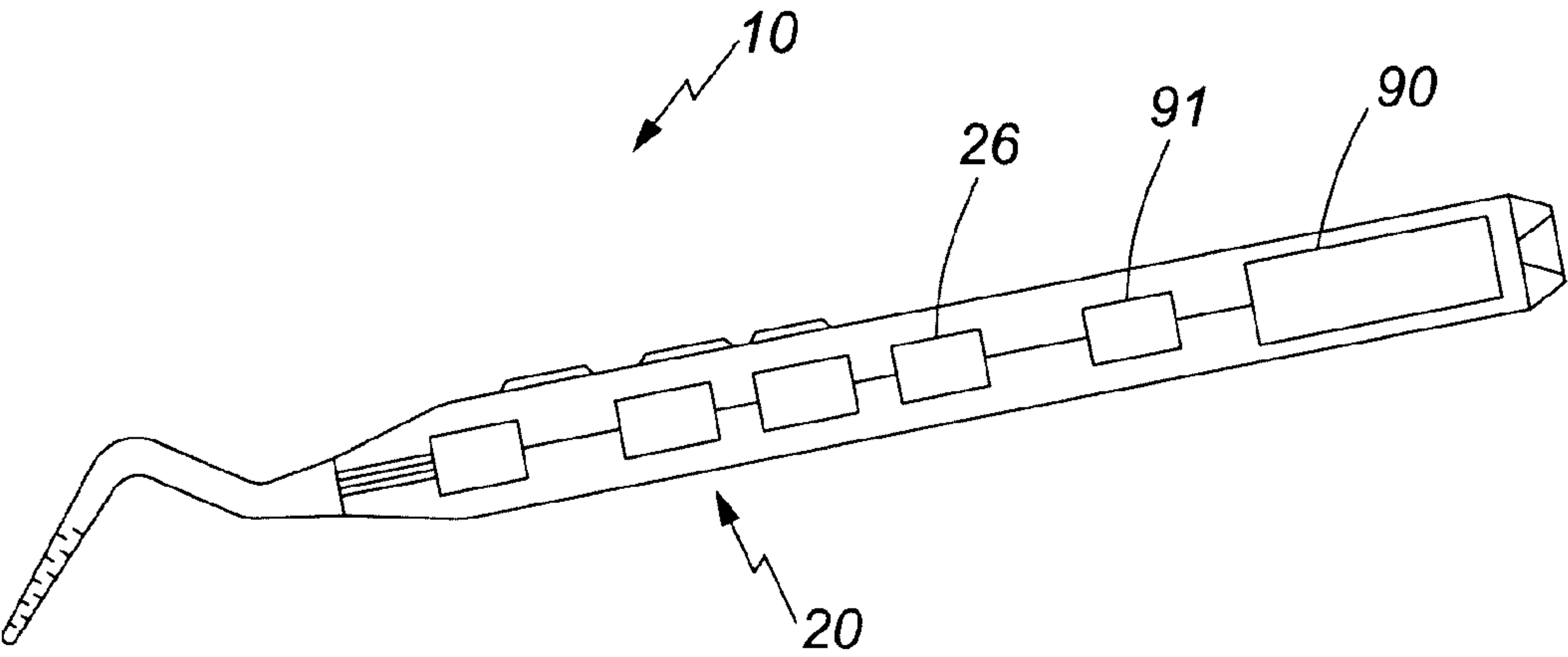


FIG. 16

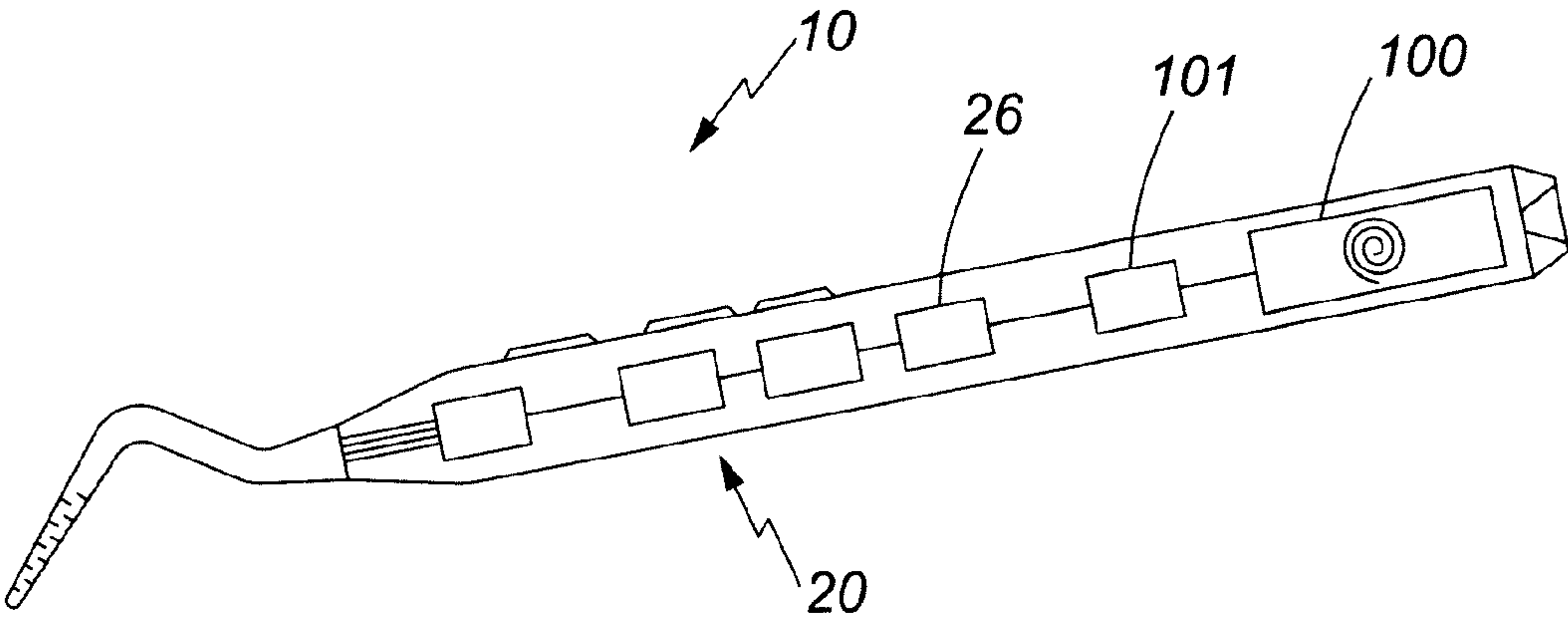


FIG. 17

